ISSN 2987-4270
PLE
Physics Learning and Education
Vol. 4 No. 1 (2026)

The Effect of Learning Using the LKPD-Assisted PjBL Model on Creative Thinking Ability in Class X Phase E of SMAN 2 Sijunjung

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ABSTRACT

Students' creative thinking skills in physics learning, particularly on alternative energy topics, remain relatively low due to teacher-centered instructional practices. This study aimed to examine the effect of the Project Based Learning (PjBL) model assisted by Student Worksheets (LKPD) on students' creative thinking skills.

This research employed a quantitative approach using a quasi-experimental design with a nonequivalent control group. The sample consisted of two classes of grade X Phase E students at SMAN 2 Sijunjung, with class X E8 as the experimental group and X E7 as the control group. Data were collected using a creative thinking skills test administered as pretest and posttest. The data were analyzed using normality tests, homogeneity tests, and independent sample t-tests.

The results showed that the experimental class achieved a higher mean posttest score 76.1 compared to the control class 63.1. The t-test results indicated a significant difference at the 5% significance level. These findings indicate that the LKPD-assisted PjBL model has a significant positive effect on students' creative thinking skills in learning alternative energy concepts.

Keywords: Project Based Learning (PjBL), Student Worksheets (LKPD), Creative Thinking Skills, Alternative Energy

I. INTRODUCTION

Education has a strategic role in shaping a generation that has character, is knowledgeable, and adaptive to the times. In the 21st century era, students are required to master four main competencies known as the 4Cs, namely critical thinking (*critical thinking*), creative thinking (*creativity*), the ability to communicate (*communication*), and the ability to collaborate (*collaboration*), as a provision to face global challenges [1]. Among these four competencies, the ability to think creatively has an important role because it allows students to generate new ideas in finding solutions to various complex problems [2]. In the context of learning science, especially physics, creative thinking skills are an important element to help students understand natural phenomena and apply them in real life [3].

Facts in the field show that students' creative thinking skills are still relatively low. Based on the results of the 2021 Global Innovation Index, Indonesia ranks 87th out of 132 countries in terms of innovation and creativity capabilities [4]. This condition shows the need for innovation in the learning process to foster the creative thinking potential of students. The results of initial observations at SMAN 2 Sijunjung also show that in alternative energy materials, students' creative thinking skills are still low with an average score of 32.8%. The weakest aspect of creative thinking ability is elaboration (the ability to develop ideas in detail), which shows that students are not able to expand ideas and apply physics concepts creatively.

The low creative thinking ability of students is also inseparable from the physics learning pattern that is still teacher-oriented and lacks the use of technology-based innovative learning media. Most physics teachers still use conventional learning methods and printed teaching materials, so that students become passive and critical and creative thinking skills do not develop optimally [5]. In addition, the ability to think critically and creatively is

Submitted: 2025-11-05 Accepted: 2026-02-04 Published: 2026-03-01

also influenced by various factors such as reading ability, learning time, learning resources used, and students' understanding of learning objectives [6]. These factors play an important role in forming active and reflective thinking patterns that support the development of higher-level thinking skills. Therefore, it is necessary to innovate teaching materials and learning models that are able to foster active participation and imagination of students through contextual and project-based activities.

These problems are influenced by the conventional learning model, where teachers dominate the learning process and students tend to be passive. This condition inhibits the development of high-level thinking skills, including creative thinking [7]. Therefore, an innovative learning model is needed that can actively involve students in building knowledge and skills. One of the models that suits these needs is Project Based Learning (PjBL). This model emphasizes project activities that are oriented towards real problem-solving so that it allows learners to learn through hands-on experience, collaboration, and exploration of ideas [8].

The PjBL model places students as the main subject in the learning process. Through the project, students are required to plan, investigate, solve problems, and produce products that are relevant to real life. According to the George Lucas Educational Foundation [9], the application of PjBL is able to improve higher-level thinking skills such as analysis, synthesis, and evaluation. According to Lestari & Yuwono [10], the use of the PjBL model is able to increase the motivation and sense of responsibility of students because they are actively involved in every stage of learning, from planning to evaluation. In addition, this model also encourages independence, responsibility, and the ability to work together because students are actively involved from the planning stage to the evaluation of project results [11**].**

To optimize the application of the PjBL model, teaching materials are needed that can guide students systematically in carrying out project activities. One of the teaching materials that is effectively used is the Student Worksheet (LKPD). LKPD functions as a learning medium that helps students understand concepts, carry out activities, and develop critical and creative thinking skills [12]. A good LKPD must meet the aspects of validity, practicality, and effectiveness in order to support the learning process [13].

Research by Anggi Permana Putri [14] shows that LKPD based *on Project Based Learning* on alternative energy materials has met the valid and practical criteria for use in learning. The results of the study strengthen the suspicion that the combination of the PjBL and LKPD models can be an effective learning alternative in developing students' high-level thinking skills.

In addition, the application of the PjBL model is also in line with the principles of the Independent Curriculum which emphasizes contextual, collaborative, and oriented learning on the Pancasila Student Profile. In this curriculum, students are given the opportunity to actively learn, explore the surrounding environment, and develop creativity through project activities [3]. PjBL encourages students to not only master knowledge, but also develop creative thinking skills in producing innovative solutions to problems relevant to daily life.

By considering these various aspects, this study aims to determine the effect of the application of the LKPD-assisted PjBL model on the creative thinking ability of students in class X Phase E of SMAN 2 Sijunjung. Through the application of the structured PjBL model and the use of valid and practical LKPD, it is hoped that students can improve their creative thinking skills, especially in understanding the concept of alternative energy that requires divergent thinking skills and deep problem-solving.

Although previous studies have demonstrated the effectiveness of Project Based Learning and LKPD in improving students' higher-order thinking skills, limited research has specifically examined the integration of LKPD-assisted PjBL in developing creative thinking skills on alternative energy topics at the senior high school level, particularly within the context of the Independent Curriculum. Therefore, this study seeks to fill this gap by empirically investigating the impact of LKPD-assisted PjBL on students' creative thinking skills.

II. METHOD

The research conducted was a quantitative analysis with a quasi experimental approach. The design used was a design of a nonequivalent control group, which consisted of two groups: an experimental group and a control group that was not randomly selected [15]. In this study, the researcher will provide the LKPD-assisted PjBL model to the experimental group, while the control group will not undergo any intervention. Before treatment, both groups will undergo a pretest to evaluate the students' initial creative thinking skills. After treatment, both groups will undergo a posttest to assess the effects of the intervention.

Table 1. Research Design

Class	***Pretest***	**Treatment**	***Posttest***

Eksperimen	O_1	X_1	O_2
Control	O_1	X_2	O_2

Information:

O_1= *Pretest* on experimental and control classes
O_2= *Posttest* on experimental and control classes
X_1= Treatment using the LKPD-assisted PjBL model
X_2= Treatment with physics learning through teaching materials and PBL models

This study involved all classes X Phase E at SMAN 2 Sijunjung as research participants.

The experimental class and the control class were selected using nonprobability sampling techniques, especially purposive sampling. The sample was selected based on several predetermined criteria, including the number of students and the students' final exam scores for the odd semester of the 2024/2025 school year. Statistical tests were then applied to designate class X Phase E8 as the experimental class and class X Phase E7 as the control class. Both classes have the same starting ability.

This study identified the LKPD-assisted PjBL model as an independent variable, and the creative thinking ability of students at SMAN 2 Sijunjung as a bound variable. Data collection was carried out quantitatively using instruments.

The research instrument used in this study is a test that is structured to assess creative thinking skills, which consists of description questions. This test has been validated by previous researchers and has a reliability coefficient of 0.79. This instrument includes physics problems related to alternative energy that are given as a pretest and posttest for the experimental class and the control class.

This study used pretest and posttest data collection methods to assess the effect of treatment on the experimental class and the control class, both before and after its application. The data analysis process involves the application of normality, homogeneity, and hypothesis test techniques.

Data analysis was conducted through descriptive and inferential statistics. Descriptive statistics were used to describe students' creative thinking scores, while inferential statistics included normality tests, homogeneity tests, and independent sample t-tests to examine differences between the experimental and control groups at a 5% significance level.

III. RESULTS AND DISCUSSION

Result

This research was carried out by researchers from May 5, 2025 to May 31, 2025 at SMAN 2 Sijunjung. This study used two classes as sample classes, namely class X Phase E8 as an experimental class that was given treatment in the form of the use of the PjBL model assisted by LKPD while class X Phase E7 as a control class was not given treatment. The implementation of this research was carried out for approximately one month, where in one week it consisted of 1 meeting in each class with an allocation of 3 x 45 minutes. This study produced data in the form of pretest and posttest values of both sample groups. The following are presented the results after measuring students' creative thinking skills for both sample groups.

1. Results *of the creative* thinking ability pretest

Table 2. Results *of the creative* thinking ability pretest

Data Centralization and Dissemination	Control Class	Experimental Classes
Number of Students	32	32
Highest Score	51,8	55,4
Lowest Score	8,9	6,3
Average	36	38,1
Median	35,3	40,2
Baku Junction	9,762	9,644

The table above shows the concentration and dissemination of the pretest data from the control class and the experimental class. In the control class, the highest score was 51.8% and in the experimental class 55.4%. The lowest score in the control class was 8.9% and in the experimental class 6.3%. The average score in the experimental class was greater than that of the control class, where the average in the experimental class was 38.14% and in the control class was 36.04%. The table also shows that the median value of the control class is 35.3, while the median value of the experimental class is 40.2.

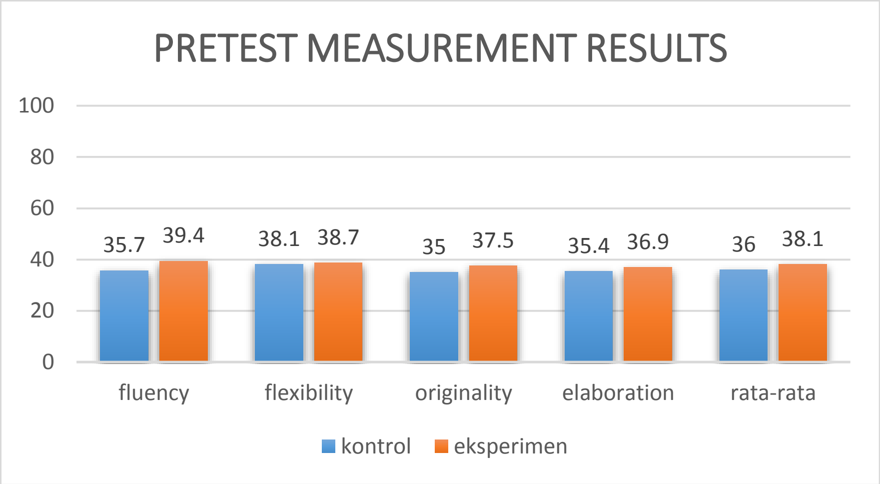

Fig. 1. Pretest Scores of Students

Based on figure 1. It was seen that for all indicators of creative thinking ability, the experimental class had a higher average score compared to the control class. In the experimental class with an average score of 38.1% and a control class of 36%, the scores of both classes were in the low category.

2. Posttest results *of* creative thinking skills

Table 3. Posttest results *of* creative thinking skills

Data Centralization and Dissemination	Control Class	Experimental Classes
Number of Students	30	32
Highest Score	83	96,4
Lowest Score	39,3	55,4
Average	63,1	76,1
Median	64,3	75,9
Baku Junction	13,111	12,545

The table above shows the concentration and distribution of posttest data from the control class and the experimental class. In the control class, the highest score was 83% and in the experimental class it was 96.4%. The lowest score in the control class was 39.3% and in the experimental class 55.4%. The average score in the experimental class was greater than that of the control class, where the average in the experimental class was 76.1% and in the control class was 63.06%. The table also shows that the median value of the control class is 64.3, while the median value of the experimental class is 75.9.

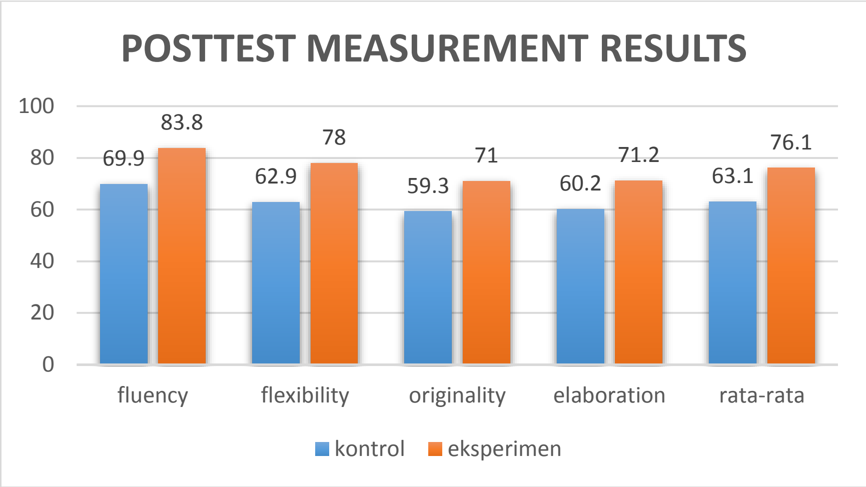

Fig. 2. Posttest Scores from Students

Based on figure 2. It was seen that for all indicators of creative thinking ability, the experimental class had a higher average score compared to the control class. In the experimental class with an average score of 76.1% and a control class of 63.1%, the figure and table above show that the final ability of students in both classes improved when assessed based on their initial ability. This shows that learning using the LKPD-assisted PjBL model has a positive effect on the creative thinking ability of students in the experimental group.

3. Data *Pretest Analysis*

a. Normality Test

The results of the normality test for both data groups from the research sample are presented in table 4.

Table 4. Pretest Normality Test Results

Class	**N**	α	L_t	L_h	**Information**
Eksperimen	32	0,05	0,157	0,106	Normal
Control	32		0,157	0,071	Normal

Based on table 4, it can be seen that at the real level 0.05 for both sample classes. This shows that each class of sample is normally distributed.$L_t > L_h$

b. Homogeneity Test

The results of the homogeneity test for both data groups from the research sample can be seen in table 5.

Table 5. Pretest Homogeneity Test Results

Class	N	$\bar{X}$	S	S^2	F_t	F_h	Dk	ket
Eksperimen	32	38,1	9,644	93,0	1,822132	1,024618	31	Homogeneous
Control	32	36	9,762	95,3			31	

Based on table 5, it can be seen that $F_h < F_t$ for both classes of samples. This shows that the sample class has a homogeneous variance.

c. Uji Hypothesis

The results of the two-mean similarity test for two data groups from the sample class are shown in table 6.

Table 6. Results of the Two-Average Similarity Test *Pretest*

Class	N	$\bar{X}$	S	S^2	t_t	t_h

Class	N	$\bar{X}$	S	S^2	t_t	t_h
Eksperimen	32	38,1	9,644	93,0	1,7	-0,9
Control	32	36	9,762	95,3		

Based on the results of the hypothesis test in table 6, it can be seen that the t_h value is small from the critical value in the table, so the research hypothesis for *the pretest* data cannot be accepted or rejected, so it can be concluded that there has not been a significant influence because the use of the LKPD-assisted PjBL model in physics learning has not been applied to students' creative thinking skills.

4. Posttest Data Analysis

a. Normality Test

The results of the normality test for both data groups from the research sample are presented in table 7.

Table 7. Posttest Normality Test Results

Class	**N**	α	L_t	L_h	**Information**
Eksperimen	32	0,05	0,157	0,152	Normal
Control	30		0,161	0,134	Normal

Based on table 7, it can be seen that at the real level it is 0.05 for both sample classes. This shows that each class of sample is normally distributed.$L_t > L_h$

b. Homogeneity Test

The results of the homogeneity test for both data groups from the research sample can be seen in table 8.

Table 8. Posttest Homogeneity Test Results

Class	N	$\bar{X}$	S	S^2	F_t	F_h	Dk	ket
Eksperimen	32	76,1	12,545	157,4	1,834937	1,092285	31	Homogeneous
Control	30	63,1	13,111	171,9			29	

Based on table 8, it can be seen that $F_h < F_t$ for both classes of samples. This shows that the sample class has a homogeneous variance.

c. Uji Hypothesis

The results of the two-average similarity test for the two data groups from the sample class are shown in table 9.

Table 9. Results of the Two-Average Similarity Test *Posttest*

Class	N	$\bar{X}$	S	S^2	t_t	t_h
Eksperimen	32	76,1	12,545	157,4	1,7	-4,0
Control	30	63,1	13,111	171,9		

Based on the results of the hypothesis test in table 28, it is proven that the value is greater than the critical value in the table, so that the research hypothesis is accepted at a significant level of 5%, so it can be concluded that there is a significant influence of the use of the LKPD-assisted PjBL model in physics learning on the creative thinking ability of class X Phase E students at SMAN 2 Sijunjung.t_h

These findings indicate that the LKPD-assisted PjBL model is more effective than conventional learning in improving students' creative thinking skills, as evidenced by higher posttest scores across all creative thinking indicators.

Discussion

The results of the analysis of research data were obtained from the results of the test analysis carried out at the beginning and end of the research. The aspect observed is only the aspect of knowledge on alternative energy materials. The aspect observed is the creative thinking ability of students. From the data that has been obtained, the value of creative thinking ability as a whole is obtained and is also in accordance with the indicators of creative thinking ability. The value of students' creative thinking ability in the pretest and posttest in general for the experimental class was greater than in the control class.

The test results showed that the creative thinking skills of students in the experimental class with the LKPD-assisted PjBL model were higher than the control class with the PBL model. This is because learning with the PjBL model assisted by LKPD contains events that are closely related to daily life and LKPD as an aid in learning so that it can increase the understanding of the learner.

The increase in creative thinking skills in the experimental class is due to the fact that learning with the LKPD-assisted PjBL model provides opportunities for students to be more active in discovering and developing new ideas through projects that are contextual with daily life. This LKPD also serves as a systematic guide in helping students explore problems, find solutions, and produce original products, thereby encouraging the emergence of creative thinking aspects such as fluency, flexibility, originality, and elaboration.

The Project Based Learning (PjBL) model is an innovative learning model that uses projects/activities as learning media, so that students can actively engage students in the learning process and problem-solving activities, and students can work in their groups and produce valuable products [16]. The project in PjBL-based learning is learning that focuses on questions or problems, which requires students to follow the concepts and core or main principles of the discipline [17]. The project-based learning model is an imaginative learning model, where learning is more focused on students (student-centered) and teachers only as stimulus and accommodation in learning, and students are given the opportunity to work independently in their groups [18].

PjBL is a learning model that uses problems as the first step in collecting and integrating new knowledge based on their experience in real activities. Through PjBL, the inquiry process begins by raising a guiding question and guiding students in a collaborative project that integrates various subjects (materials) in the curriculum. The PjBL model is an in-depth investigation of a real-world topic, this will be valuable for students' attention and effort [3]. Johnson & Lamb [19] state that: project based learning focuses on creating a product or an artifact by using problem-based and inquiry-based learning depending on the depth of the driving question. The PjBL model can apply a student-centered learning model to build and apply the concepts of the resulting project by exploring and solving real-world problems independently.

This model uses projects in groups and between groups that give rise to student interaction through syntax such as evaluating data, drawing conclusions, presenting projects in class, and discussions. Each syntax in the PjBL model contributes to the development of students' creative thinking skills. The PjBL model consists of five main syntax, namely planning the investigation process according to the driving questions, looking for theoretical background, presenting and discussing the background in the classroom, determining the study group and the method of data collection and analysis, and finally evaluating the data, drawing conclusions, and presenting the project in the preferred class [20]. As for the syntax

In the fluency aspect, students in the experimental class were able to generate more ideas compared to students in the control class. This can be seen from the results of the tests given and the LKPD as well as from the group discussions, where students can mention various alternative energy sources along with their advantages and disadvantages. The PjBL model that emphasizes exploratory activities encourages students to put forward ideas without fear of being wrong. According to Guilford in Munandar [7], the ability to think fluently is characterized by the number of ideas that are generated quickly and relevant to the problem at hand.

In the aspect of *flexibility*, students in the experimental class showed the ability to adapt ideas to various situations and project contexts. Just as learners are asked to design simple tools based on alternative energy, learners are able to use a variety of approaches and materials available. LKPD that is designed to be open can provide space for students to choose various ways and strategies. Meanwhile, in the control class, students tend to be fixated on one way of solving because learning is one-way. This is in line with Torrance's opinion [21] that creative thinking requires the ability to move from one way of thinking to another flexibly

In the aspect of originality, students in the experimental class showed higher creativity in producing solutions and project designs. The project-based LKPD provides space for students to innovate, such as in choosing local materials as an alternative energy source or making modifications to simple tools. The resulting product shows a new idea that is not fixated on the example given by the teacher. This result is in line with Munandar's opinion [7] that creativity arises when individuals are given the freedom to imagine and innovate in solving real problems.

In the elaboration aspect, students in the experimental class show good ability in developing and detailing the ideas that students have made. Learners not only mention the basic ideas, but also explain the steps, working mechanisms, and design of tools in detail in the alternative energy projects created. Like, in the project "making miniature windmills," students not only describe the shape of the wheel, but also explain how the angle of the blades, the direction of the wind, and the materials used affect the speed of rotation. This shows the ability to think elaboratively, which is the ability to expand and deepen ideas into something more complex and meaningful [21]. Meanwhile, students in the control class tended to only give brief and in-depth explanations because the learning did not require them to develop ideas in detail.

The results of the students' work in the picture below which is the answer to the LKPD also show an increase in creative thinking skills at each stage of the project. The students' answers show the development of ideas, variations of solutions, and increasingly detailed explanations from one meeting to the next. This strengthens the finding that the application of the LKPD-assisted PjBL model is able to foster real creative thinking aspects in the classroom.

Fig. 3. LKPD Answer Sheet

The results of this study are also in line with the findings of previous relevant research. Research by Anggi Permana Putri [22] shows that LKPD based on Project Based Learning developed on alternative energy materials has a very high level of validity and practicality, so it is suitable for use in learning. Furthermore, Altatri Adelisha [23] found that the application of the Project Based Learning model has a positive effect on improving students' creative thinking skills, because project activities allow students to explore ideas and develop solutions to real problems. Research by Sholicha & Wulandari [24] also reinforces these findings, where the application of problem-based learning models has been proven to improve creative thinking skills through the active involvement of students in finding solutions to given problems. Meanwhile, Febriani Wahyu Ningsih [25] showed that the Project Based Learning model has a significant effect on students' critical thinking skills, which are closely related to creative thinking skills.

The improvement in students' creative thinking skills supports constructivist learning theory, which emphasizes that knowledge is actively constructed through meaningful learning experiences. The structured projects provided through LKPD-assisted PjBL enabled students to explore ideas, collaborate, and produce innovative solutions, thereby fostering creative thinking development.

Theoretically, the results of this study are supported by the theory of constructivism put forward by Piaget, which states that knowledge is built through active learning experiences. The LKPD-assisted PjBL model implements the principles of constructivism by providing opportunities for learners to build their own knowledge through the experience of designing, researching, and presenting project results. This process helps to strengthen conceptual understanding and encourages creative thinking skills naturally.

Thus, it can be concluded that the application of the Project Based Learning model assisted by LKPD is effective in improving students' creative thinking skills. This model not only helps students understand alternative energy materials in depth, but also cultivates 21st-century skills such as critical thinking, creative, collaborative, and communicative. However, there are several limitations in the implementation of the research, such as time constraints and the availability of props to support the optimal implementation of the project. However, overall, the results of this study show that the PjBL model with the help of LKPD can be used as an innovative and meaningful learning alternative in physics subjects.

IV. CONCLUSION

This study concludes that the implementation of the LKPD-assisted Project Based Learning model significantly improves students’ creative thinking skills in alternative energy learning. The findings imply that integrating project-based learning with structured worksheets can serve as an effective instructional strategy to support creative thinking development in physics education.

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