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Effects of Project-Based Learning on Student Achievement: Understanding of Science Concepts, Intermediate Process Skills, and Creativity

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Abstract. The research explores the dynamic landscape of education in Indonesia, marked by ongoing changes and enhancements across multiple domains. These transformations encompass curriculum revisions, improvements in educational standards, upgrades in school infrastructure, and advancements in the professional capabilities of educators including teachers and educational administrators. A primary objective of these reforms is to equip students with the competencies requisite for success in the 21st century, notably critical thinking, collaboration, communication, and creativity, often referred to as the 4Cs.This research uses a mixed-methods model, combining qualitative and quantitative data. Initial research is conducted through observation and interviews, followed by pretest and posttest given to students. The results show a significant improvement in students' understanding of scientific concepts, scientific process skills, and creativity after implementing project-based learning (PjBL). Additionally, students' response to PjBL is positive.The research concludes that PjBL affects students' understanding of scientific concepts, scientific process skills, and creativity. However, internal and external factors such as students' interest, motivation, learning environment, teachers, and learning materials also influence the effectiveness of learning.This research employs a mixed-methods approach, integrating both qualitative and quantitative data. Initial investigation involves observations and interviews, followed by administering pretests and posttests to students. The findings demonstrate a notable enhancement in students' comprehension of scientific concepts, scientific process skills, and creativity subsequent to the implementation of PjBL. Moreover, students' reception of PjBL is affirmative.
Keywords: Understanding Concepts, Process Skills, Creativity, Project-Based Learning

Introduction

Education in the 21st century demands innovation in teaching methods that not only focus on the transfer of knowledge but also on the development of skills needed to face future challenges. These competencies are referred to as the 4Cs: critical thinking, collaboration, communication, and creativity. These four competencies prepare human resources to meet the needs of high-quality graduates through the educational process (Siswanti et al., 2022).

One approach that has gained attention is Project-Based Learning (PjBL), which is believed to provide a deeper and more contextual learning experience for students. PjBL offers students the opportunity to engage in real-world problem-solving, which can enhance creativity, conceptual understanding, and intermediate process skills that are crucial in science education. Through PBL, students can explore and apply scientific concepts in practical scenarios, thereby bridging the gap between theory and practice. Thisapproach not only fosters a more engaging and interactive learning environment but also equips students with the essential skills needed to navigate and succeed in a rapidly evolving world.The PjBLmodel can bridge the gap for students to develop creativity through project-based problem-solving activities(Kusumaningrum and Djukri, 2016). Hwang et al. (2007) state that creativity is a skill that can be nurtured and developed through the process of problem-solving.

Creative thinking is the ability to generate new, original, and useful ideas that can be used to solve problems or find innovative solutions in various situations.The ability to think creatively is an individual's capacity to generate something new, whether it be ideas or tangible works, that are relatively different from what has existed before (Ningsih et al., 2021). Creativity not only enables students to solve complex real-world problems, but it also impacts their mindset (Rafik, et al., 2022).Creative thinking skills play an important role in achieving learning outcomes because creativity enables students to find innovative solutions and understand concepts more deeply through a more contextual and relevant approach.

Conceptual understanding is the ability to grasp, interpret, and apply fundamental knowledge in various contexts. It involves not just knowing facts, but also understanding the relationships and principles underlying those concepts, enabling students to solve problems and apply their knowledge in real-world situations.Students' ability to construct or formulate science concepts is based on their prior knowledge, integrating new knowledge into existing schemas in their minds. By constructing new schemas, they form comprehensive concepts (Fiteriani, 2017).Ultimately, conceptual understanding lays the groundwork for acquiring and employing intermediate skills, while these skills, in turn, reinforce and deepen conceptual understanding through practical application and experimentation. This dynamic interaction enhances students' overall competency in the subject and contributes to their academic achievement.

Intermediate skills are those abilities that lie between basic skills and advanced skills. In the context of education or learning, intermediate skills refer to competencies that require a moderate level of expertise or proficiency. These skills are typically developed after mastering the fundamentals but before achieving mastery or specialization in a particular area. For example, in science education, intermediate skills may include conducting experiments, analyzing data, interpreting results, and applying scientific principles to solve problems. These skills require a deeper understanding of concepts and methodologies compared to basic skills but may not yet require the advanced expertise needed for specialized research or professional practice.There are three types of science process skills: basic, intermediate, and advanced. Basic process skills are most suitable for preschool children and include observing, comparing, classifying, measuring, and communicating. Intermediate skills are appropriate for higher levels of education and encompass inferring and predicting. Advanced process skills include hypothesizing, defining, and controlling variables (Charlesworth & Lind, 1979). Another viewpoint states that indicators of science process skills consist of observing, interpreting observations, grouping, predicting, communicating, asking questions, hypothesizing, planning experiments, using tools and materials, applying concepts, and conducting experiments (Rustaman et al., 2005)

Regarding this matter, the researcher conducted a series of activities to gather facts in schools through interviews with science teachers and initial observations aimed at determining the creativity of students in learning, as well as their knowledge and understanding of science concepts. Based on the results of these interviews, it can be qualitatively described that the skills possessed by students in schools are still lacking and have low values when interpreted into skill indicators such as science concepts or scienceprocesses, especially in terms of creativity. This is also based on the continuous use of the same conventional teaching methods in the learning process. Teachers at the school rarely apply other teaching methods to achieve students' skills, which can affect students' learning outcomes.

In their empirical study, Zhang and Ma (2023) found that PBL provides evidence of improved learning outcomes, higher-order thinking skills, and 21st-century skills. Hanif et al (2019) research in STEM education (science, technology, engineering, and mathematics) indicates that PBL can significantly enhance student creativity. In Usmeldi's (2019) study, it is explained that there is a significant difference in the levels of competence and creativity between students who engage in PjBL and those who do not. The higher test scores after the project-oriented problem-based learning (POPBL) experiment indicate that interdisciplinary POPBL instruction combined with participatory design pedagogy can foster interdisciplinary creativity (Chang et al., 2022). Wulandari (2019) also explained in her research that PjBL can develop creative character.

Research indicates that PjBL can enhance creativity, improve conceptual understanding, and develop intermediate process skills. However, there is a gap in these studies as the indicators have been researched separately. While extensive research has been conducted on the influence of PjBL on improving science process skills, research that presents these three skill aspects together is very limited. Therefore, research is needed, especially since these three skills support each other in achieving the competencies required in the 21st century, namely the 4C competencies. These three skills are crucial for students and have long-term benefits due to their interrelatedness and mutual support. Therefore, this research aims to determine the extent to which PjBL with the theme of biodiversity and assisted by eco-enzyme products can enhance students' creativity, understanding of concepts, and intermediate process skills.

Methods

This research is a mixed-methods study. This method is used to provide a more comprehensive understanding of the phenomena under investigation by combining the strengths of qualitative and quantitative data. It allows researchers to explain and delve deeper into qualitative findings that may not be explained solely by quantitative data. This is consistent with the opinion of (Sugiyono, 2016), that mixed-methods research combines qualitative and quantitative research methods in a research activity to obtain more comprehensive, valid, reliable, and objective data.

The implementation process of this research combines qualitative and quantitative methods, thus employing an embedded experimental model design. According to Creswell (2006), the embedded experimental model design with a sequential approach (qualitative and quantitative) is often chosen when researchers need qualitative data to develop an instrument that is later implemented in a quantitative study. This design is also very useful when researchers need to embed or integrate qualitative components into a quantitative design, such as in experimental or correlational designs.

In practice, qualitative research is conducted by collecting data during the preliminary research stage through observation and interviews, as well as during the research intervention stage through observation. Quantitative research, on the other hand, is conducted from the implementation of the research intervention, namely through interval data collection from the pretest and posttest data of students. To facilitate understanding of the stages of this research, the research activity stages can be seen in the research activity schema presented in the Figure 1.

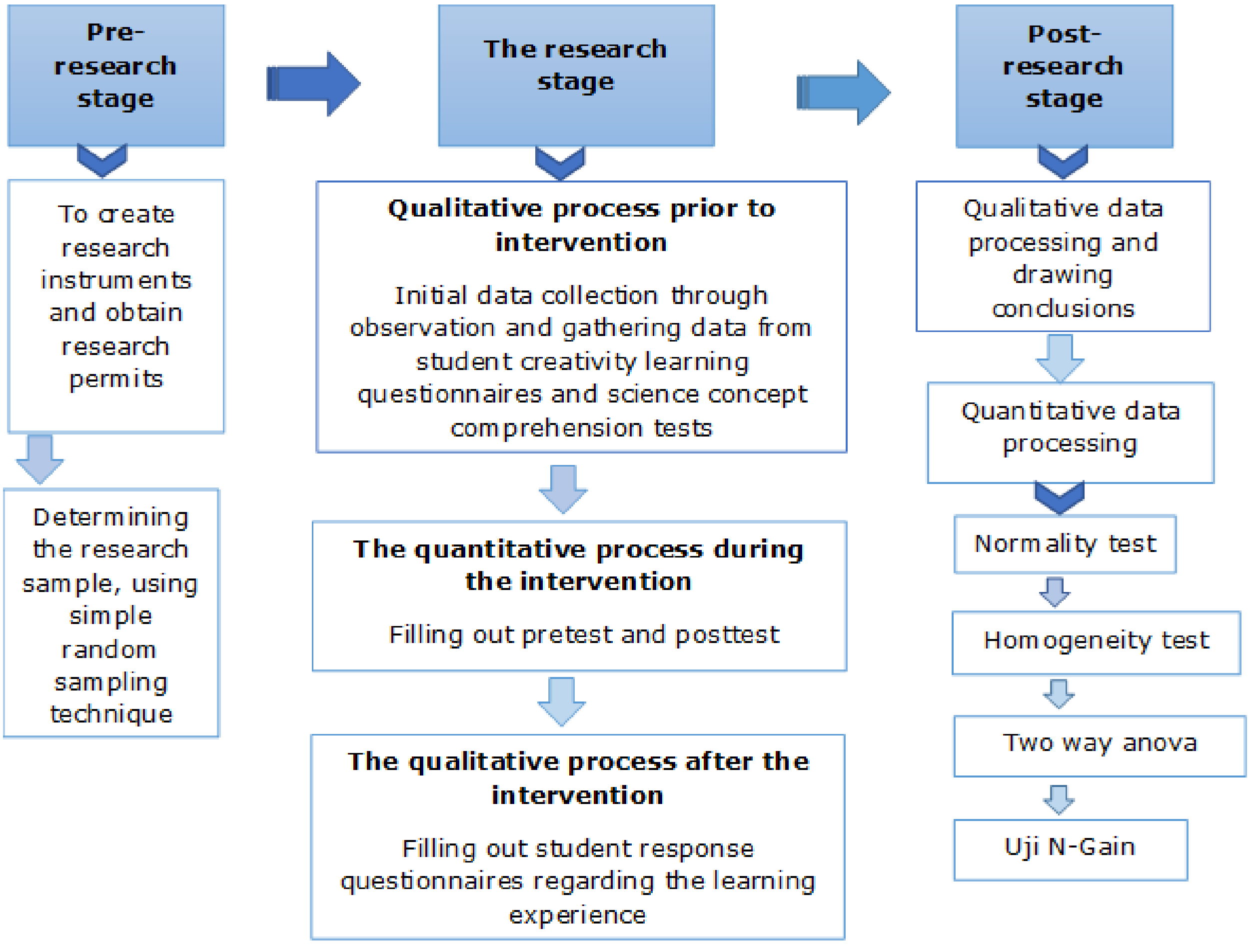

Figure 1. Research Flow

In the quantitative research, the study is a type of quasi-experimental research where the research design used is pretest posttest nonequivalent control group design. This design involves conducting a pretest before the treatment and a posttest after the treatment. The treatment given to the experimental group involved using PjBL, while the control group received conventional teaching methods.

The sampling technique used in this research is simple random sampling, also known as simple random sample. According to (Sugiyono, 2016), this technique involves randomly selecting sample members from a population without considering the strata within that population. Considering that this research falls under quasi-experimental research, according to Creswell (2002), it is stated that "Approximately 15 participants in each group in experiment," which means about 15 participants per group in the experiment. However, the sample size can be adjusted according to the research procedure's needs. Additionally, referring to (Sugiyono, 2016), the determination of sample size states that "If the sample is divided into categories, then the sample size for each category should be at least 30." Based on this information, according to the method used, there are two categories, which are two classes. Therefore, 30 samples are used for each class in the research.

The instruments used in this study are learning outcome assessment tests. The tests used are objective tests in the form of pretests and posttests on ecology and biodiversity materials, specifically sub-topic A: environmental influences on organisms, and sub-topic D: human impacts on ecosystems, oriented towards three measured aspects. The types of questions include 10 multiple-choice questions to assess understanding of scientific concepts and 15 multiple-choice questions on intermediate process skills, as well as 5 essay questions to measure students' creative thinking abilities. These instruments underwent validity and reliability testing, as outlined by (Sugiyono, 2016).

The data collection procedure in this study follows a mixed-methods approach with an embedded design, conducted as outlined in the following steps:

1. A preliminary study is conducted to gather data on students' creativity and understanding of concepts before the pretest or instructional phase, aiming to assess the extent of initial knowledge and data on the measured aspects. (Qualitative, observational in nature)

2. Pretest is conducted to examine the mean scores on the three measured aspects before the research intervention.

3. Posttest to examine the mean scores on the three measured aspects after the research intervention.

4. Qualitative data collection is conducted again by examining students' responses to the implemented instruction.

5. Integrating and interpreting quantitative and qualitative data outcomes.

The data analysis technique involves calculating the mean of pretest and posttest scores and conducting the N-gain test (Hake, 1999) to examine the effectiveness of PjBL on students' understanding of scientific concepts, intermediate process skills, and creativity. The process of data analysis can be seen through the Figure 2.

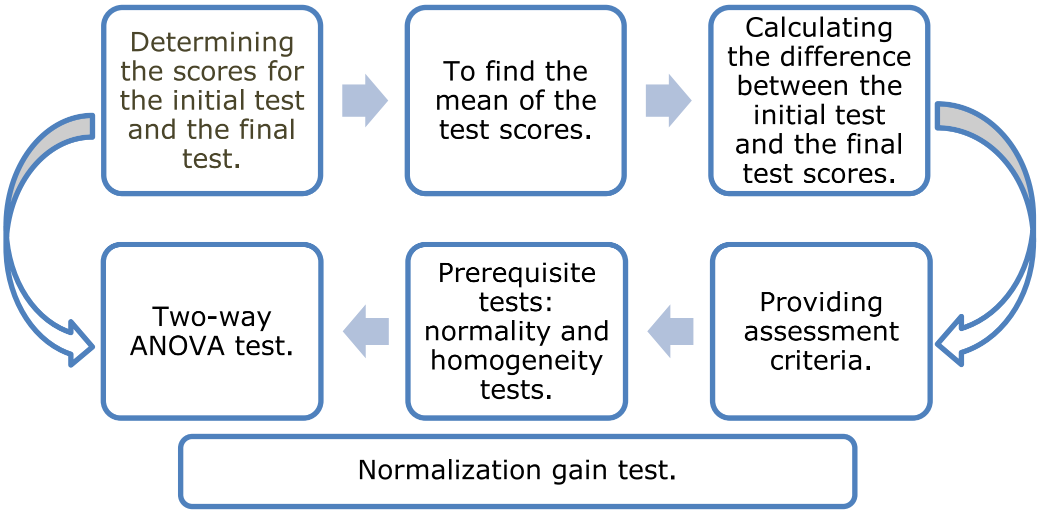

Figure 2. Data Analysis Stage

Results and Discussion

According to the data analysis procedure, the initial step is to determine the pretest and posttest scores, then calculate the mean of these tests, followed by comparing the scores. After calculating and comparing the average test results for both theexperimental and control groups, the obtained results are presented in the table below:

Table 1. Results Pretest and Posttest of The Three Aspects

Aspects	Experiment Class			Control Class		
	Pretest	Posttest	Category	Pretest	Postest	Category
Understanding of Science Concepts	38.00	64.00	Average	41.43	47.00	Average
Intermediate Process Skills	44.60	70.7	Good	63.97	66.30	Average
Creative Thinking Skills	46.67	76.67	Good	44.67	53.33	Average

Based on the data presented in the Table 1, the average pretest and posttest scores for all three aspects show a significant increase for the experimental class.These results indicate an improvement in test scores for the experimental group using PjBL-based learning. From the results of the pretest and psttest on these three aspects, the improvement for each indicator of the aspects of understanding of science concepts, science process skills, and creative thinking skills can be seen in the Figure 3.

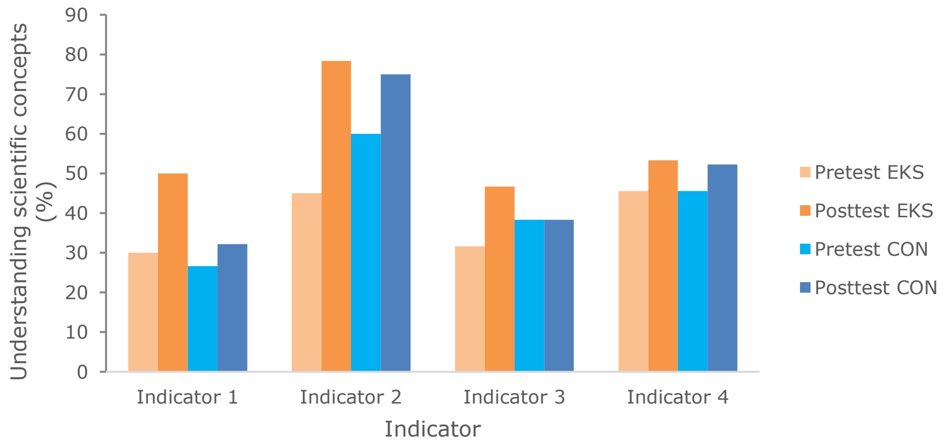

Figure 3. Percentage of Understanding Scientific Concepts for Each Indicator

Based on the average percentage results for each indicator of science concept understanding above, it can be observed that the experimental class experienced a significant improvement. This can be seen from the highest indicator increase, achieving a score of 78.33% in indicator 2 "classifying objects according to specific properties as per the concept". This score rose sharply from the pretest score of 45. The second highest score was obtained by indicator 4, "presenting concepts in various representations", with a percentage of 53.33, an increase from the pretest result of 45.56.With the average increase per indicator aspect of students' science concept understanding, it indicates the impact of PjBL. The results of this study are supported by the research of Ewisahrani et al. (2020), which presents that the use of PjBL can enhance science concept understanding, as indicated by high improvement scores (n-gain scores) in concept comprehension test results, averaging 0.83 or 93%. Additionally, this study reveals that after learning science using PjBL, students' comprehension of knowledge aspects increased with an average score of 84.45. This learning model also effectively develops students' Environmental Care Attitude, evidenced by Mustika & Ain (2020) students' learning mastery and attitude development during the learning process.Further evidence that PjBL enhances science concept understanding is supported by research conducted by Mustika & Ain (2020). In this study, two cycles were used to enhance understanding of science concepts and creativity. The first cycle achieved an average score of 75.93, which increased to 85.93 in the second cycle. This improvement demonstrates the effectiveness of learning through media creation using the PjBL model.

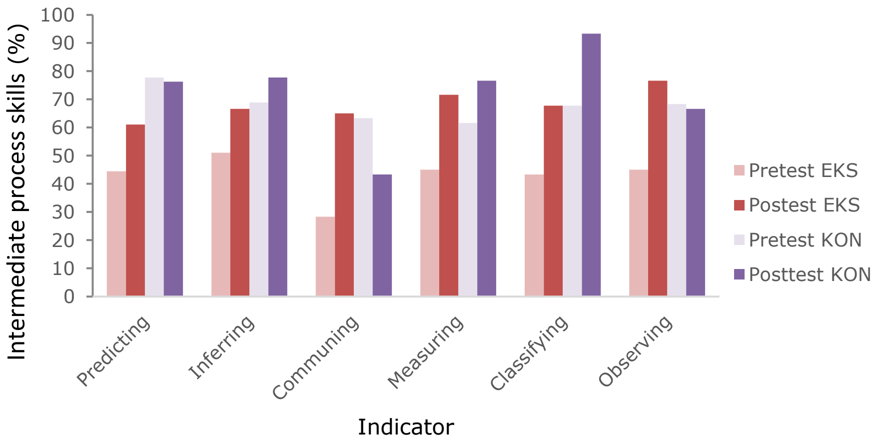

Figure 4. Percentage of Intermediate Process Skills for Each Indicator

Based on the chart presenting the percentage data for each indicator of intermediate process skills, it is evident that the results of students' intermediate process skills in the experimental class improved. The highest indicators in the experimental class were as follows: observation with an average score of 76.67, measurement with 71.67, classification with 67.78, conclusion with 66.67, communication with 65, and prediction with 61.1. The results of this study are supported by the research of Nasir et al., (2019), stating that the use of the PjBL model can enhance science process skills, particularly in the indicator of identifying variables, with a percentage of 71.32.The findings of Nasir's research are further reinforced by Hasanah et al. (2024) study, which demonstrated the effects of PjBL, especially in the indicators of identifying variables and designing experiments, obtaining the highest average percentage of 77.6%, increasing by 2.7% after the PjBL learning process. Furthermore, Hasanah's research also revealed that overall science process skills of students using the PjBL model were categorized as very good, with a percentage of 81.25%. Based on these results and supported by several relevant studies with similar goals and outcomes, it is evident that PjBL models contribute to improving intermediate process skills effectively.

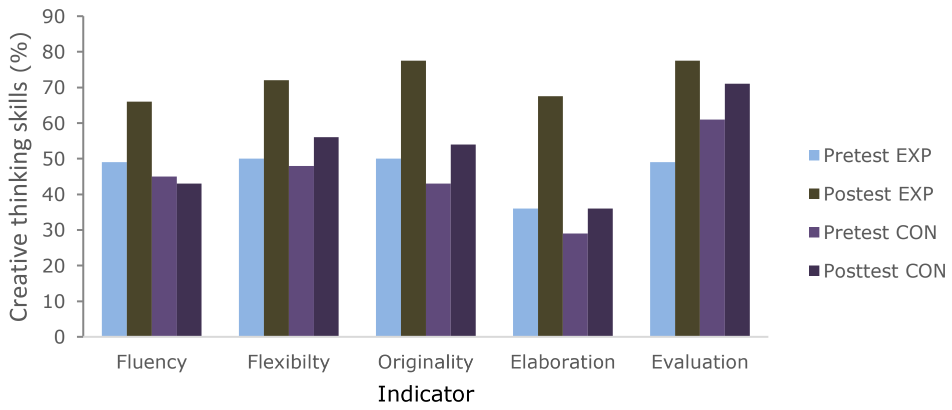

Figure 5. Percentage of Creative Thinking Skills for Each Indicator

Referring to the results presented in the above diagram, it can be concluded that each indicator in the aspects of understanding science concepts, intermediate process skills, and creative thinking skills in the experimental class has shown improvement. Based on the figure 5, the highest indicators in creative thinking are originality and evaluation, at 77.5%.This can be interpreted as an indication that students have successfully applied their creative skills in generating new ideas or creative solutions and evaluating those ideas.Based on the research by Zakiah & Fajriadi (2019) creative thinking skills are reviewed based on innovative factors knownthe average of originality capability is 86.Next is the prerequisite testing process, namely the normality test. In this test, the Kolmogorov-Smirnov test is used with a significance level >0.005 It is declared to be normally distributed (Supriadi, 2021). The data from the normality test conducted for these three aspects are as follows:

Table 2. Normality Test Results Understanding of Science Concepts

Kolmogorov smirnov Test	Standarize Residual Sig	Category
Pretest Experiment Class	0.351 > 0.05	Normal
Posttest Experiment Class	0.133 > 0.05	Normal
Pretest Control Class	0.370 > 0.05	Normal
Posttest Control Class	0.241 > 0.05	Normal

Table 3. Normality Test Result of Intermediate Process Skills

Kolmogorov smirnov Test	Standarize Residual Sig	Category
Pretest Experiment Class	0.200 > 0.05	Normal
Posttest Experiment Class	0.200 > 0.05	Normal
Pretest Control Class	0.137 > 0.05	Normal
Posttest Control Class	0.76 > 0.05	Normal

Table 4. Normality Test Results of Creative Thingking Skills

Kolmogorov smirnov Test	Standarize Residual Sig	Category
Pretest Experiment Class	0.200 > 0.05	Normal
Posttest Experiment Class	0.200 > 0.05	Normal
Pretest Control Class	0.185 > 0.05	Normal
Posttest Control Class	0.82 > 0.05	Normal

Through the presented output in the table above, it is known that all scores of tests on aspects of understanding scientific concepts, intermediate process skills, and creative thinking skills conducted on both the experimental and control groups follow a normal distribution since they exceed the significance level of 0.005. After determining that the data is normally distributed, the next step is testing for homogeneity. This test aims to determine whether the samples used are from the same population (Sianturi, 2022). In homogeneity testing, the Levene test is employed with a significance level > 0.005. If the average significance value exceeds this threshold, the data is considered homogeneous. Below are the results of homogeneity testing for the three aspects investigated in this study.

Table 5. Homogeneity Test Result

	Homogeneity Test				
	LeveneStatistik	df1	df2	Sig	Information
Understanding of Science Concepts	0.541	1	58	0.465	Homogeneous
Intermediate Process Skills	1.036	1	58	0.313	Homogeneous
Creative Thingking Skills	0.98	1	58	0.758	Homogeneous

The next stage in data analysis is conducting a two-way ANOVA test. This test is performed to demonstrate the influence exerted by this PjBL on aspects such as understanding of scientific concepts, intermediate process skills, and creative thinking skills. The hypotheses proposed for the two-way ANOVA testing are as follows:

Ha_1 = It is suspected that there is a significant influence of the PjBL model on the understanding of scientific concepts

Ha_2 = It is suspected that there is a significant influence of the PjBL model on the intermediate process skills

Ha_3 = It is suspected that there is a significant influence of the PjBLmodel on the creative thinking skills

The decision-making basis is as follows:

1. If the significance value (Sig) (2-tailed) > 0,05, then H0 accepted and Ha rejected
2. If the significance value (Sig) < 0,05, then Ha accepted dan H_0 rejected

The results of the two-way ANOVA test on students' understanding of scientific concepts, intermediate process skills, and creative thinking skills can be seen in the Table 5.

Table 5. ANOVA Two Way Test Results

	Dependent Variables:	Value Sig
PjBL Model	Understanding of Scientific Concepts	0.000
	Intermediate Process Skills	0.000
	Creative Thinking Skills	0.000

After establishing that the data and variables in this study are normally distributed and homogenous, and are declared to have an influence in the two-way ANOVA test. The next step is to conduct the normalized Gain (N-gain) test. The N-gain test is performed to determine the effectiveness criteria of the three skill aspects. N-gain analysis <g> is expressed in mathematical formula as follows:

$$< g > = \frac{\%\,(Sf) - \%(Si)}{100 - \%(Si)}$$

Information:

<g> = N-gain score

Si = Pretest score

Sf = Posttest score

Based on the calculation results obtained using SPSS 25 application, the N-gain results are as follows:

Table 6. N-gain Test Results in All Aspects

Aspect	Experiment Class with PjBL			Controll Class with Konvesional		
	N-gain (%)	Information	Interpretation effectiviness	N-gain (%)	Information	Interpretation effectiviness
Understanding of science concepts	67.00	Medium	Quite effective	18.25	Low	Not effective
Intermediate process skills	48.74	Medium	Quite effective	-3.01	Low	Not effective
Creative Thingking Skills	58.61	Medium	Quite effective	15.45	Low	Not effective

Therefore, referring to the results presented in the table above, the N-gain test results for the aspects of understanding scientific concepts, intermediate process skills, and creative thinking skills in the experimental class using PjBLfall within the range of 56-75, which falls into the category of quite effective. However, for the control class that received conventional learning treatment, it falls into the category ofhighly ineffective as the N-gain scores are below the 40% threshold.The results of this study align with the N-gain scores obtained by Hujjatusnaini et al. (2022), in the implementation of an innovative PjBL model integrated with 21st-century skills, proving to be quite effective in learning across all groups. The results indicated that students in the low-level class (mean=56.78), medium-level class (mean=58.90), and high-level class (mean=76.36) fall into the effective category. This suggests that the implementation of the learning model is more successful in enhancing HOTS among students in high-level classes compared to those in low-level and medium-level classes.

After analyzing the results of the pretest-posttest conducted with both the PjBLand conventional learning models, the researchers also sought to determine the extent of students' response to the learning process using the PjBL model. The questionnaire comprised 10 statements related to the learning process implemented during the treatment using the PjBL model, with 5 positive and 5 negative statements. The average score of the response questionnaire was 84.2333 (84%), indicating that all students in the experimental class enjoyed PjBL. Additionally, PjBL received an excellent assessment in terms of learning evaluation.

This study examines the impact of implementing PjBLin an experimental class of middle school students. The research was conducted through a quasi-experiment using a non-equivalent control group pretest-posttest design. Additionally, a control class was used as a reference to compare with the experimental class; the control class received conventional treatment. The study began with an initial observation to determine the students' level of conceptual understanding of ecology and biodiversity, which would be addressed in the PjBL learning process in this research.

Based on the pretest and posttest results, the experimental class performed well overall. The results showed a significant increase in the lowest, highest, and average scores. This is reflected in the average score for scientific concept understanding, which was 64 and categorized as moderate. The average score for intermediate process skills was 70.7, categorized as good, and the average score for creative thinking skills was 76.67, also categorized as good. The data can be seen in the Figure 6.

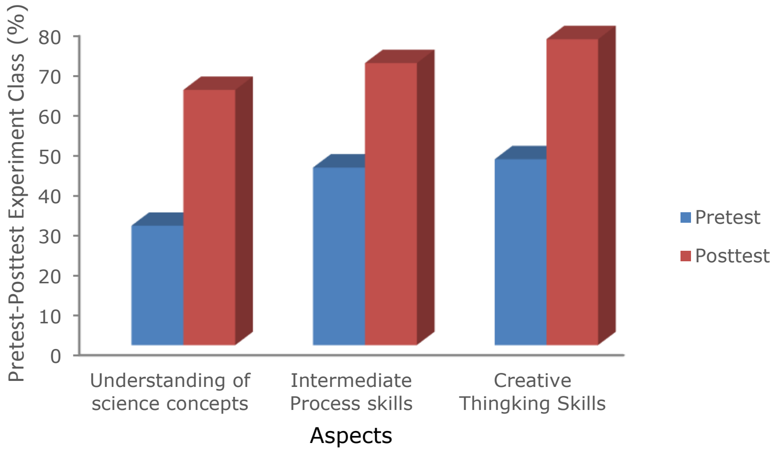

Figure 6. Percentage of Pretest-Posttest Experiment Class Results

Figure 6 shows that PjBL can increase students' understanding of science concepts from the initial percentage of 30% to 64%. This increase shows that PjBL methods can help students master scientific concepts better. By engaging students in real, relevant projects, they can connect theory with practice, facilitating a more holistic and applicable understanding of the material studied.These findings are consistent with the research of Biazus & Mahtari (2022), where students' creative thinking skills showed a significant difference after learning ($p < 0.05$). The pretest mean score of students before learning was 51.80, while the posttest mean score of students after learning was 74.40 for the experimental group taught using PjBL. Munawarah et al. (2022) found that after implementing the PjBL model with teaching aids, students in the experimental class scored 81.19 on the post-test, compared to 66.0 in the control class. This approach improved students' science process skills specifically in the area of work and energy materials.Based on the results by Yuniarti et al. (2022), an average pretest score of 54.58 and an average posttest score of 82.36 were obtained in the experimental class. This indicates that the PjBL model can enhance students' understanding of concepts related to virus materials.

Based on the review by Zhang & Ma (2023), PjBL has a significant positive effect on students' thinking skills (SMD = 0.387, $p < 0.001$) and affective attitudes (SMD = 0.379, $p < 0.001$). This indicates that the impact of PjBL on students' learning outcomes extends beyond academic performance to include self-emotional attitudes and values, creative thinking skills, computational thinking skills, and other HOTS.The results of this research are in accordance with the statement by Ewisahrani et al (2020) that the application of a PjBL model can increase students' understanding of science concepts. Sholahuddin et al (2023) also explained in their research that the results of the analysis of the influence of the PjBL model on students' understanding of concepts shows effectiveness values with categories high due to differences in atmosphere learn in class. By using the PjBLmodel, students can discuss and questions often arise between students, and teachers, so this shows the active participation of students in the learning process. The statement by Rima et al. (2023) also explains that the implementation of PjBL can make learning more effective and help students understand a material concept well.

PjBL provides space for active student engagement in the learning process, where they not only receive information passively but also engage in exploration, investigation, and real-world problem-solving. Additionally, PjBL fosters collaboration, communication, and critical thinking, all of which contribute to a deeper and more comprehensive understanding of the material being studied. Thus, PjBL not only enhances academic outcomes but also develops essential 21st-century skills for students.

Intermediate process skills include predicting, inferring, communicating, measuring, classifying, and observing, which are essential for applying scientific concepts in more complex and dynamic situations. In the context of PjBL, the results shown in Figure 6 indicate an improvement in skills from 44.6% to 70.7%.PjBLhas provided students with opportunities to develop problem-solving skills both independently and collaboratively, as well as to integrate various disciplines to complete the given projects. Consequently, the intermediate process skills gained from PjBL not only enhance students' academic abilities but also prepare them to face real-world challenges in the future.

Aligned with the results of this study, Firdaus et al. (2020) explained that intermediate process skills in PjBLincrease because students are given the opportunity to participate and create during the learning process. It is clear that the PjBLmodel encourages students to learn by creating and working on a project. Marhaeni & Sudiana (2022) also explained that PjBLhas a significant impact on improving students' intermediate process skills. Atmajaya et al (2021) explain that PjBLprioritizes the use of process skills involving physical and mental activities to solve problems, develop concepts, and construct solutions to the challenges faced by students. During the learning process, students are guided in conducting experiments and creating a product. The implementation of PjBLcan enhance reasoning and the ability to think independently, as well as train students' cognitive skills by discovering and solving problems they encounter using their knowledge and producing tangible, beneficial products for real life.

In Figure 6, the category of creative thinking also shows an increase, from 46.67 to 76.67. This increase indicates that PjBLcan encourage students to be more creative in solving problems and generating new ideas. With this method, students are more actively engaged in the learning process, developing their creativity through exploration and innovation in the projects they work on. PjBL not only helps students better understand the subject matter but also hones their creative thinking skills, which are essential for facing real-world challenges.

Komalasari et al. (2021), showed similar results in their research, indicating that PjBLcan enhance students' creative attitudes. This is because, through this learning model, students are trained in creative thinking during the learning process by searching for and finding solutions, as well as solving problems. Ramadhan & Hindun (2023) explain that PjBL often involves solving real-world problems that encourage students to think creatively in facing challenges. The process of designing, planning, and executing projects requires the discovery of new ideas, innovative strategies, and thinking beyond conventional boundaries. Students learn to adapt and deal with unexpected situations, sharpening their ability to think creatively. Collaboration within teams, which often becomes an integral part of this approach, also positively contributes to creativity. Students are encouraged to share ideas, solve problems together, and build solutions collectively. This creates an environment that stimulates the exchange of ideas and original concepts among students, combining various perspectives to achieve more innovative solutions.

Conclusion

The conclusion of this study shows that PjBLsignificantly enhances students' intermediate process skills, understanding of scientific concepts, and creative thinking abilities. This improvement is evident from the pre-test and post-test results, which show a significant increase of 17% in concept understanding, 26.1% in intermediate process skills, and 30% in creative thinking.

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