

# Integrating Project-Based Learning and Place-Based Education on Renewable Energy to Enhance Students' Creativity and Environmental Awareness

Siti Rukoyah<sup>1</sup>, Anna Permanasari<sup>2</sup>, Surti Kurniasih<sup>3</sup>

<sup>1</sup> Universitas Pakuan, Bogor, Indonesia; [sitirukoyah24@guru.smp.belajar.id](mailto:sitirukoyah24@guru.smp.belajar.id)

<sup>2</sup> Universitas Pakuan, Bogor, Indonesia; [anna.permanasari@unpak.ac.id](mailto:anna.permanasari@unpak.ac.id)

<sup>3</sup> Universitas Pakuan, Bogor, Indonesia; [surti\\_kurniasih@unpak.ac.id](mailto:surti_kurniasih@unpak.ac.id)

---

## ARTICLE INFO

### Keywords:

creativity;  
environmental awareness;  
place-based education;  
project-based learning;  
renewable energy

---

### Article history:

Received 2025-03-28

Revised 2025-08-13

Accepted 2025-12-23

---

## ABSTRACT

Developing students' creativity and environmental awareness is essential in sustainability-oriented science education. Integrating Project-Based Learning (PjBL) with a Place-Based Education (PBE) framework offers a promising approach by connecting classroom learning with real-world environmental contexts. This study employed a quasi-experimental design using a pretest–posttest control group. The sample consisted of 74 junior high school students in Bogor, Indonesia, including 35 students in the control group and 39 students in the experimental group. The experimental group received PjBL integrated with PBE, while the control group implemented PjBL without a place-based framework. Data were collected using creative thinking tests, environmental awareness questionnaires, observation sheets, and response questionnaires from students, teachers, and community members. Instrument validity and reliability were confirmed through preliminary testing. The results indicated that the PjBL–PBE model was highly implementable and effective. Students' creative thinking skills in the experimental group showed a higher improvement (N-Gain = 56.18%) compared to the control group. Environmental awareness also increased substantially in the experimental group (67.15%), while the control group showed only a modest improvement (13.62%). Stakeholder responses demonstrated strong support for the learning model (91.60%). These findings suggest that integrating PjBL with a place-based framework effectively enhances students' creative thinking and environmental awareness in renewable energy education.

This is an open access article under the [CC BY-NC-SA](https://creativecommons.org/licenses/by-nc-sa/4.0/) license.



---

## Corresponding Author:

Anna Permanasari

Universitas Pakuan, Bogor, Indonesia; [anna.permanasari@unpak.ac.id](mailto:anna.permanasari@unpak.ac.id)

---

## 1. INTRODUCTION

Recent educational reforms emphasize the importance of contextual, meaningful, and student-centered learning to equip learners with essential twenty-first-century competencies, including creativity, critical thinking, and environmental responsibility. In Indonesia, the Merdeka Belajar curriculum promotes pedagogical flexibility, encouraging educators to design learning experiences that are responsive to students' needs and local contexts. However, empirical evidence indicates that many schools still struggle to operationalize this flexibility due to limited resources, rigid instructional practices, and insufficient integration between classroom learning and real-world contexts. These challenges often result in learning experiences that remain abstract and disconnected from students' lived environments, thereby limiting opportunities for deeper cognitive engagement and character development.

One pedagogical approach that addresses these limitations is Place-Based Education (PBE), which situates learning within local ecological, social, and cultural contexts. PBE emphasizes authentic problem-solving through direct engagement with communities and the surrounding environment, enabling students to construct knowledge that is both relevant and meaningful (Deringer et al., 2020; Littrell et al., 2020). Prior studies have shown that PBE can enhance students' environmental awareness, sense of responsibility, and connection to their local environment, particularly when learners actively participate in community-based activities (Gallay et al., 2020; Khadka et al., 2021). Nevertheless, despite its pedagogical potential, PBE remains underutilized in formal science education, as many teachers report difficulties related to curriculum alignment, logistical constraints, and collaboration with external stakeholders.

Project-Based Learning (PjBL) offers a complementary instructional model that emphasizes inquiry, collaboration, and the creation of tangible products as outcomes of learning. Research consistently demonstrates that PjBL supports the development of creative thinking skills, including fluency, flexibility, originality, and elaboration, by engaging students in complex, open-ended problem-solving processes (Chen et al., 2022; Mursid et al., 2022). When implemented effectively, PjBL encourages students to take ownership of their learning, integrate interdisciplinary knowledge, and apply theoretical concepts to real-world challenges. However, conventional implementations of PjBL often remain classroom-bound and lack sustained engagement with authentic community contexts, which may limit their potential impact on students' environmental awareness and social responsibility.

Integrating PjBL with a Place-Based Education framework presents a promising strategy to address these limitations by combining the strengths of both approaches. Through this integration, students are not only engaged in designing and producing projects but are also encouraged to interact directly with community members, local experts, and environmental settings as sources of problems and solutions. Renewable energy education provides an especially relevant context for such integration, as it connects scientific concepts with pressing global and local issues related to climate change, sustainability, and technological innovation. Learning about renewable energy through community-based projects allows students to explore environmentally friendly technologies while developing creative and context-sensitive solutions aligned with local needs (Khadka et al., 2021; Zainal, 2023).

Despite growing interest in PjBL and PBE, empirical studies that systematically examine their integrated implementation in science education, particularly in the context of renewable energy, remain limited. Existing research has largely focused on either project-based learning or place-based education as separate pedagogical approaches, with fewer studies investigating how their integration influences both cognitive outcomes, such as creative thinking skills, and affective outcomes, such as environmental awareness, at the secondary school level. Addressing this gap is essential to provide

empirical evidence that can inform curriculum development and instructional practices aimed at fostering sustainable and contextually grounded science learning.

The novelty of this study lies in the development and empirical evaluation of an integrated Project-Based Learning–Place-Based Education (PjBL–PBE) instructional model that explicitly positions the local community as both a source of authentic problems and a co-creator of solutions in renewable energy education. Unlike previous studies that have examined PjBL or PBE in isolation, this research introduces a modified PjBL–PBE syntax that embeds structured community interaction—such as expert consultation, field-based observation, and collaborative solution design—within each phase of the project cycle. Furthermore, this study simultaneously investigates the impact of the integrated model on students’ creative thinking skills and environmental awareness, offering a more holistic understanding of learning outcomes that encompass both cognitive and affective domains. By situating renewable energy projects within real local contexts, this research provides empirical evidence that contextualized, community-engaged project learning can meaningfully enhance students’ originality, problem-solving capacity, and environmental responsibility, thereby contributing a practical and theoretically grounded model for sustainable science education.

## 2. METHODS

This research has been designed using quasi experimental method with Pretest-Posttest Control Group Design (Abraham & Supriyati, 2022), (Anshori & Iswati, 2017). The experimental group received Project-Based Learning (PjBL) treatment with PBE framework, while the control group received Project-Based Learning without PBE framework. The research design is shown in the following table:

**Table 1.** Quantitative Research Design

Group	Pretest	Treatment	Posttest
Control Class	O <sub>1</sub>	X	O <sub>2</sub>
Experiment Class	O <sub>3</sub>	Y	O <sub>4</sub>

Description:

O<sub>1</sub> : Pretest of control group

O<sub>2</sub> : Posttest of control group

O<sub>3</sub> : Pretest of experimental group

O<sub>4</sub> : Posttest of the experimental group

X : Project Learning (control)

Y : Implementation of the Project using the Place-based education framework (experiment).

Population is a group of individuals who have the same characteristics and the sample is a subgroup of the target population that will be studied by researchers to generalize about the target population (Creswell, 2012). The research sample consisted of 74 students of SMP N 19 Bogor City and Sekolah Alam Bogor, who were selected using random sampling technique. Data collection was carried out using a random sampling technique, namely random selection of classes from two schools that both implemented project-based learning. The control class came from SMP Negeri 19, which has implemented Merdeka Curriculum and is accustomed to using projects, while the experimental class came from Sekolah Alam Bogor, which also applies a similar approach. All students from the randomly selected classes were used as research samples. The population of this study is presented in Table 2.

**Table 2.** Research Population

No	Name of School	Number of Grades	Respondents
1.	SMP Sekolah Alam Bogor (Private School)	IX-A	20
		IX-B	19
2.	SMP Negeri 19 Kota Bogor (Public School)	IX-B	35
<b>Total number of respondents</b>			<b>74</b>

The data collection technique used an essay question instrument and a questionnaire instrument. The instrument is calibrated through expert judgment to analyze content and construct validity. In the validity test, researchers will ask for advice and input from lecturers (experts) to make judgments on the instruments that have been made, then test the validity using the Pearson correlation formula and reliability with Cronbach's Alpha. Data analysis is carried out descriptively inferentially, including prerequisite tests (homogeneity and normality analysis). Comparative testing used an independent t-test to compare two independent groups to see if their means were significantly different. Meanwhile, the N-Gain formula was used to measure the improvement of learning outcomes, revealing the improvement of creative thinking skills (Hake, 1999). The following table categorizes the effectiveness of N-Gain.

$$N - gain = \frac{Posttest\ score - Pretest\ score}{Max\ score - Pretest\ score}$$

**Table 3.** N-Gain Effectiveness Interpretation Categories

Percentage (%)	Interpretation
< 40	Ineffective
40-55	Less Effective
56-75	Effective Enough
>75	Effective

(Hake, 1999)

### 3. FINDINGS AND DISCUSSION

#### 3.1 Findings

The implementation of Project-Based Learning integrated with a Place-Based Education framework (PjBL-PBE) resulted in measurable improvements in students' creative thinking skills and environmental awareness. Data were collected through pretest and posttest instruments, observation sheets, and questionnaires administered to both control and experimental groups. Learning is carried out with the PjBL-PBE syntax; the learning steps are briefly shown in the following figure.

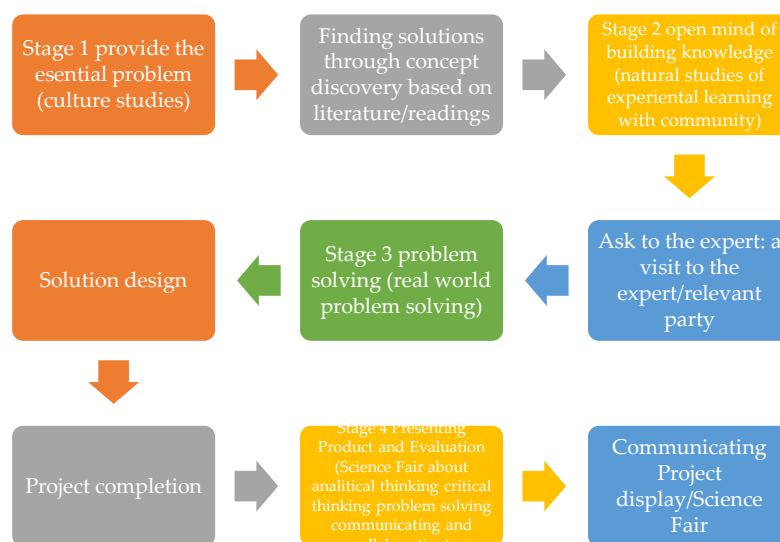


Figure 1. Syntax of PjBL with Place-based education framework

After the statement of the problem, which can be done by teacher or student initiative, students search for relevant concepts through searches of library sources such as books and internet searches. The concept is then used as the basis for finding a solution in the form of a prototype project. To ensure the steps, students are directed to communicate through visits to the source of the solution, discussing with experts. Sources of information can be related industry partners, the community, or community communities such as NGOs (Non-Governmental Organizations). The results of the visit are then assessed for suitability with the concept, and used as a basis for designing biogas, solar panel, and waterwheel projects. In its implementation, students are very enthusiastic in following every stage of learning. Students in their groups seemed active in expressing ideas, thoughts, helping each other find the most appropriate solution. More enthusiasm was seen when discussing with experts in the field.

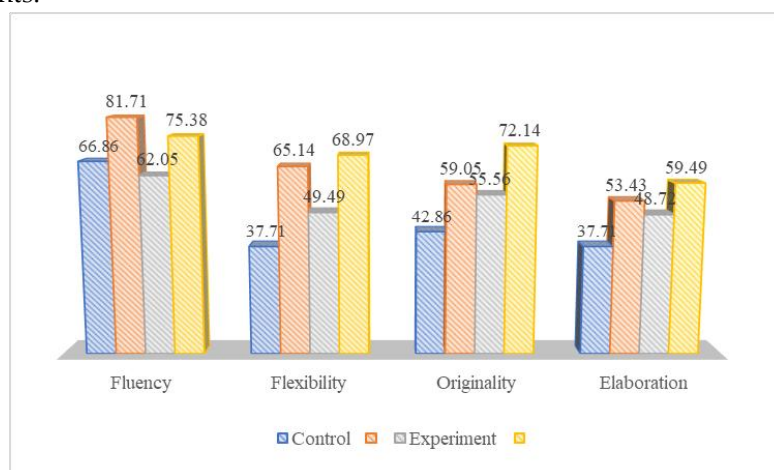


Figure 2. Explains the process of project-based learning with the PBE framework. The following information; a) Ask the expert, b) Visit the community, c) Product planning and d) Presentation of product results/science fair

Based on the observation of the lesson, it can be concluded that basically student activeness is very dependent on how the teacher facilitates student interaction. If a lot of space is given for discussion, and while being directed by the teacher, then students will totally collaborate in their groups to produce their best projects. Thus, the hope for the growth of students' creative thinking skills becomes a necessity. The use of environmental issues as a trigger also led to the development of students' environmental awareness to be better. Both of these are evidenced by the analysis of students' creative thinking test results before and after learning, as well as how students' environmental awareness grows during learning.

### 3.1.1 Creativity

Student creativity is measured by creative thinking instruments and creative products produced during the learning process. The creative thinking instrument includes students' ability to generate innovative ideas, problem solving, and flexibility in designing renewable energy solutions. Creative thinking indicators include fluency, flexibility, originality and elaboration. The results of students' creative thinking are listed in the following graph. Meanwhile, creative products include real projects that are implemented, such as mini solar panel models, hydropower plants and simple biogas systems made by students.



**Figure 3.** Results of students' creative thinking skills

Based on the data from the pretest and posttest results of students' creative thinking skills in the two groups, namely control and experimental, there was a significant increase in each aspect of creative thinking, namely Fluency, Flexibility, Originality, and Elaboration. In the Fluency indicator, there was an increase from 66.86 in the pretest to 81.71 in the posttest in the control group, while in the experimental group, it increased from 62.05 in the pretest to 75.38 in the posttest. This increase shows that students' ability to generate many diverse ideas is growing. Furthermore, in the Flexibility indicator, the score in the control group increased from 37.71 in the pretest to 65.14 in the posttest, while in the experimental group it increased from 49.49 in the pretest to 68.97 in the posttest. This shows that students are increasingly able to think from various points of view and produce diverse solutions. In the Originality of Ideas indicator, the control group experienced an increase from 42.86 in the pretest to 59.05 in the posttest, while the experimental group increased from 55.56 in the pretest to 72.14 in the posttest. This increase reflects students' ability to generate unique and original ideas is increasing. Finally, in the Elaboration indicator, the score in the control group increased from 37.71 in the pretest to 53.43 in the posttest, while in the experimental group it increased from 48.72 in the pretest to 59.49 in the posttest. This shows that students are increasingly able to develop ideas with detail and depth.

Overall, these results show that the implementation of project-based learning with the Place-based education framework is able to improve students' creative thinking skills in both groups. Based on the pretest and posttest data from the two groups, namely the control group and the experimental group, the Originality of Ideas indicator in the experimental group showed the highest result with a score of 72.14 on the posttest, which is a significant increase from the pretest score of 55.56. Originality refers to the ability of students to generate ideas that are unique, innovative, and have never been thought of before. In the context of renewable energy learning, this indicator is very important because it encourages students to find creative and sustainable solutions related to environmentally friendly energy utilization. The increase in scores from 55.56 to 72.14 indicates that the project-based learning approach with the Place-based education (PBE) framework successfully stimulates students' ability to create original and innovative ideas.

The improvement of pretest and posttest learning in the control and experimental classes can be seen through the N-Gain scores listed in the table below.

**Table 4.** Mean Value of Pretest Posttest and N-Gain Score

Class	Pretest	Posttest	N-Gain Score	N-Gain Persen (%)
Experiment	53.95	69.00	0.56	56.18
Control	46.29	64.83	0.49	49.28

The figure above displays a comparison of pretest, posttest, and N-Gain results between the control group and the experimental group. In the control group, the average pretest score of 46.29 increased to 64.83 during the posttest, resulting in an N-Gain value of 49.28. Meanwhile, the experimental group showed an average pretest score of 53.95, which increased to 69.00 at posttest, with an N-Gain value of 56.18. Although the numerical increase in scores from pretest to posttest was greater in the control group, the N-Gain results showed that the increase in the experimental group was proportionally more significant. Based on the interpretation of N-Gain values, the control group fell into the medium effectiveness category, while the experimental group approached the medium-high category. This indicates that the learning method or treatment applied to the experimental group was more effective in improving learning outcomes compared to the method used in the control group.

Normality and homogeneity testing of data is done after knowing the N-Gain score test. Normality testing using the Kolmogorov-Smirnov formula and the homogeneity test determines whether the resulting data is normally distributed and whether the data within each class is homogeneous or not. The data can be seen in the figure below;

**Table 5.** Statistical Test Results to Prove the Research Hypothesis

Class	Number of Students	Normality Test		Homogeneity Test		Hypothesis Test Sig (2-Tailed)	
		Sig Value	Description	Sig Value	Description	Sig Value	Description
Control (Pretest)	35	0.200	Normal	0.470	Homogen	0.000	Significant
Control (Posttest)	35	0.026	Abnormal	0.511	Homogen		
Experiment (Pretest)	39	0.038	Abnormal	0.511	Homogen		
Experiment (Posttest)	39	0.002	Abnormal	0.446			

This study aims to compare creative thinking skills between the control class of 35 students and the experimental class of 39 students on renewable energy material. Based on the Kolmogorov-Smirnov normality test, only the pretest data in the control class were normally distributed with a significance value of 0.200, while the other data showed an abnormal distribution (significance value <0.05).

Therefore, the analysis continued using the Mann-Whitney non-parametric statistical test. The homogeneity test of the pretest data showed that both groups had homogeneous variances, with a significance value of 0.470 for the control class and 0.511 for the experimental class, respectively. The results of hypothesis testing with Mann-Whitney resulted in a U value of 338.500 and a significance (Asymp. Sig. 2-tailed) of 0.000, which means there is a significant difference between the control and experimental groups in improving creative thinking skills. Thus, the null hypothesis ( $H_0$ ) is rejected and the alternative hypothesis ( $H_1$ ) is accepted. This finding indicates that the treatment or learning method given to the experimental group has a significant effect on improving students' creative thinking skills compared to the control group.

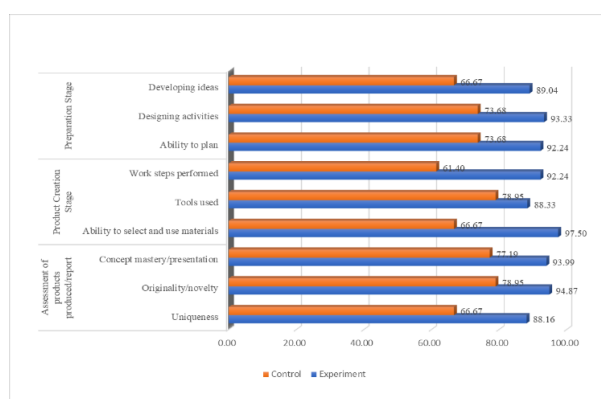
The table above presents the results of the normality test of creative thinking data in the control group and experimental group, both at the pretest and posttest stages, using the Kolmogorov-Smirnov method. Based on the data analyzed, the study involved two groups: a control class with 35 students and an experimental class with 39 students. The results of the normality test showed that only the pretest data of the control class were normally distributed (sig. 0.200), while the other data was not normally distributed with a significance value below 0.05. Therefore, in further analysis, the Mann-Whitney non-parametric statistical test was used to determine whether the increase in N-Gain obtained is meaningful or not in both classes.

Based on the analysis results, the homogeneity test on the pretest showed that both groups had homogeneous variances with a significance value of 0.470 for the control class and 0.511 for the experimental class. Hypothesis testing resulted in a significance value of 0.000 (sig < 0.05) which showed a significant difference in the control class. In addition, analysis using the Mann-Whitney U test with a U value of 338.500 and a significance value (Asymp. Sig. 2-tailed) of 0.000 confirmed a significant difference between the creative thinking scores of control and experimental group participants. Overall, this finding indicates a significant difference in the research related to the creative thinking ability of the two groups.

Based on the results of the Mann-Whitney test,  $H_0$  is rejected, and  $H_1$  is accepted, meaning that there is a significant difference in the increase in the value of creative thinking in renewable energy material in the control class and the experimental class, as evidenced by the 2-tailed p-value of 0.000. Data is said to have a significant difference if the 2-tailed sig < 0, 05. Thus, the treatment or learning method applied to the experimental group has a significant effect on improving creative thinking skills compared to the control group.

### 3.1.2 Creative Product Assessment

The results of the creative product assessment between the control class and the experimental class are based on several aspects in three stages of the main aspects, namely the preparation stage, the product manufacturing stage, and the assessment stage of the resulting product. The results of the product assessment are listed in the figure below;

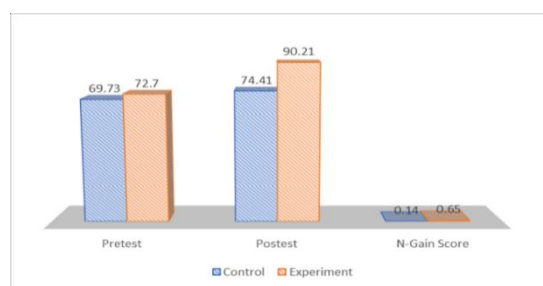


**Figure 4.** Creative Product Assessment

Based on Figure 4, it generally shows that the experimental class obtained higher scores than the control class in each aspect assessed. In the preparation stage, the experimental class excelled in developing ideas (89.04), designing activities (93.33), and planning skills (92.24) compared to the control class, which obtained 66.67, 73.68, and 73.68, respectively. In the product manufacturing stage, the experimental class showed better results in work steps (92.24), tool utilization (88.33), and the ability to select and use materials (97.50), while the control class only obtained 61.40, 78.95, and 66.67. As for the product assessment stage, the experimental class again excelled in concept mastery and presentation (93.99), originality and novelty (94.87), and uniqueness (88.16) compared to the control class which obtained 77.19, 78.95, and 66.67, respectively. This significant difference in assessment indicates that the approach applied in the experimental class was more effective in improving students' creativity and skills in producing creative products. The indicator that can reflect students' enthusiasm in the creative process is "Mastery of concepts/presentation". In this aspect, the experimental class obtained a score of 93.99, while the control class only reached 77.19. This difference indicates that students in the experimental class had a better understanding of the concepts presented and showed more effective presentation skills than students in the control class. It can also indicate that the learning method applied in the experimental class was able to increase students' confidence and enthusiasm in conveying their ideas and work.

### 3.1.3 Environmental Awareness

The renewable energy learning interaction between students and the community has also been proven to increase students' environmental awareness. Through direct observation of energy conservation efforts and the application of environmentally friendly technology carried out by the community, students become more sensitive to environmental issues and are motivated to play an active role in preserving nature. This Place-based education approach that emphasizes real experiences and direct involvement allows students to understand the impact of their actions on the environment, thus forming a more responsible and sustainable attitude. This can be seen from the following figure.



**Figure 5.** Results of Improvement in Environmental Awareness Instrument

Based on the data obtained, there is a significant increase in students' environmental awareness in two different groups, namely the control group and the experimental group, after the implementation of Place-based education-based learning. In the control group, the pretest score showed 69.73, which then increased to 72.90 in the posttest, with an overall average of 71.315. Meanwhile, in the experimental group, the pretest score reached 72.71 and experienced a higher increase in the posttest with a score of 80.15, resulting in an overall average of 76.43. The greater increase in the experimental group indicates that the learning approach involving the community and the surrounding environment is able to increase students' environmental awareness more effectively. This could be due to more intensive interaction between students and the community, as well as direct experience in observing and practicing environmental conservation efforts. Thus, place-based learning is proven to have a positive impact in increasing students' environmental awareness in both groups. Positive responses to the implementation of Place-based education learning were also shown by students, parents, and teachers. Based on the data obtained, 91.60% of them fully support this place-based learning. The support reflects the awareness of the importance of an approach that involves the surrounding community and environment in the learning process, which not only enhances students' creativity but also builds higher environmental awareness.

### 3.2 Discussion

The findings of this study demonstrate that integrating Project-Based Learning with a Place-Based Education framework (PjBL–PBE) produces a meaningful improvement in students' creative thinking skills and environmental awareness compared to project-based learning implemented without a place-based orientation. The significantly higher N-Gain scores and Mann–Whitney test results indicate that embedding learning activities within authentic community contexts enhances both cognitive and affective learning outcomes. These results suggest that the contextual richness and social interaction inherent in place-based learning provide additional cognitive stimuli that support deeper engagement and more meaningful knowledge construction.

The most notable improvement was observed in the originality dimension of creative thinking. This finding aligns with constructivist learning theory, which emphasizes that knowledge is actively constructed through interaction with the environment and social agents rather than passively received (Creswell, 2012). By engaging directly with community members and renewable energy practitioners, students encountered real constraints, practical challenges, and diverse perspectives that stimulated the generation of novel ideas. Previous studies have similarly reported that authentic, real-world problem contexts promote originality by encouraging learners to move beyond routine solutions and explore innovative approaches (Chen et al., 2022; Kuo et al., 2022). The present findings extend this body of research by demonstrating that originality is further enhanced when project-based learning is explicitly grounded in local contexts through structured community engagement.

Improvements in fluency, flexibility, and elaboration also support the premise that PjBL–PBE fosters a comprehensive development of creative thinking skills. Fluency and flexibility are closely associated with opportunities for open-ended inquiry and collaborative problem-solving, both of which were central features of the learning design. Students were encouraged to propose multiple ideas, revise their designs based on expert feedback, and adapt solutions to local environmental conditions. Such iterative processes are known to promote flexible thinking and the ability to shift perspectives when addressing complex problems (Mursid et al., 2022; Sumarni & Kadarwati, 2020). The elaboration of ideas, reflected in students' ability to refine and detail their projects, further indicates that contextualized projects support sustained cognitive engagement rather than superficial task completion.

The superior performance of the experimental group in creative product assessment provides additional evidence that the PjBL–PBE model supports the translation of conceptual understanding into tangible outcomes. Students who participated in community-based projects demonstrated stronger mastery of concepts, higher originality, and more effective presentation skills. This finding supports earlier research suggesting that project-based learning is most effective when students are required to produce authentic products for real audiences (Retnowati et al., 2020; Yamin et al., 2020). The inclusion of community members and public exhibitions, such as science fairs, likely increased students' sense of responsibility and ownership of their work, motivating them to refine both the technical and communicative aspects of their projects.

Environmental awareness also showed a substantially greater increase in the experimental group, underscoring the affective impact of place-based learning. Direct observation of renewable energy practices and interaction with community actors enabled students to connect abstract environmental concepts with tangible environmental issues in their immediate surroundings. This experiential exposure is consistent with previous studies demonstrating that place-based education enhances environmental sensitivity and pro-environmental attitudes by fostering emotional connections to local environments (Gallay et al., 2020; Khadka et al., 2021). The findings suggest that environmental awareness is not merely the result of knowledge acquisition but is deeply influenced by lived experiences and social interactions that highlight the relevance of environmental issues to students' daily lives.

The integration of renewable energy as a thematic focus further strengthened the effectiveness of the PjBL–PBE model. Renewable energy education inherently involves interdisciplinary knowledge, technological problem-solving, and ethical considerations related to sustainability. By situating renewable energy projects within local contexts, students were encouraged to consider both global environmental challenges and local feasibility, thereby developing a more nuanced understanding of sustainability. This finding aligns with research indicating that sustainability education is most effective when it combines scientific knowledge with local relevance and community engagement (Khadka et al., 2021; Zainal, 2023). The present study contributes empirical evidence that renewable energy projects can serve as a powerful context for integrating cognitive and affective learning objectives.

Despite these positive outcomes, several limitations must be acknowledged. The study involved two schools with different institutional characteristics, which may have influenced student engagement and learning culture. Although both schools implemented project-based learning, variations in resources, pedagogical traditions, and student backgrounds could have contributed to the observed differences. Additionally, the relatively small sample size limits the generalizability of the findings. Future studies should involve a larger number of schools and more diverse educational settings to strengthen external validity. The reliance on self-report questionnaires for measuring environmental awareness may also introduce subjectivity, suggesting the need for complementary qualitative methods such as interviews or reflective journals.

Overall, this study provides empirical support for the effectiveness of integrating Project-Based Learning with a Place-Based Education framework in secondary science education. The findings highlight the importance of contextualized, community-engaged learning experiences in fostering creative thinking and environmental awareness. By positioning students as active problem-solvers within their local environments, the PjBL–PBE model aligns with contemporary educational goals that emphasize sustainability, creativity, and social responsibility. These results suggest that educators and curriculum developers should consider adopting integrated pedagogical approaches that connect classroom learning with real-world contexts to better prepare students for complex environmental and societal challenges.

#### 4. CONCLUSION

The implementation of the Project-Based Learning model based on Place-Based Education (PjBL-PBE) has significant implications for fostering a more contextual, collaborative, and meaningful learning process. Through the direct involvement of students with the surrounding community and environment, this approach not only enriches the learning experience but also fosters character development and creative thinking skills. Students' activeness in digging up information, interacting with experts, and displaying project results in public spaces such as Science Fair reflects the transformation of a more participatory and reflective learning attitude. More than just improving grades, this model creates space for students to build a sense of ownership of the ideas and solutions they create. However, the generalizability of these findings is still limited by the small sample size and the context of the study, which only includes two schools with different characteristics. These factors may affect the results and need to be taken into account in further interpretation. For this reason, future research is recommended to be conducted on a wider scale with the involvement of schools from different backgrounds. Further research could also expand the focus on socio-emotional aspects as well as the long-term influence of the PjBL-PBE model on student engagement in environmental issues and the development of community-based solutions. As such, this approach has the potential to be an important foundation in the development of an adaptive and future-oriented curriculum.

**Acknowledgement:** Thanks are expressed to the Directorate of Research, Technology and Community Service; Directorate General of Higher Education, Research and Technology, Ministry of Education, Culture, Research and Technology of the Republic of Indonesia through funding for Master's Thesis Research Grants for Fiscal Year 2025. SK No 7928/LL4/PG/2025; 021/LPPM-UP/KPTM/VI/2025

#### REFERENCES

- Abraham, I., & Supriyati, Y. (2022). Desain Kuasi Eksperimen Dalam Pendidikan: Literatur Review. *Jurnal Ilmiah Mandala Education*, 8(3), 2476–2482. <https://doi.org/10.58258/jime.v8i3.3800>.
- Anshori, M., & Iswati, S. (2017). *Metodologi Penelitian Kuantitatif* (Cetakan pe). Surabaya: Erlangga University Press. Retrieved from [https://www.google.co.id/books/edition/Metode\\_Penelitian\\_Kuantitatif\\_Edisi\\_2/rKbJDwAAQB-AJ?hl=id&gbpv=1&dq=Fraenkel,+J.+%26+Wallen,+N.,+\(2003\),+How+to+Design+and+Evaluate+Research+in+Education,+Mcgraw+Hill+Publishing,+New+Jersey&pg=PA155&printsec=frontcove](https://www.google.co.id/books/edition/Metode_Penelitian_Kuantitatif_Edisi_2/rKbJDwAAQB-AJ?hl=id&gbpv=1&dq=Fraenkel,+J.+%26+Wallen,+N.,+(2003),+How+to+Design+and+Evaluate+Research+in+Education,+Mcgraw+Hill+Publishing,+New+Jersey&pg=PA155&printsec=frontcove).
- Chen, S. Y., Lai, C. F., Lai, Y. H., & Su, Y. S. (2022). Effect of project-based learning on development of students' creative thinking. *International Journal of Electrical Engineering and Education*, 59(3), 232–250. <https://doi.org/10.1177/0020720919846808>.
- Creswell, J. W. (2012). *Educational Research (Planning, Conducting, and Evaluating Quantitative and Qualitative Research)* (Fourth Ed; P. A. Smith, Ed.). Sage Publications.
- Deringer, S. A., Hodges, J. S., & Griffin, K. (2020). Mindfulness as a tool for place-based educators. *Journal of Outdoor and Environmental Education*, Vol. 23, pp. 121–135. Springer Science and Business Media LLC. <https://doi.org/10.1007/s42322-020-00053-8>.
- Dorji, K., Kinley, , & Sivitskis, A. (2021). Implementation of Place-Based Education: A Case Study in a Primary School at Talhogang, Bhutan. *Creative Education*, Vol. 12, pp. 2390–2409. Scientific Research Publishing, Inc. <https://doi.org/10.4236/ce.2021.1210180>.
- Gallay, E., Pykett, A., Smallwood, M., & Flanagan, C. (2020). Urban youth preserving the environmental commons: student learning in place-based stewardship education as citizen scientists. *Sustainable Earth*, Vol. 3. Springer Science and Business Media LLC. <https://doi.org/10.1186/s42055-020-00026-1>.

- H. -C. Kuo, Y. -T. C. Yang, J. -S. Chen, T.-W. H. and M.-T. H. (2022). The Impact of Design Thinking PBL Robot Course on College Students' Learning Motivation and Creative Thinking. *IEEE Transactions on Education*, 65(2), 124–131. <https://doi.org/doi: 10.1109/TE.2021.3098295>.
- Hake, R. R. (1999). Analyzing change/gain scores. *Unpublished.[Online] URL: Http://Www. Physics. Indiana. Edu/\~ Sdi/AnalyzingChange-Gain. Pdf*, 16(7), 1073–1080. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/22025883%5Cnhttp://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:ANALYZING+CHANGE/GAIN+SCORES#0%5Cnhttp://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Analyzing+change/gain+scores#0>.
- Jumirah, J., Sari, P. A., Kusnadi, E., & Oktaviani, A. D. (2021). Analisis Kesadaran Lingkungan Siswa Sekolah Pada Kegiatan Green-Chemistry Dalam Kondisi New Normal Pandemi Covid-19. *DIKSAINS : Jurnal Ilmiah Pendidikan Sains*, 2(1), 31–36. <https://doi.org/10.33369/diksains.2.1.31-36>.
- Kemdikbud. (2023). Kurikulum Merdeka dan Platform Merdeka Belajar. Retrieved from <https://merdekabelajar.dairikab.go.id/tentang-kurikulum-merdeka-dan-platform-merdeka-mengajar/>.
- Khadka, A., Li, C. J., Stanis, S. W., & Morgan, M. (2021). Unpacking the power of place-based education in climate change communication. *Applied Environmental Education and Communication*, 20(1), 77–91. <https://doi.org/10.1080/1533015X.2020.1719238>.
- Littrell, M. K., Tayne, K., Okochi, C., Leckey, E., Gold, A. U., & Lynds, S. (2020). Student perspectives on climate change through place-based filmmaking. *Environmental Education Research*, Vol. 26, pp. 594–610. Informa UK Limited. <https://doi.org/10.1080/13504622.2020.1736516>.
- Mursid, R., Saragih, A. H., & Hartono, R. (2022). The Effect of the Blended Project-based Learning Model and Creative Thinking Ability on Engineering Students' Learning Outcomes. *International Journal of Education in Mathematics, Science and Technology*, 10(1), 218–235. <https://doi.org/10.46328/ijemst.2244>.
- Noviani, L. (2020). Pengaruh Inovasi Produk, Kreativitas Produk, dan Kualitas Produk terhadap Keunggulan Bersaing (Studi Kasus pada Kerajinan Tikar Eceng Gondok "Liar"). *Jurnal Manajemen Danbisnis (Jumanis)*, 2(1), 2076–2086. Retrieved from <http://ejournal.lppm-unbaja.ac.id/index.php/jmb/article/view/982>.
- Retnowati, R., Istiana, R., & Nadiroh, N. (2020). Developing Project-Based Learning Related to Local Wisdom in Improving Students' Problem-Solving Skills. *JETL (Journal of Education, Teaching and Learning)*, 5(1), 137. <https://doi.org/10.26737/jetl.v5i1.1035>.
- Saputri, M., Syukri, M., & Elisa. (2022). Analysis of momentum and impulse on students' creative thinking skill through project based learning integrated STEM (science, technology, engineering, mathematics). *Journal of Physics: Conference Series*, 2193(1). <https://doi.org/10.1088/1742-6596/2193/1/012066>.
- Siti Dwi Amriani, Ita Uzzakah, Rian Agus Prakoso, Peggy Ayu Sabella, Miftahus Surur, & Agusti Agusti. (2024). Analisis Penerapan Model Pembelajaran Project Based Learning (PjBL) Untuk Meningkatkan Kreativitas Siswa. *Jurnal Kajian Penelitian Pendidikan Dan Kebudayaan*, 2(2), 13–25. <https://doi.org/10.59031/jkppk.v2i2.316>.
- Sumarni, W., & Kadarwati, S. (2020). Ethno-stem project-based learning: Its impact to critical and creative thinking skills. *Jurnal Pendidikan IPA Indonesia*, 9(1), 11–21. <https://doi.org/10.15294/jpii.v9i1.21754>.
- Takano, T. (2022). How experiences transform over time: A retrospective study on place-based education in Micronesia and the Philippines. *Journal of Adventure Education and Outdoor Learning*, 22(1), 12–23. <https://doi.org/10.1080/14729679.2020.1854098>
- Wijaya, T. T., Zhou, Y., Ware, A., & Hermita, N. (2021). Improving the Creative Thinking Skills of the Next Generation of Mathematics Teachers Using Dynamic Mathematics Software. *International*

- Journal of Emerging Technologies in Learning*, 16(13), 212–226. <https://doi.org/10.3991/ijet.v16i13.21535>.
- Wright, D. S. (2021). Middle school science teachers' agency to implement place-based education curricula about local wildlife. *Environmental Education Research*, 27(10), 1519–1537. <https://doi.org/10.1080/13504622.2021.1960955>.
- Yamin, Y., Permanasari, A., Redjeki, S., & Sopandi, W. (2020). Implementing project-based learning to enhance creative thinking skills on water pollution topic. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, 6(2), 225–232. <https://doi.org/10.22219/jpbi.v6i2.12202>.
- Yustina. (2020). The effects of blended learning and project-based learning on pre-service biology teachers' creative thinking skills through online learning in the COVID-19 pandemic. *Jurnal Pendidikan IPA Indonesia*, 9(3), 408–420. <https://doi.org/10.15294/jpii.v9i3.24706>.
- Zainal, A. (2023). *Green technology: Penerapan teknologi ramah lingkungan berbagai bidang* (Efitra & Sepriano, Eds.). PT Sonpedia Publishing Indonesia. <https://books.google.co.id/books?id=ncS7EAAAQBAJ>