

Project-Based Learning: A Catalyst for Enhancing Students' Interest and Science Learning Outcomes on Animal Life Cycles Topic

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ABSTRACT The rapid shift toward innovative and student-centered learning demands science education models that not only improve academic achievement but also foster students' interest and engagement. Project-Based Learning (PjBL) has emerged as a promising pedagogical approach that integrates real-world contexts into classroom experiences, especially in elementary-level science instruction. This study aims to interpret: 1) The effect of the PjBL model simultaneously on students' science learning interests and outcomes in the animal life cycle topic; 2) The effectiveness of using the PjBL model on students' science learning interests and outcomes on the material in the animal life cycle topic. This study is quantitative and employs a quasi-experimental approach. The research sample comprised students in grade IV C (control class) and grade IV D (experimental class) at SD Negeri 92 Kendari in 2024. The data collection techniques used in this study were questionnaires, tests, and observations. The results of the study showed that: 1) The PjBL model significant effect on students' science learning interest and outcomes with a significance value of $0.000 < 0.05$; 2) The PjBL model is effective in increasing students' interest in learning science with a gain value of 78.35%, and quite effective in increasing students' science learning outcomes with a gain value of 69.31%. These findings confirm that the PjBL model is both effective and practical for enhancing students' interest in and outcomes in science, particularly on the topic of the animal life cycle, offering valuable insights for future curriculum design and instructional strategies in primary science education.

Keywords: Project-based learning, Science learning interest, Science learning outcomes

1. INTRODUCTION

Learning models in education serve as conceptual frameworks that guide teachers in designing and implementing effective learning processes. Choosing the appropriate learning model is very important because it can create a conducive learning environment where students can be actively involved and feel motivated to learn. To effectively enhance student engagement and learning outcomes, a robust model must adapt to both the material and diverse student characteristics (Xu et al., 2023). Furthermore, the flexibility and relevance of learning models to local contexts and individual student characteristics are key to enhancing effectiveness. They further emphasize that a failure to adapt the model to classroom dynamics can impede the achievement of learning objectives. Therefore, educators must understand that not all learning models are suitable for certain situations, and the right choice can significantly impact the educational activities.

Moreover, Project-Based Learning (PjBL) is among the student-centered approaches that have gained significant recognition. This model focuses on engaging students in real-life project activities, encouraging active participation and collaboration in solving problems. The main characteristics of PjBL include project-based, collaborative, and problem-solving-focused learning. Although it requires more thorough preparation and a longer time, PjBL offers benefits in enhancing students' critical thinking, fostering creativity, and developing collaboration skills (Almulla, 2020). Thus, this model has a positive correlation with student interest and learning outcomes, especially in science subjects, because it can increase student engagement and motivation in understanding the concepts taught.

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However, elementary school students' interest in science subjects can vary significantly. Jirout (2022) explains that the innate curiosity in early childhood contributes to varying levels of science engagement and the relevance of content to everyday life. Some students show high interest, while others are less interested, often because of less engaging learning methods. This phenomenon affects student learning outcomes, which also vary: some students achieve satisfactory results, while others still fall below standard. Factors such as learning interest, learning methods, and learning environment greatly influence these learning outcomes (Schilhab, 2021). Therefore, a specific learning approach is needed to help students better understand and apply science concepts and materials. One of the science materials that experiences the mentioned phenomenon is the Grade IV science material on the animal life cycle. Susilowati et al. (2021) explained that animal life cycles are a rich and complex scientific topic that requires students to develop an in-depth understanding. The animal life cycle includes a series of changes experienced by living things from birth to adulthood, as well as the reproductive process that ensures the survival of the species.

In the learning process, students will learn the various stages of the life cycle, from birth or hatching through growth and development to reproduction and death. Each stage has unique characteristics that need to be understood, such as the difference between complete metamorphosis (e.g., butterflies) and incomplete metamorphosis (e.g., grasshoppers). The complex characteristics of this topic require an appropriate learning approach. One practical approach is project-based learning. With this method, students can conduct in-depth research on the life cycle of a particular animal, observe each stage, and present their findings. This method strengthens not only students' conceptual comprehension but also their hands-on abilities and teamwork skills (Meier & Hendel, 2019).

In addition to the project-based approach, the effectiveness of learning about animal life cycles is greatly influenced by how the material is presented in ways that stimulate students' imagination and visual understanding. Visualization is also a critical approach in this learning. Using images, videos, and animations can help students visualize the life cycle's stages and the changes that occur at each stage. For example, watching an animation of a butterfly's metamorphosis can provide a better understanding of the process than just reading text. In addition, group discussions can encourage students to share thoughts and ideas about animal adaptations to their life cycles. Students can learn from each other by discussing the various factors influencing the life cycle and deepening their understanding of the interactions between animals and the environment (Vega-Garzón et al., 2022).

Such various learning approaches are expected to enable students to relate theoretical concepts to real

phenomena so that they not only understand the animal life cycle academically but also develop awareness and responsibility for environmental and biodiversity conservation. PjBL methodologies have demonstrated significant effectiveness in increasing students' pro-environmental behavior and environmental awareness (Azrai et al., 2023). Evidence also shows that integrating PjBL into secondary school curricula significantly improves students' environmental literacy competencies, including environmental knowledge, attitudes, and actions (López & Palacios, 2024). By engaging in context-based, real-life learning experiences, students become better equipped to understand and respond to the challenges faced by animals and ecosystems in their natural environments.

Initial observations at SD Negeri 92 Kendari revealed that fourth-grade students' interest in science subjects remained low. Many students were seen playing during the lesson, chatting with their deskmates, and disregarding the teacher's instructions when the material was being explained to the class. Based on interviews with science teachers, it was suspected that this phenomenon was due to a learning approach still centered on the teacher. Teachers have not fully implemented student-centered learning, leading students to show low enthusiasm during instruction. In a typical lesson on animal life cycles, for instance, the teacher stands at the front of the classroom, explaining the topic while pointing to an image of a life cycle. Students are instructed to listen attentively and copy the information into their notebooks. The lesson culminates with students receiving a worksheet to label the stages on an identical image. Researchers hypothesize that this conventional teaching approach leads to student boredom and a lack of enthusiasm, as it deprives students of the excitement of independent discovery in their learning. The situation is reinforced by data on students' science learning outcomes on the animal life cycle material in the previous year, which were generally still low before remedial, namely 52 out of 105 students, or 49.52% of students had not met the Learning Objective Completion Criteria (*KKTP - Kriteria Ketercapaian Tujuan Pembelajaran*) standards set by the teacher, namely 80% of students scored ≥ 75 . Therefore, the researcher tried to provide a solution by implementing the PjBL model in science learning (animal life cycle material), which is expected to increase students' interest and learning outcomes.

Implementing the PjBL model is expected to make students actively involved in projects relevant to the animal life cycle material, increasing their interest and learning outcomes. It is supported by research conducted by Taupik and Fitria (2021), which indicates a notable impact of the project-based learning model on elementary students' science achievement, specifically on the theme of a healthy environment. A similar study by Muzria & Indrawati (2020) found that the project-based learning approach improved

students' academic performance. A study conducted by Ningsih et al. (2022) revealed that the project-based learning model positively affects elementary students' cooperative behavior. This learning approach has proven effective in fostering students' collaborative abilities. Ningsih et al. (2022) argue that effectiveness is indicated by a post-test score higher than the pre-test score for the cooperative attitude.

The three mentioned studies have examined the effect of the PjBL model on various learning variables. However, the present study focuses on a narrower scientific topic—namely, the animal life cycle—allowing for an in-depth exploration of how PjBL can be tailored to enhance students' understanding and engagement with a specific scientific concept. Furthermore, the present study combines two main foci—learning interest and learning outcomes—providing a more comprehensive understanding of how PjBL can influence academic performance and students' intrinsic motivation to learn. By targeting fourth-grade students, the present study recognizes that younger students may have different learning dynamics and levels of engagement than older students, thereby allowing PjBL strategies to be adjusted to suit learners' developmental stages. Finally, the use of a quasi-experimental design in this study aims to control for variables that may influence the results, thereby providing more substantial evidence of PjBL's effectiveness in this specific context. Overall, the novelty of this study lies in its focused approach, dual emphasis on interest and learning outcomes, specific target group, and methodological rigor, which collectively contribute to a better understanding of how PjBL can be implemented effectively to enhance both interest and learning outcomes in science education. Specifically, within the topic of animal life cycles, students are expected to begin by gathering essential information, design a plan for an animal life cycle project, create a schedule, monitor project progress, assess the outcome, and evaluate the experience after the project is completed.

2. METHOD

2.1 Types of Research, Location and Research Time, and Research Variable

This study employs a quantitative, quasi-experimental design. The research involves implementing a Project-Based Learning (PjBL) model as a treatment to observe its effects on students' interest in science and learning outcomes, particularly in grade IV, on the topic of animal life cycles. Furthermore, the study was conducted at SD Negeri 92 Kendari, located at Jl. Kapten Pierre Tendean, Baruga, Kendari City, Southeast Sulawesi, from May to June 2024. Then, the independent variable (X) in this study is the application of the PjBL model in the experimental class. The dependent variables (Y) are the students' Science Learning Interests (B₁) and Science Learning Outcomes (B₂).

2.1 Research Design

The research design in this research is *the Control Group Pretest and Posttest Design*, with the following scheme.

Pretest	Treatment	Posttest
Y ₁	X	Y ₃
Y ₂	-	Y ₄

Descriptions:

Y₁ : Pretest scores of the experimental class

Y₂ : Pretest scores of the control class

Y₃ : Posttest scores of the experimental class

Y₄ : Posttest scores of the control class

X : Treatment of the PjBL model

(Sharpe & Cribbie, 2023).

2.2 Population

The study population comprised all fourth-grade students at SD Negeri 92 Kendari, totaling 106 students (Table 1).

Table 1 Description of research population

No.	Grade	Number of Students	Average Score of Diagnostic Tests
1.	IV A	26	57.8
2.	IV B	27	51.3
3.	IV C	27	67.4
4.	IV D	26	66.9
Amount		106	

(Source: Grade IV Teacher of SD Negeri 92 Kendari).

2.3 Sample

The sample was selected through purposive sampling, a method in which the researchers choose participants based on specific criteria aligned with the study's objectives (Fauzy, 2019). Two classes with relatively homogeneous academic performance were selected and given different treatments. Class IV C served as the experimental group and received instruction using the PjBL model, which emphasizes active learning through structured group projects, critical thinking, and real-world problem-solving. In contrast, Class IV D served as the control group and was taught using the conventional direct instruction model, which typically involves teacher-centered lectures, minimal student collaboration, and limited hands-on activities.

Based on the population data, these two classes were chosen because they had shown nearly equal average scores in previous science assessments and similar academic records. This formed the basis for assuming that both classes possessed comparable levels of ability prior to the intervention. This assumption is important to ensure that differences in post-treatment outcomes are more confidently attributed to the instructional approach rather than pre-existing ability gaps. Random assignment of instructional models to the two classes further minimized potential selection bias.

2.4 Data Collection Techniques and Instruments

Questionnaire

A questionnaire was used to collect data on students' interest in learning about the animal life cycle. The questionnaire was administered before and after the learning process on animal life cycles, both in the experimental class (grade IV C), where the PjBL model treatment was implemented, and in the control class (grade IV D), which did not receive the PjBL model treatment.

The questionnaire was closed-ended, namely a questionnaire containing questions and alternative answers that had been pre-determined by the researchers so that respondents only answered by giving a check mark (✓) to the answer considered most appropriate to the participant's actual situation. The variable measured in this questionnaire is Science Learning Interest. This variable is operationally defined through four key indicators: (1) students' feelings of enjoyment in participating in learning, (2) students' involvement in learning, (3) students' interest in learning, and (4) students' attention to learning. (Hasim, 2022).

Test

The test in this study was conducted twice: a pretest and a posttest. A pretest is conducted to assess students' initial knowledge before receiving the PjBL model treatment. The posttest is administered after the PjBL model treatment to assess students' science learning on animal life cycles. The test was administered in a multiple-choice format to make it easier for researchers to provide objective assessments of each student's abilities, including comparing the life cycles of several types of living things and linking the life cycles to conservation actions.

The multiple-choice test was designed to assess students' understanding of animal life cycles, aligned with core competencies and cognitive levels. The indicators cover various levels of Bloom's taxonomy, including remembering (C1), understanding (C2), applying (C3), analyzing (C4), and evaluating (C5). Each item targets specific skills such as identifying metamorphosis types, determining growth stages, analyzing life cycles, and connecting concepts to daily life and conservation.

Observation

The observation sheet was developed to evaluate the implementation of the Project-Based Learning (PjBL) model based on specific learning syntax and observable indicators. These include: initiating learning by posing essential questions; designing the project through teacher explanations and group discussions; creating a schedule collaboratively; monitoring project progress and providing continuous guidance; assessing outcomes through oral evaluations and feedback; and evaluating the experience by facilitating project presentations and student reflections on their learning process. This framework aligns with the

model proposed by the George Lucas Educational Foundation (2014) (Purnomo & Ilyas, 2019).

2.5 Data Analysis Techniques

Descriptive Statistical Analysis

This study uses descriptive statistics—means and standard deviations—assisted by data analysis software to analyze students' science learning interests across the following three categories.

$$\begin{aligned} X > (M + 1.SD) &= \text{High} \\ M - SD \leq X < (M + 1.SD) &= \text{Moderate} \\ X < (M - 1.SD) &= \text{Low} \end{aligned}$$

Where:

M = Mean

SD = Standard Deviation (Djemari, 2008).

Descriptive statistics also analyze the categorization of value intervals and their predicates based on the *KKTP* value of 75 (set by the school), as shown in Table 2.

Table 2 Score intervals and predicates

Predicate Interval	Predicate	Information
93-100	A	Very good
84-92	B	Good
75-83	C	Adequate
<75	D	Fair

(Supartin et al., 2023)

Inferential Statistical Analysis

Inferential statistical analysis in this study consisted of prerequisite tests and hypothesis testing. The prerequisite tests included the normality test and the homogeneity-of-variance test. The normality of the data was assessed using the Kolmogorov–Smirnov test, which is suitable for assessing normality (Field, 2013). In addition, Levene's test was employed to assess the homogeneity of variances across groups, ensuring the assumption of equal variances required for parametric tests (Gastwirth et al., 2009).

For hypothesis testing, this study used multivariate analysis of Variance (MANOVA). MANOVA was selected because it allows for the simultaneous analysis of the effects of an independent variable—in this case, the Project-Based Learning (PjBL) model—on multiple dependent variables, namely students' science learning interest and science learning outcomes. This approach is practical for detecting group differences across multiple outcome variables while accounting for potential intercorrelations among them (Tabachnick & Fidell, 2013).

All statistical decisions were made based on a significance level of $\alpha = 0.05$, and effect sizes were interpreted according to standard guidelines to assess the practical significance of the findings.

N-Gain Score Test

The N-Gain score was calculated to determine the effectiveness of the Project-Based Learning (PjBL) model in improving students' interest in learning and science

learning outcomes in the animal life cycle material. The N-Gain was computed using the following formula:

$$\text{N-Gain} = \frac{\text{Post-test Scores} - \text{Pre-test Scores}}{\text{Ideal Scores} - \text{Pretest Scores}}$$

The obtained average N-Gain values were then classified according to the interpretation criteria proposed by Hake (1999) in Hartati (2021), as presented in Table 3.

Table 3 Interpretation of n-gain average score

Value (g) %	Category
$g \leq 40$	Ineffective
$40 < g \leq 55$	Less Effective
$55 < g \leq 75$	Quite Effective
$g > 75$	Effective

3. RESULTS AND DISCUSSION

3.1 Description of Students' Learning Interest Data in the Experimental and Control Classes

The description of students' learning interest data before and after the treatment, obtained from the experimental and control classes, is presented in Table 4.

Table 4 presents descriptive analyses of students' interest in science learning in the experimental and control classes, both before and after the treatment. Before treatment, students in the control class showed slightly lower learning interest than those in the experimental class. However, after the treatment, there was a significant increase in both classes. This increase indicates that the treatment applied to the experimental class was very effective in improving students' learning interest. In addition, the standard deviation in the experimental class dropped drastically, indicating that students' learning interest in that class became more homogeneous after the treatment. Conversely, although the control class also experienced an increase, the decrease in standard deviation was not as significant as in the experimental class, suggesting that the variation in learning interest in the control class remained relatively large. (Slavin, 2009) stated that a reduction in a class's standard deviation indicates the success of an instructional method in equalizing students' levels of learning interest, which serves as one of the indicators of the effectiveness of the learning model implemented in instructional activities. Overall, the data indicate that the treatment not only increased the average level of learning interest in science but also improved uniformity among students in the experimental class, indicating the effectiveness of the teaching method used.

The analysis of students' interest in science learning was conducted both before and after the implementation of the PjBL model. Table 5 presents the frequency and percentage of students in each category based on the established reference criteria.

To enhance clarity and facilitate comparison, the data are also visualized in Figure 1, which shows the distribution of students across categories before and after the treatment in both the experimental and control classes (Figure 1)

Table 5 and Figure 1 present the analysis results for category tendencies in the students' science-learning-interest variable before and after the treatment, in both the experimental and control classes. Before the treatment, the average students in both classes were in the medium category. Nevertheless, the proportion of students with a high interest in the control class was slightly higher than in the experimental class. Overall, the data indicate that before the treatment, students' interest in science in both classes was predominantly at a medium level. While this may initially seem satisfactory, a medium level of interest is not yet sufficient to achieve the competencies targeted in science education, which require sustained motivation, active engagement, and higher-order thinking skills. This finding underscores the need for more effective interventions to enhance students' learning interest, particularly in the experimental class, which has strong potential for further development with the application of an appropriate instructional model.

After the treatment, the average students in both classes remained in the medium category. However, the number of students interested in science learning in the experimental class was higher than in the control class. On the other hand, after the treatment, the number of students in the control class with high science learning interest was greater than in the experimental class. These findings can serve as a basis for designing more effective interventions to increase student interest, especially in the experimental class, so that more students can be placed in the high-interest category.

The data indicate that before the treatment, students' interest in science in both classes was generally at a medium level. After the treatment, changes occurred across categories: while some students' interest increased, particularly in the experimental class, the proportion in the high category decreased slightly, and those in the low category remained unchanged.

These variations suggest that the treatment did not uniformly enhance students' interest, indicating that the

Table 4 Descriptive analysis results of students' science learning interest variable

Description	Before Treatment		After Treatment	
	Experimental	Control	Experimental	Control
N	26	27	26	27
Mean	74,42	72,06	92,58	83,48
Standard Deviation	8,04	8,79	2,8	7,05

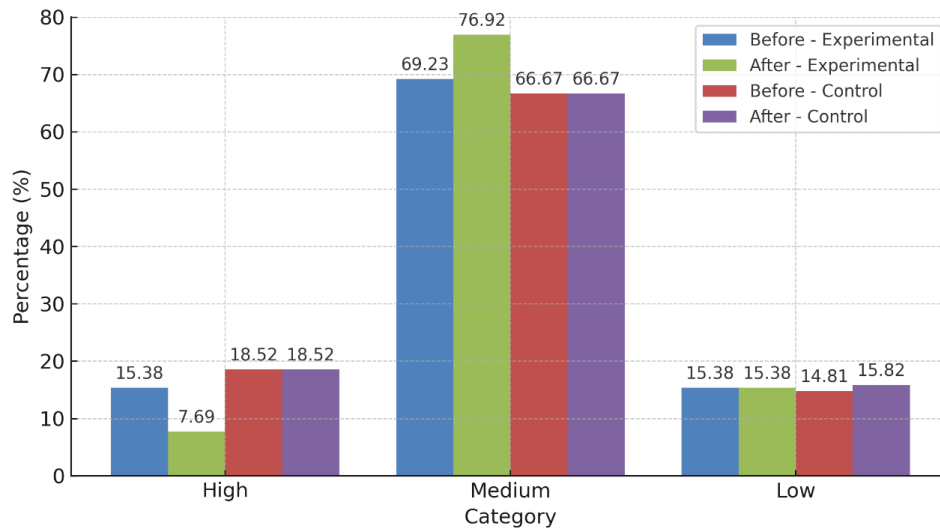


Figure 1 Distribution of students' science learning interest before and after treatment

Table 5 Students' science learning interest before and after treatment

Before Treatment	Experimental Class	Reference Criteria for Data Categorization	Frequency	%	Category	
After Treatment	Experimental Class	$X > 83,46$	4	15,38	High	
		$67,38 \leq X \leq 83,46$	18	69,23	Medium	
		$X < 67,38$	4	15,38	Low	
		Control Class				
	Experimental Class	Reference Criteria for Data Categorization	Frequency	%	Category	
		$X > 80,85$	5	18,52	High	
		$63,27 \leq X \leq 80,85$	18	66,67	Medium	
	Control Class	$X < 63,27$	4	14,81	Low	
		Experimental Class	Reference Criteria for Data Categorization	Frequency	%	Category
			$X > 95,38$	2	7,69	High
$89,78 \leq X \leq 95,38$	20		76,92	Medium		
$X < 89,78$	4		15,38	Low		
Control Class	Reference Criteria for Data Categorization	Frequency	%	Category		
	$X > 90,53$	5	18,52	High		
	$76,43 \leq X \leq 90,53$	17	62,96	Medium		
	$X < 76,43$	5	18,52	Low		

model may benefit certain groups of learners more than others. Differences may influence such patterns in students' prior motivation, learning habits, or responsiveness to the instructional approach (Santos et al., 2023; Rehman et al., 2024). Therefore, further investigation is needed to identify the factors contributing to these changes and to optimize the learning model to foster sustained motivation and engagement in science learning.

3.2 Description of Students' Learning Outcome Data in the Experimental and Control Classes

The description of pre-test and post-test learning outcomes data obtained from the experimental and control classes, with detailed data, is shown in Table 6.

Table 6 presents the descriptive analysis results for the students' science learning outcomes variable in both the experimental and control classes before the treatment (pre-test) and after the treatment (post-test). In the pre-test, the

Table 6 Descriptive analysis results of students' science learning outcome variable

Description	Experimental	Control
Pre-test Mean	53.65	50.19
Pre-test SD	7.55	10.91
Post-test Mean	84.96	67.89
Post-test SD	6.02	13.22

average score of students in the experimental class was slightly higher than in the control class. This indicates that students in the experimental class had slightly better prior understanding compared to those in the control class before the treatment was applied. However, after the treatment, a significant increase occurred in both classes. This increase indicates that the treatment applied in the experimental class was very effective in improving

students' learning outcomes. In addition, the decrease in the standard deviation in the experimental class indicates that students' learning outcomes became more uniform, suggesting that

the applied treatment not only improved the average achievement but also minimized disparities among students. This pattern implies that the instructional strategy facilitated more equitable learning progress, enabling lower-achieving students to catch up with their peers while maintaining the performance of higher-achieving students. In contrast, the increase in standard deviation observed in the control class suggests that disparities in learning outcomes widened, indicating that the conventional approach benefited only certain groups of learners while leaving others behind.

The findings of this study are consistent with those reported by Giwanti et al. (2021), who found a significant improvement in students' scientific literacy learning outcomes through the implementation of PjBL. Their research employed a quasi-experimental design with a non-equivalent control group and found that classes implementing the PjBL model showed greater improvements in learning outcomes than those using an expository teaching model. Overall, the data show that the treatment in the experimental class not only successfully increased students' average science learning outcomes but also improved uniformity among students, indicating the effectiveness of the teaching method used.

Based on the detailed data in Table 6, the tendencies of students' pre-test and post-test learning outcomes across categories or levels in the experimental and control classes are shown in Table 7.

Table 7 presents the analysis results for the category tendency of students' science learning outcomes in the experimental and control classes, based on the KKTP set at 75, for both the pre-test and post-test. In the pre-test, the majority of students in both the experimental and control classes were in the poor category. This indicates that before the treatment, most students in both classes had not yet reached the expected mastery standard. However, after the treatment, a significant change occurred. In the

post-test of the experimental class, the majority of students were in the good category. Meanwhile, in the control class, most students were still in the fair and poor categories. The significant increase in the experimental class demonstrates the effectiveness of the applied treatment, which improved students' learning outcomes overall, whereas the control class showed a more limited improvement. This data reflects that the intervention conducted in the experimental class not only increased the average score but also helped more students achieve higher categories in science learning outcomes.

The results of this study are consistent with those of Zhao & Wang (2022), who demonstrated that implementing the PjBL model in science education enhances both cognitive and non-cognitive competencies among students. Additionally, Pratiwi et al. (2023) found that PjBL significantly boosts student motivation and learning outcomes by fostering active engagement, collaboration, and problem-solving. Aifah & Astriani (2024) also reported that PjBL improved both collaboration skills and cognitive learning outcomes, as evidenced by a statistically significant increase in students' N-gain scores after the intervention. Together, these findings reinforce the conclusion that PjBL interventions can effectively enhance students' overall learning performance.

3.3 The Effect of the Project-Based Learning (PjBL) Model on Students' Science Learning Interest and Learning Outcomes on the Topic of Animal Life Cycles

Prior to conducting the MANOVA analysis, assumption tests, including normality and homogeneity tests, were carried out. The Shapiro–Wilk normality test indicated that the data for both dependent variables, learning interest and learning achievement, had p-values greater than 0.05, suggesting normality. The homogeneity of variance-covariance test using Box's M resulted in $M = 4.263$ with a p-value of 0.215 ($p > 0.05$), indicating that the variance-covariance matrices across groups were homogeneous. A summary of the assumption test results is presented in Table 8.

Table 7 Category tendency analysis results of students' science learning outcome variable

Data Categorization Interval Based on KKTP	Frequency				Category
	Pre-test		Post-test		
	Experimental	Control	Experimental	Control	
$92 < x \leq 100$	-	-	3	-	Very good
$83 < x \leq 92$	-	-	13	1	Good
$75 \leq x \leq 83$	1	3	8	13	Fair
$x < 75$	25	24	2	13	Poor

Table 8 Prerequisite tests for statistical analysis

Assumption Test	Dependent Variable	Test Statistic	p-value	Description
Normality (Shapiro–Wilk)	Learning Interest	0.973	0.178	Normal
Normality (Shapiro–Wilk)	Learning Achievement	0.969	0.124	Normal
Homogeneity of Variance-Covariance (Box's M)	Both Variables	$M = 4.263$	0.215	Homogeneous

Table 9 The summary of the MANOVA results

Multivariate Test	Wilks' Λ	F	df1	df2	p-value	Description
Wilks' Λ	0.756	8.882	2	55	0.000	Significant effect

Table 10 The summary of the univariate analysis

Dependent Variable	F	df1	df2	p-value	Mean Experimental	Mean Control	Description
Learning Interest	12.347	1	56	0.001	84.21	78.04	Significantly different
Learning Achievement	14.092	1	56	0.000	82.68	75.93	Significantly different

Table 11 N-gain score test results

No.	Posttest	Pretest	Post-Pre	Ideal Score - Pre	N Gain Score	Category
Experiment Class						
Mean Science Learning Interest	92.58	75.42	16.46	24.58	0.78	Effective
Mean Science Learning Outcomes	84.96	53.65	33.73	46.35	0.69	Quite Effective
Control Class						
Mean Science Learning Interest	92.58	50.19	42.39	49.81	0.85	Effective
Mean Science Learning Outcomes	83.48	72.06	11.42	53.65	0.21	Ineffective

Note: Ideal Score = 100

Based on the fulfilled assumptions, a MANOVA was performed to determine the effects of the learning model on students' learning interest and achievement simultaneously. The multivariate test results showed Wilks' $\Lambda = 0.756$, $F(2, 55) = 8.882$, and a p-value of 0.000 ($p < 0.05$), indicating a significant effect of the learning model on both dependent variables. The summary of the MANOVA results is presented in Table 9.

To further examine the effect of the learning model on each dependent variable, univariate analyses were conducted. The results indicated that for learning interest, $F(1, 56) = 12.347$ with a p-value of 0.001 ($p < 0.05$), and for learning achievement, $F(1, 56) = 14.092$ with a p-value of 0.000 ($p < 0.05$). This suggests that there were significant differences in both learning interest and achievement between the experimental and control groups. The average learning interest score in the experimental group (84.21) was higher than in the control group (78.04). Similarly, the average learning achievement score in the experimental group (82.68) was higher than in the control group (75.93). The summary of the univariate analysis is presented in Table 10.

The positive effect of PjBL on students' interest can be explained through several mechanisms. A study conducted by (Espino-Díaz et al., 2025) shows that PjBL can increase students' interest in learning, which contributes to better learning outcomes. Furthermore, PjBL involves the exploration of analysis and synthesis skills, which are essential components of good science learning outcomes. Research by (Markula & Aksela, 2022) found that the implementation of PjBL significantly increased interest and enthusiasm in exploring critical thinking skills, which positively impacted students' learning outcomes. PjBL also provides opportunities for students to work collaboratively, thereby enhancing social interaction and communication skills. Group project work allows students to learn from one another and develop important social

skills. Students' interest in science learning and their learning outcomes can be improved by collaboration in PjBL, as shown by research from Hasan & Juhannis (2024)

Overall, the findings of this study align with previous studies, which have shown that PjBL has a significant positive impact on students' learning interest and outcomes. Thus, implementing the PjBL model in science education is expected to be an effective strategy to improve educational quality and prepare students to face future challenges.

3.4 The Effectiveness of the Treatment on Students' Science Learning Interest and Learning Outcomes on the Topic of Animal Life Cycles

The effectiveness test of the treatment in improving students' science learning interest and learning outcomes was carried out using the N-Gain Score test (Table 11)

Based on Table 11, the N-Gain Score analysis reveals distinct patterns of improvement between the experimental and control classes. In the experimental class, the N-Gain for science learning interest was 0.78 (78.53%), categorized as Effective, while the N-Gain for science learning outcomes was 0.69 (69.31%), categorized as Quite Effective. These findings indicate that implementing the Project-Based Learning (PjBL) model produced substantial and relatively balanced improvements in both the affective domain (learning interest) and the cognitive domain (learning outcomes), with both measures falling within effective or near-effective classifications.

In contrast, the control class recorded an even higher N-Gain for science learning interest at 0.85 (85.95%), also categorized as Effective, yet the N-Gain for science learning outcomes was only 0.21 (21.28%), categorized as Ineffective. This disparity suggests that while the control group experienced a substantial increase in learning interest, this was not accompanied by a proportionate enhancement in learning outcomes. Such a pattern may be

due to instructional activities in the control class that were sufficiently stimulating to sustain interest but did not significantly enhance students' mastery of the subject matter.

The comparison of these results shows that PjBL does not necessarily yield the most significant improvement in learning interest compared to conventional methods. However, it produces markedly better outcomes in cognitive achievement. This is reflected in the fact that the experimental class achieved Quite Effective learning outcomes, whereas the control class achieved Ineffective outcomes.

Overall, the findings suggest that PjBL's relative effectiveness is more pronounced in improving students' cognitive performance than in boosting their learning interest. Moreover, the control class results underscore the importance of considering non-treatment factors, as they may also influence affective gains and introduce bias if omitted from the analysis.

Several previous studies support these findings and provide a broader context regarding the effectiveness of the PjBL model. Research by (Hwang et al., 2016) showed that the implementation of project-based learning can enhance student motivation and learning outcomes in science subjects, in line with the results of this study, which demonstrated a significant increase in students' science learning interest and outcomes. In addition, research by (Zhang et al., 2022) found that active learning models (PjBL) can improve student engagement and academic performance, supporting the finding that this approach is efficacious in improving learning outcomes. The constructivist concept popularized by figures such as (Vygotsky, 1978) It is also relevant in this context, as it emphasizes the importance of active learning experiences and social interaction in constructing knowledge. In this study, implementing the PjBL model created a learning environment that supports exploration and collaboration, enabling students to construct their own understanding of science concepts. By integrating findings from these recent studies, it can be concluded that active and interactive learning approaches, such as PjBL, significantly improve students' interest in and outcomes in science, affirming the importance of innovative and participatory teaching methods in creating more engaging and compelling learning experiences.

4. CONCLUSION

Based on the research findings and discussion, it can be concluded that the Project-Based Learning (PjBL) model simultaneously affects students' learning interest and learning outcomes. This is supported by the MANOVA results, which showed a significance value of 0.000 for Pillai's Trace, indicating a statistically significant effect. Furthermore, the PjBL model proved effective in increasing students' interest in learning science, particularly

on the topic of the animal life cycle, with an improvement rate of 78.35%, as shown by an N-gain score of 0.78. Additionally, the model demonstrated moderate effectiveness in enhancing students' learning outcomes on the same topic, with a 69.31% increase indicated by the N-gain score of 0.69. These findings suggest that implementing the PjBL model positively influences students' affective and cognitive domains in science learning.

REFERENCES

- Aifah, D. N., & Astriani, D. (2024). Project-based learning model (PjBL) to improve collaboration skills and student cognitive learning results. *Pensa E-Jurnal : Pendidikan Sains*, 12(1), 20–25.
- Almulla, M. A. (2020). The effectiveness of the project-based learning (PjBL) approach for engaging students in learning. *SAGE Open*, 10(3). doi:10.1177/2158244020938702
- Azrai, E. P., Heryanti, E., Ramadhani, V., & Ilyas, M. (2024). Enhancing students' pro-environmental behavior through project-based learning. *Biosfer*, 17(2), 317–325. doi:10.21009/biosferjpb.28352
- Djemari, M. (2008). *Teknik penyusunan instrumen tes dan nontes* [Techniques for constructing test and non-test instruments]. Yogyakarta: Mitra Cendikia Press.
- Espino-Díaz, L., Luque-González, R., Fernández-Caminero, G., & Álvarez-Castillo, J.-L. (2025). Exploring the impact of project-based learning on awareness of sustainable development goals and university students' growth. *European Journal of Educational Research*, 14(1), 283–296. doi:10.12973/eu-jer.14.1.283
- Fauzy, A. (2019). *Metode sampling* [Sampling method]. Tangerang Selatan: Universitas Terbuka.
- Field, A. (2013). *Discovering statistics using SPSS* (4th ed.). London, UK: SAGE.
- Gastwirth, J. L., Gel, Y. R., & Miao, W. (2009). The impact of Levene's test of equality of variances on statistical theory and practice. *Statistical Science*, 24(3), 343–360. doi:10.1214/09-STS301
- Hartati, R. (2016). Peningkatan aspek sikap literasi sains siswa SMP melalui penerapan model problem-based learning pada pembelajaran IPA terpadu [Improving the scientific literacy attitude aspect of junior high school students through the application of the problem-based learning model in integrated science learning]. *Edusains*, 8(1), 90–97. doi:10.15408/es.v8i1.1796
- Hasan, K., & Juhannis, H. (2024). Religious education and moderation: A bibliometric analysis. *Cogent Education*, 11(1). doi:10.1080/2331186X.2023.2292885
- Hasim, D. A. (2022). *Pengaruh kedisiplinan dan minat belajar terhadap hasil belajar ilmu pengetahuan alam siswa SMPN 9 Kendari* [The influence of discipline and learning interest on the science learning outcomes of students at SMPN 9 Kendari] (Tesis tidak dipublikasikan). Institut Agama Islam Negeri Kendari, Kendari, Indonesia.
- Hwang, R. H., Wu, J. J., Hsiung, P. A., & Lai, C. F. (2016, September). *Design and implementation of a learning platform for a computer science capstone course based on project-based learning and creative thinking*. Makalah dipresentasikan pada 44th Annual Conference of the European Society for Engineering Education - Engineering Education on Top of the World: Industry-University Cooperation, SEFI 2016.
- Jirout, J. J., Zumbunn, S., Evans, N. S., & Vitiello, V. E. (2022). Development and testing of the curiosity in classrooms framework and coding protocol. *Frontiers in Psychology*, 13, 1–14. doi:10.3389/fpsyg.2022.875161
- López, J. A., & Palacios, F. J. P. (2024). Effects of a project-based learning methodology on environmental awareness of secondary school students. *International Journal of Instruction*, 17(1), 1–22. doi:10.29333/iji.2024.1711a
- Markula, A., & Aksela, M. (2022). The key characteristics of project-based learning: how teachers implement projects in K-12 science

- education. *Disciplinary and Interdisciplinary Science Education Research*, 4(2), 1–17. doi:10.1186/s43031-021-00042-x
- Meier, R. M., & Hendel, S. A. (2019). A project-based learning unit plan: An inquiry into frogs. *Open Journal of Social Sciences*, 07(11), 70–78. doi:10.4236/jss.2019.711006
- Muzria, W., & Indrawati, T. (2020). Pengaruh model project-based learning terhadap hasil belajar siswa pada pembelajaran tematik terpadu sekolah dasar [The effect of the project-based learning model on student learning outcomes in integrated thematic learning in elementary school]. *Jurnal Pendidikan Tambusai*, 4(3), 2232–2238.
- Ningsih, R. I., Wijayanti, R. R., & Affaf, M. (2022). The effect of the use of project-based learning models and flip-based e-modules on statistics materials on students' interest and learning outcomes of class XI TKJ students at SMK Ifadah. *Journal of Etika Demokrasi*, 7(2), 341–349.
- Pratiwi, D. T., Zahratunnisa, F., & Rahmawan, S. (2025). The impact of project-based learning (PjBL) on students ' motivation and learning outcomes: A literature review. *ASEAN Journal for Science Education*, 4(1), 53–58. Diperoleh dari <https://ejournal.bumipublikasinusantara.id/index.php/ajsed/article/view/607>
- Purnomo, H., & Ilyas, Y. (2019). *Tutorial pembelajaran berbasis proyek* [Project-based learning tutorial]. Yogyakarta: K-Media.
- Rehman, N., Huang, X., Mahmood, A., AlGerafi, M. A. M., & Javed, S. (2024). Project-based learning as a catalyst for 21st-century skills and student engagement in the math classroom. *Heliyon*, 10(23), e39988. doi:10.1016/j.heliyon.2024.e39988
- Santos, C., Rybska, E., Klichowski, M., Jankowiak, B., Jaskulska, S., Domingues, N., . . . Rocha, J. (2023). Science education through project-based learning: A case study. *Procedia Computer Science*, 219, 1713–1720. doi:10.1016/j.procs.2023.01.465
- Schilhab, T. (2021). Nature experiences in science education in school: Review featuring learning gains, investments, and costs in view of embodied cognition. *Frontiers in Education*, 6, 1–19. doi:10.3389/educ.2021.739408
- Sharpe, D., & Cribbie, R. A. (2023). Analysis of treatment-control pre-post-follow-up design data. *The Quantitative Methods for Psychology*, 19(1), 25–46. doi:10.20982/tqmp.19.1.p025
- Slavin, R. E. (2009). *Educational psychology: Theory and practice* (9th ed.). Boston, MA: Pearson/Allyn and Bacon.
- Supartin, S., Arbie, A., Buhungo, T. J., & Katili, S. (2023). Learning physics using a contextual teaching and learning approach for children with physical impairment. *JIPF (Jurnal Ilmu Pendidikan Fisika)*, 8(3), 319. doi:10.26737/jipf.v8i3.4102
- Susilowati, A. Y., Sayekti, I. C., & Eryani, R. (2021). Penerapan media realia untuk meningkatkan motivasi belajar siswa pada siswa sekolah dasar [Application of realia media to increase student learning motivation in elementary school students]. *Jurnal Basicedu*, 5(4), 2090–2096. doi:10.31004/basicedu.v5i4.1160
- Tabachnick, B. G., & Fidell, L. S. (2013). *Using multivariate statistics* (6th ed.). Upper Saddle River, NJ: Pearson Education.
- Taupik, R. P., & Fitria, Y. (2021). Pengaruh model pembelajaran project-based learning terhadap pencapaian hasil belajar IPA siswa sekolah dasar [The effect of the project-based learning model on the science learning outcomes of elementary school students]. *Jurnal Basicedu*, 5(3), 1525–1531. doi:10.31004/basicedu.v5i3.958
- Vega-Garzón, J. C., Robayo-Sánchez, L. N., Cruz-Maldonado, O. A., & Cortés-Vecino, J. A. (2022). Visualization technologies for learning and teaching veterinary acarology and entomology. *Journal of Veterinary Medical Education*, 49(2), 199–203. doi:10.3138/jvme-2020-0034
- Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.
- Xu, X., Shi, Z., Bos, N. A., & Wu, H. (2023). Student engagement and learning outcomes: an empirical study applying a four-dimensional framework. *Medical Education Online*, 28(1). doi:10.1080/10872981.2023.2268347
- Zhang, L., Kirschner, P. A., Cobern, W. W., & Sweller, J. (2022). There is an evidence crisis in science educational policy. *Educational Psychology Review*, 34(2), 1157–1176. doi:10.1007/s10648-021-09646-1
- Zhao, Y., & Wang, L. (2022). A case study of student development across project-based learning units in middle school chemistry. *Disciplinary and Interdisciplinary Science Education Research*, 4(1). doi:10.1186/s43031-021-00045-8