EduFisika Jurnal Pendidikan Fisika
Volume 10 Number 3, December 2025, pp. 362-373
P-ISSN:2477-7935
E-ISSN: 2548-6225
DOI: 10.59052/edufisika.v10i3.47853

ANALYSIS OF THE EFFECTIVENESS OF PROJECT-BASED LEARNING ON STUDENTS' CREATIVE THINKING SKILLS

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Article Info
Received: 29 Oct 2025
Accepted: 02 Dec 2025
Publication: 13 Dec 2025

Abstract :

This study aims to examine the effectiveness of the Project-Based Learning (PjBL) model in fostering students' creativity skills in the context of heat-related topics. Creativity is widely recognized as a key competency required in the 21st century. The research employed a quasi-experimental approach using a Non-Equivalent Control Group Design, with the participants consisting of Grade XI senior high school students. The instrument used was an essay test with four questions developed to assess various dimensions of creativity, including fluency, flexibility, originality, and elaboration. The results indicate that applying the PjBL model in the experimental class significantly enhances students' creative thinking abilities. The hypothesis testing yielded a Sig. (2-tailed) value of 0.000 < 0.05, leading to the rejection of H0 and acceptance of H1. H1 was accepted because the experimental group implemented the project-based learning model. These findings demonstrate that PjBL is effective in strengthening students' creativity skills. The control group achieved an N-Gain score of 0.33, categorized as low, while the experimental group obtained an N-Gain score of 0.56, categorized as medium. Furthermore, the effect size of 1.9683 indicates a very large impact. Overall, the study confirms that the PjBL model is well-suited for physics instruction aimed at improving students' creative thinking skills.

Keywords: Creative Thinking Skills, Physics Learning, Project-based learning

INTRODUCTION

Mastering creative thinking has become a key expectation for students in the 21st century. Such skills enable learners to tackle problems, generate original ideas, and adapt to rapid changes (Azis, 2024). To navigate these demands, individuals must develop a range of abilities—including the capacity to think creatively. Responding effectively to the fast-paced shifts occurring in various aspects of real life requires this competence. However, empirical findings repeatedly indicate that many high school students still exhibit low levels of creative thinking. This issue largely stems from the continued dominance of teacher-centered approaches, leaving students with limited opportunities to participate actively. Creative thinking is essential for encouraging students to innovate, solve challenges, and remain adaptive in the face of change (Apsoh et al., 2023).

In physics classrooms, instruction typically emphasizes conceptual understanding and has not yet fully supported the development of students' creative thinking abilities. According to (Nurnaningsih et al., 2023), students' creative thinking skills in physics remain relatively low. In fact, creative thinking is an intellectual capability that can be cultivated by all learners. It offers unique benefits to the learning experience, particularly by enhancing students' engagement both academically and socially (Parihah et al., 2023). Creative thinking is highly relevant across learning contexts, as it not only enables students to acquire deeper knowledge but also contributes to effective learning processes (Sundari et al., 2024). It assists learners in expanding their understanding and broadening their viewpoints (Sudianto, S., Dwijanto, & Dewi, 2019).

Unfortunately, classroom activities are still heavily teacher-directed, limiting students' chances to explore and express their creativity. Instruction that depends primarily on textbooks, routine teaching strategies, and monotonous content delivery further restricts the development of creative thinking skills (Aini Noor Khofifah et al., 2023; Nurhayati, 2017). This situation highlights the need for innovative and effective instructional models that can foster creativity. One model with strong potential is Project-Based Learning (PjBL), first introduced by John Dewey in the late 19th century. PjBL encourages students to understand concepts through exploration and creative problem-solving. It places strong emphasis on student engagement in authentic projects and follows six stages: (1) identifying essential questions, (2) planning the project, (3) organizing a timeline, (4) supervising student progress and project development, (5) evaluating outcomes, and (6) reflecting on the learning experience.

Project-Based Learning is widely recognized as an approach capable of nurturing creative thinking. It centers on real-world projects that involve students throughout the entire process—from planning and development to presenting their work (Thomas, 2020). The model highlights exploration, problem-solving, and product creation, all of which contribute to the enhancement of creativity. It encourages learners to innovate, propose fresh ideas, and connect multiple concepts to produce meaningful outcomes (Bell, 2020; Mutmainnah, M., Ainurrahman, A., 2022).

Several previous studies have demonstrated positive effects of PjBL in physics education, particularly regarding learning outcomes and 21st-century skills. For example, Aini (2022) found that PjBL improved students' conceptual understanding of mechanics, while (Pratama, 2023) reported that PjBL promoted more active participation in problem-solving. Similarly, Rahman (2021) observed that PjBL strengthened students' critical and collaborative thinking in science learning.

However, most prior research has primarily emphasized conceptual mastery, cognitive achievement, or critical thinking. Studies that specifically investigate how PjBL supports students' creative thinking skills in physics remain scarce. Nugraheni (2019), for example, explored PjBL in the context of heat and heat transfer, but the creative thinking indicators used were still general and did not examine dimensions such as flexibility, originality, and elaboration in depth. Moreover, students focusing on heat transfer, particularly phase transfer, are relatively scarce.

Therefore, a research gap exists regarding the effectiveness of *Project-Based Learning* in improving students' creative thinking skills in more applied physics topics, such as heat transfer in phase changes. This study aims to fill this gap by designing a simple experimental project, namely the creation of a thermos, as a learning medium. By doing so, the research is expected to contribute to the development of physics learning strategies that not only enhance conceptual understanding but also foster students' creative thinking skills in a more comprehensive.

RESEARCH METHOD

Research Design

The research design used is a quasi-experiment. The research design is a Non-Equivalent Control Group Design. Because this research is categorized into two groups. Namely, the first class serves as the experimental group, and the second class serves as the control group. The study population comprises students of AL-ANSHARIYAH Pamoroh High School, Kadur, Pamekasan. The research instruments consisted of a creative thinking skills test and a student activity observation sheet. To ensure the quality of the instruments, content validation was conducted by two experts, both lecturers in physics education. This validation aimed to assess the suitability of the test items for the indicators of creative thinking skills and their relevance to the learning material.

Research Target/Subject

The study population comprises students of AL-ANSHARIYAH Pamoroh High School, Kadur, Pamekasan. 2 classes are used as the control and experimental groups. Class XI A is the control group with 18 students, while Class XI B, with 18 students, is the experimental group.

Research Procedure

The variables used by the researcher are the per-indicator variable, namely the project-based learning model, and the response variable, namely Creative thinking skills. The indicators of Creative thinking ability in this study are: (1) Determining basic questions, (2) Compiling projects, (3) Making activity schedules, (4) Monitoring and evaluating students and the progress of the projects being carried out, (5) Testing results, and (6) Evaluation of experience. Meanwhile, the control group received treatment using a conventional approach that includes five aspects, namely: (1) Observing phenomena; (2) Questions and answers; (3) Implementing study groups; (4) Presenting discussion conclusions; and (5) Providing feedback from teachers.

Instruments and Data Collection Techniques

The researchers' instruments to collect data included four descriptive questions, a creative thinking ability observation sheet, and documentation validated by a validator. Validity testing was conducted to assess the instrument's validity.

Data Analysis Technique

The data collection was analyzed using the prerequisite tests: normality and homogeneity tests. This was followed by hypothesis testing, N-Gain, and Effect Size testing. The N-Gain and Effect Size categories are as follows:

Table 1. N-Gain Limits (Hake, 1998)

N-Gain Limitation	Limitation
$g \geq 0.70$	Tall
$0.30 > g \geq 0.70$	Medium
$g < 0.30$	Low

Table 2. Effect size Interpretation

Effect Size	Limitation
$d < 0.2$	Very small
$0.2 \leq d < 0.5$	Small
$0.5 \leq d < 0.8$	Medium
$0.8 \leq d < 1.0$	Big
$d \geq 1.0$	Very large

RESULTS AND DISCUSSION

This research was conducted at SMA AL-ANSHARIYAH Pamoroh, Kadur, Pamekasan. The research subjects were 11th-grade students. The study sample included two classes, namely 11th-grade students (control group) and 11th-grade students (experimental group). The experimental group received the treatment by applying the PjBL model, meanwhile the control group applied the conventional model. Based on the study conducted, the results of the prerequisite tests were obtained: normality test, homogeneity test, hypothesis test, N-Gain, and Effect size.

a) Assumption Test

1. Normality test

A normality test is implemented to verify if the data collected by researchers is distributed normally (Nasrum, 2018).

Table 1. Results of Normality Test

		Shapiro-Wilk		
		Statistic	df	Sig
Creative thinking skills	Posttest eksperimen	.961	18	.617
	Pretest eksperimen	.947	18	.386
	Pretest control	.953	18	.475
	Posttest control	.942	18	.311

As indicated by the normality test results, the creative thinking score data in both classes were usually distributed. This is evidenced by the Sig value > 0.05. The pretest in the experimental group had a significance value of 0.386 > 0.05, and the posttest had a significance value of 0.617 > 0.05. The pretest of the control group had a significance value of 0.475 > 0.05, and the posttest had a significance value of 0.311 > 0.05. As a result, the data from both classes met the assumption of normality and could proceed to the next stage, namely the homogeneity test.

2. Homogeneity Test

After the findings are normally distributed, a homogeneity test is conducted to determine whether the data from the two groups are the same. the research has different variances.

Table 2. Results of Homogeneity Test

	Levene Statistic	df 1	df 2	Sig
Experimental group	2.2774	1	33	.105
Control group	.080	1	33	.779

According to the homogeneity testing data, the significance value for the homogeneity of variances test for the pretest and posttest indicates that the variances within the two groups are the same. The significance value for the treatment group was only 0.105; the control group was 0.779. Both have a sig value > 0.05. In conclusion, the data on creativity ability from both classes support the hypothesis of homogeneity of variation, indicating that the experimental and control groups are homogeneous.

b) Hypothesis Testing

This research uses a t-test to verify if there is a significant discrepancy.

Table 3. Hypothesis Test Results (T-Test)

		F	Sig	T	Df	Sig. (2-tailed
Experimental group	Equal variances assumed	13.659	.001	14.343	34	.000
	Equal variances not assumed			14.343	19.733	.000
Control group	Equal variances assumed	4.654	.038	20.353	34	.000
	Equal variances not assumed			20.353	27.302	.000

The level of significance presented in the data table is 0.000, which is less than 0.05. The findings between the baseline and follow-up tests differ significantly. The research hypothesis is that the project-based learning (PjBL) model hones students ' creativity. This is because the implementation of the PjBL model in the experimental group is designed to encourage active student participation in project activities, thereby maximizing improvements in creative thinking abilities.

c) N-Gain

Although both are in the same class, the Normalized Gain value in the experimental group was 0.56, which exceeds that of the control group, which showed an average N-Gain of 0.33, both of which are classified as moderate. This study shows that the project-based learning model improves pupils' creativity relative to the control group's learning approach.

Table 4. Average N-Gain Results

Group	Mean N-Gain Score	Category
Control	0,33	Medium
Experiment	0,56	Medium

In addition, the improvement of each aspect of students' creative thinking abilities was tested using N-Gain analysis.

Table 5. Average Results of N-Gain Values Per Indicator

Creative thinking skills	Control group		Experimental group	
	N-Gain score	Category	N-Gain score	Category
Fluency	0,45	Medium	0,75	Tall
Flexibility	0,28	Low	0,49	Medium
Originality	0,30	Medium	0,58	Medium
Elaboration	0,28	Low	0,52	Medium

Table 5 shows that the N-Gain score for the indicator of pupils' creative thinking ability in the experimental group is higher than that in the control group.

d) Effect Size

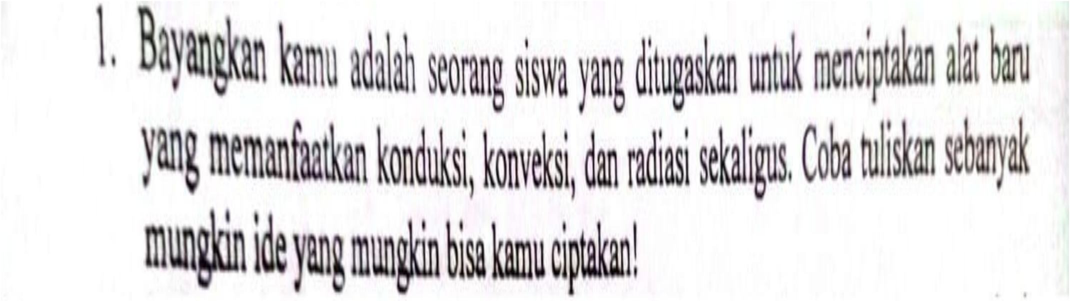
The effect size determines how significant the variable is to other variables.

Table 6. Effect Size Results

Result	Group	N	Mean	Std.Deviation	Std. Error Mean
	Posttest eksperimen	18	81.67	6.481	1.528
	Nilai effect size	1.9683	62.67	12.015	2.832
	Interpretasi	1.9683%			
	Category	Very large			

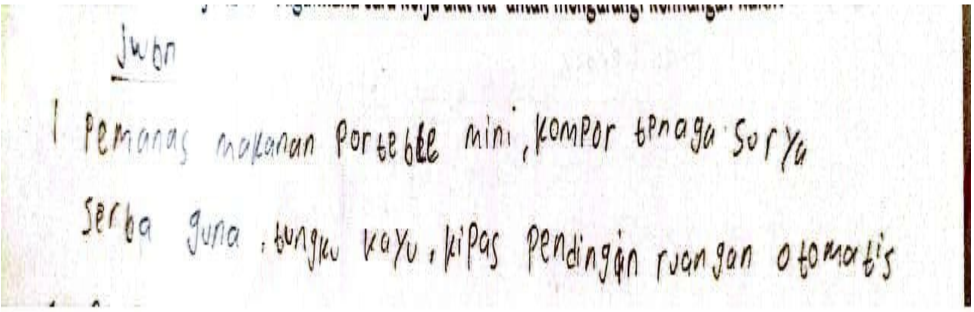
The calculation results yielded an effect size of 1.9683. This value indicates a significant effect of the measured variable on the predictor variable in this analysis. According to commonly used interpretations of effect size categories, a value above 0.8 is considered a significant effect. Therefore, a value of 1.9683 is well above this threshold, and the results indicate that the intervention had a significant effect.

The assessment, using essay questions designed with reference to indicators of innovative thinking abilities, was validated by experts and tested with pupils who were not included in the study sample.



1. Bayangkan kamu adalah seorang siswa yang ditugaskan untuk menciptakan alat baru yang memanfaatkan konduksi, konveksi, dan radiasi sekaligus. Coba tuliskan sebanyak mungkin ide yang mungkin bisa kamu ciptakan!

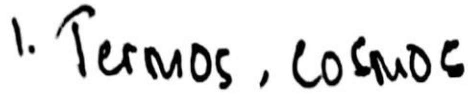
Question 1 measures students' ability to think fluently. Students' answers on the aspect of fluent thinking, namely the ability to produce various relevant ideas or solutions, from the experimental group are shown below.



Jwbn

1 Pemanas makanan Portebble mini, kompor tenaga surya serba guna, tungku kayu, kipas pendingin ruangan otomatis

According to the example answers in the experimental group, they reflect good fluency thinking, providing many relevant answers and creating new ideas using physics concepts. Thus, the experimental group's answers are in accordance with the theory. However, the control group's answers were less comprehensive than those in the experimental group. An example of this is student responses to the fluency dimension of thinking in the control group.



1. Termos, Cosmos

According to the findings from the comparison group, which differed from the experimental group, students were capable of providing multiple responses to the questions. Pupils in the control group were only capable of presenting two ideas, while the experimental class provided several ideas for question number 1.

Pretests and posttests were administered to students to complement the data collection techniques. Next, prerequisite tests were used to analyze the obtained data, including homogeneity and normality tests. After meeting the prerequisite tests, the hypothesis, N-Gain, and effect size were tested. The prerequisite test indicated that the data had equal variances and were normally distributed. Therefore, the prerequisite test was deemed feasible to proceed.

The findings of the hypothesis test are presented in Table 3, which demonstrates a p-value of 0.000, less than 0.05. This study proves that a difference exists between the treatment and control groups. Consequently, project-based learning serves as an effective instructional approach for developing creative abilities in the topic of heat. The results of this study are consistent with those (Fitriyah & Ramadani, 2021), who reported that PjBL supports all aspects of creative thinking, particularly fluency. The effectiveness of PjBL in this research is further supported by the N-Gain findings, in which students in the experimental group achieved a score of 0.68 (moderate category), while the control group reached only 0.36. As presented in Table 4, each creative thinking indicator experienced a meaningful improvement. This aligns with the findings of (Pramesti et al., 2022), who confirmed that PjBL significantly enhances students' creative thinking performance. The role of PjBL in fostering creativity has also been highlighted in earlier studies. This agrees with previous studies (Safriana et al., 2022) for example, concluded that students who actively engage in project-based learning tend to obtain higher creative thinking scores. Similar conclusions were (Barell, 2020; Pramesti et al., 2022) whose analyses showed that PjBL encourages students to develop innovative thinking skills.

Project-Based Learning is widely regarded as a relevant 21st-century instructional model, particularly in improving students' creative thinking abilities (Fatma, 2021; Hidajat, 2022). Its effectiveness stems from its defining characteristics, which emphasize students' active involvement in planning and completing project tasks, thereby supporting the development of original ideas and creative problem-solving (Safriana et al., 2022). Thus, PjBL can be considered an effective model for enhancing innovative thinking.

Each step in the PjBL model contributes meaningfully to students' creative development. In the first stage—introducing essential questions—students encounter contextual problems related to everyday heat-transfer phenomena. This step encourages fluent thinking by generating multiple ideas, flexible thinking through varied interpretations, and elaborative thinking by developing more detailed explanations (Ngalimun, 2020; Utami, R. P., Probosari, R. M., & Fatmawati, 2019).

In the second stage, project design, students are given opportunities to express independent ideas while still adhering to the principles of creative thinking. This phase stimulates all four indicators of creativity: fluency (through the emergence of diverse ideas), flexibility (through various solution strategies), elaboration (via detailed idea development), and originality (through the creation of unique solutions) (Rohman, A., & Husna, 2021).

The third stage involves developing a project activity plan with the facilitator. Here, elaboration skills are emphasized, as students must create a systematic schedule outlining each part of the project, from preparation to reporting (Rohman, A., & Husna, 2021).

In the fourth stage, monitoring and evaluating progress, students have opportunities to refine every aspect of their creative thinking. The facilitator guides students in shaping ideas, completing projects with flexibility and originality, and organizing detailed work procedures (Noviyana, 2020).

The fifth stage—testing and presenting project results—further supports fluency in communicating ideas, flexibility in responding to questions, elaboration in explaining detailed processes, and originality in demonstrating unique products (Candra, R. A., Prasetyo, A. t., & Hartati, 2019; Sakti, I., Nirwana, N., & Swistoro, 2021).

Finally, the reflection stage encourages students to review their learning experience and provide feedback within their group. This step strengthens fluency and flexibility through discussion, argumentation, and responses to questions posed by peers and instructors (Nurhadiyati, A., Rusdinal, R., & Fitria, 2020; Rohman, A., & Husna, 2021).

The outcomes of the simple thermos project show that students were able to apply the three primary mechanisms of heat transfer—conduction, convection, and radiation—within a single device design. The purpose of this project was to illustrate how heat-transfer principles can be used to maintain the temperature of a hot liquid for a longer duration.

The simple thermos was constructed from two used plastic bottles arranged to create a double-wall structure. The inner bottle held the hot water, while the outer bottle served as a protective and insulating layer. Cotton was inserted into the space between the bottles to slow down conductive heat transfer. To reduce convection, the gap was sealed tightly to prevent air movement, thereby minimizing heat flow through circulating air. Radiation was reduced by lining the inner bottle with aluminum foil, whose reflective surface redirects heat waves back into the liquid, reducing heat loss by radiation.

After assembling the thermos, hot water was poured into the inner bottle, and the temperature was recorded at five-minute intervals using a thermometer. The results revealed that the temperature gradually decreased slowly, indicating that the thermos design was successful in inhibiting heat transfer effectively through all three mechanisms. Through this project, students realized that the insulation process in a thermos is not governed by a single principle, but instead involves the combined roles of conduction, convection, and radiation. Beyond strengthening their grasp of physics concepts, the activity also nurtured analytical thinking and problem-solving skills by requiring them to apply scientific principles to real-world situations.

Creative thinking skills are examined through four core dimensions: fluency, flexibility, originality, and elaboration.

a. Fluency

Fluency refers to a student's capacity to produce a broad range of creative and varied ideas. As stated by (Munandar, 2019) this indicator includes the ability to propose multiple alternative solutions, respond to questions in diverse ways, and express more than one idea.

The application of the project-based learning model was found to improve students' fluency and creative thinking. This was evident from the students' ability to generate numerous relevant ideas when solving assigned problems. Learners in the experimental group provided answers that were more varied and more appropriate than those in the control group. The fluency indicator in the experimental class reached 64.5%, categorized as good, while the control class obtained 50.5%, which fell into the fairly good category. Moreover, the experimental group achieved an average N-Gain score of 0.75, classified as high, whereas the control group scored 0.45, categorized as moderate.

The findings indicate that the PjBL model supports students in accessing and expanding information widely through exploratory project activities. Participation in completing projects also motivates learners to generate innovative ideas related to physics concepts. These results affirm the effectiveness of PjBL in enabling students to explore and develop information more broadly (Annisa, R., Effendi, M. H., & Damris, 2019). Furthermore, the experience of working on projects encourages students to create new ideas that are contextually relevant to physics, as emphasized by (Guilford, 2020; Trisnayanti, Y., Ashadi, Sunarno, W., & Masykuri, 2020).

b. Flexibility

Flexibility refers to a learner's ability to generate varied solutions and analyze a problem from different points of view (Munandar, 2019). This aspect was assessed through questions 3, 4, and 5. Based on the data analysis, students in the experimental group demonstrated flexible thinking by offering a range of responses to the given problems. In contrast, students in the control group tended to provide uniform answers with little variation.

The flexibility indicator in the experimental class reached 48.66%, which falls into the fairly good category, while the control class achieved 39.33%, also categorized as fairly good. The average N-Gain for this indicator in the experimental group was 0.49, compared to 0.28 in the control group. These results are consistent with findings from (Fatma, 2021; Nurfadilah & Siswanto, 2020) which indicate that PjBL can promote flexible thinking by engaging students in project tasks that require consideration of multiple viewpoints.

c. Originality

Originality refers to a student's capacity to produce novel and uncommon ideas (Munandar, 2019). This aspect was assessed through students' responses to questions 1, 3, 4, and 5. The results showed that learners in the experimental group demonstrated a stronger ability to think originally than those in the control group, as reflected in the appearance of creative solutions and unconventional strategies for addressing the problems provided.

In the experimental class, the originality indicator reached 49.5%, while the control class obtained 38.25%, which is classified as fairly adequate. The N-Gain score of the experimental group was 0.58 and the control group achieved 0.30, both falling into the moderate category. These findings indicate that students' originality improved significantly throughout the exploratory learning process. This aligns with the views of (Candra, R. A., Prasetyo, A. t., & Hartati, 2019; Nurhadiyati, A., Rusdinal, R., & Fitria, 2020) who stated that growth in originality is closely linked to the development of fluency and flexibility in creative thinking.

d. Elaboration

Elaboration refers to students' ability to expand ideas thoroughly, provide comprehensive explanations, and add details that enrich their proposed solutions (Munandar, 2019) This aspect was assessed through questions 2, 4, and 5.

Students in the experimental group displayed stronger elaboration skills than those in the control group. This was reflected in their more detailed and systematic responses, which clearly outlined the processes and stages involved. The experimental group achieved an elaboration score of 46.33%, while the control group reached only 36.33%, with both categorized as fairly good. Furthermore, the experimental group obtained an average N-Gain of 0.52, which falls into the medium category, compared to the control group's lower score of 0.28. These findings align with (Candra, R. A., Prasetyo, A. t., & Hartati, 2019) who highlighted that students' elaboration skills can be significantly strengthened through procedures embedded in the Project-Based Learning (PjBL) model, particularly during the project-planning stage, where learners are encouraged to refine ideas, design strategies, and structure their work systematically.

This study suggests that teachers should develop project-based learning activities that connect to students' real-world experiences, implement PjBL to enhance creative thinking and problem-solving skills, and incorporate simple experiments to reinforce conceptual understanding. Additionally, teachers should function as facilitators rather than information transmitters, fostering student independence and responsibility. Such approaches can make physics learning more meaningful, engaging, and aligned with the demands of 21st-century competencies.

CONCLUSION

This study demonstrates that Project-Based Learning (PjBL) effectively supports students in developing their creative thinking abilities related to the concept of heat. Significant growth was observed across the four major indicators of creative thinking—fluency, flexibility, originality, and elaboration. Students' fluency and reasoning skills improved as seen in the wide range of ideas they produced while designing and constructing a simple thermos. Their flexibility emerged through the varied strategies they used to address problems and their ability to adjust project designs based on the materials available. Originality was reflected in the appearance of novel and inventive ideas during the creation of their products. Meanwhile, elaboration was evident in the depth, detail, and organized structure of their explanations throughout the project. The PjBL model encourages active participation by engaging students in exploration, hands-on experimentation, and contextual problem-solving within a collaborative and reflective learning environment. Through its structured stages, PjBL not only creates meaningful learning experiences but also promotes higher-order thinking. The model's effectiveness is further supported by the results of the hypothesis testing, which produced a Sig. (2-tailed) value of 0.000 (<0.05), indicating that H_a is rejected and H_0 is accepted. The experimental group also achieved an average N-Gain of 0.56, categorized as moderate, compared with 0.33 in the control group. Furthermore, the effect size of 1.9683 is classified as very large, showing that the PjBL model exerts a substantial and strong influence on students' learning outcomes. Overall, the application of project-based learning contributes meaningfully to enhancing high school students' creative thinking, particularly in physics.

Recommendations: for teachers are encouraged to apply Project-Based Learning not only to strengthen students' conceptual understanding but also to enhance their creative thinking abilities. Project designs should be practical, closely linked to everyday situations, and incorporate various creativity indicators such as fluency, flexibility, originality, and elaboration. Emphasis on collaboration and reflective activities is also essential to help students refine and expand their ideas more effectively. For future researchers, examining the influence of PjBL on physics topics other than heat and exploring its long-term effects on students' creativity is recommended. Studies involving larger samples, diverse educational contexts, or comparisons with other innovative models—such as STEM or Inquiry-Based Learning—may also provide broader and more generalizable insights.

ACKNOWLEDGMENTS

Special thanks are extended to Universitas Islam Madura, with particular acknowledgment to the Physics Education Department.

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