



The Influence of PBL and PjBL Models and Learning Motivation on Science Learning Outcomes

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Abstract: This study aims to analyze the influence of the Problem Based Learning (PBL) and Project Based Learning (PjBL) learning models and learning motivation on the science learning outcomes of class IX students at SMPN 1 Pacet. The study employed an experimental method with a 2x2 factorial design. The research sample consisted of two randomly selected classes, each with 30 students. The research instruments included a science learning achievement test and a learning motivation questionnaire, both of which had been tested for validity and reliability. The data were analyzed using a two-way ANOVA after meeting the assumptions of normality and homogeneity. The results showed that the learning model significantly influenced science learning outcomes (Sig. = 0.000). Students learning using PjBL showed greater improvement in learning outcomes than those using PBL. Learning motivation also significantly influenced learning outcomes (Sig. = 0.000), with students learning through PjBL demonstrating higher learning outcomes than those learning through PBL. Furthermore, there was a significant interaction between the learning model and learning motivation on science learning outcomes (Sig. = 0.016), indicating that the effectiveness of the learning model depends on students' levels of learning motivation. In conclusion, these findings emphasize the importance of selecting an appropriate learning model and the need to consider motivational factors to optimize science learning outcomes.

Keywords: Motivation; PBL; PjBL; Science learning

Introduction

Teaching science plays a very important role for students in learning about themselves and the natural world around them. Science lessons provide the theoretical knowledge and practical skills necessary to understand technology and natural phenomena (Karimov et al., 2024). An understanding of science is becoming increasingly important in line with globalization and rapid technological advances. The aim of science education is to improve students' critical and analytical thinking skills, which are essential for facing various challenges in the future (BNSP, 2022).

Science education also plays an important role in shaping students' character. Through experiment and observation-based learning, students are taught to

appreciate the scientific process and think logically. This is in line with the national education vision, which seeks to create a young generation that not only has a high level of education but also a positive attitude towards technology and science. Students who have a deep understanding of science tend to have greater opportunities for success in higher education and careers in STEM fields.

One key element that influences student learning outcomes is the learning model (Bhuttah et al., 2024; Du et al., 2024; James et al., 2025). Learning objectives are achieved subsequent to the learning process (Ivanka et al., 2024). Choosing the right model can increase student participation and motivation to learn (Al-Hafdi et al., 2024; Shao et al., 2024; Yaseen et al., 2025). For instance, integrating project-based learning with blended instructional strategies increased student engagement

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and motivation while developing critical thinking skills. Students showed higher participation levels and reported greater satisfaction with the learning process. Problem-based learning and project-based learning models have been proven effective in teaching science (Rizki et al., 2024), deepening students' understanding of concepts and improving their critical thinking skills (Husna & Rintayati, 2024; Wijnia et al., 2024). The results of the analysis indicate that both learning models have the potential to be improved when applied.

The PBL learning model emphasizes problem solving as the center of learning activities (AlAli, 2024). In this method, students are directly involved in the learning process by actively trying to find solutions to the problems they face. PBL includes the stages of problem identification, information gathering, analysis, and solution delivery (W. Chen et al., 2025; Rehman et al., 2025; Rocksén et al., 2025). This approach can improve students' problem-solving and critical thinking skills (Vargas-Rodriguez et al., 2021). Conversely, according to Afzal & Tumpa (2025), the PjBL learning approach provides opportunities for students to collaborate in groups to design, implement, and present projects relevant to the lessons they are learning. This approach encourages students to take initiative and responsibility for their learning process (Basri et al., 2024; Levin & Major, 2025.; Lee & Lee, 2025). PjBL has the potential to increase student motivation and help them develop collaboration skills, which are crucial in today's workplace (Bell, 2010). Both models have their respective advantages, both models can be applied because they have a positive impact on science learning which creates an interesting and enjoyable atmosphere. Students gain the ability to remember scientific information and acquire skills to apply this knowledge in everyday life.

Based on the research results, the application of PBL and PjBL learning models in schools can improve student learning outcomes. The PjBL model effectively improves cognitive, affective, and psychomotor outcomes (Wulandari et al., 2024). Pangestu et al. (2024) stated that PjBL and PBL are alternative models that improve learning outcomes (Saddam Hussein). PBL has a significant impact on learning outcomes, creativity, and student motivation during the learning process. The PBL model shows a significant increase in learning outcomes when compared to conventional methods (Handhika et al., 2021). Furthermore, student motivation is also a crucial element that influences their learning outcomes. Students who have a high level of motivation are usually more involved in the learning process and are better prepared to face challenges in the academic field. The application of the Problem-Based Learning (PBL) and Project-Based Learning (PjBL) models has a significant impact on student motivation in learning

mathematics (I. A. Husna et al., 2024; Syah et al., 2024). Student learning outcomes in science teaching at SMPN 1 Pacet are still not satisfactory. Based on the results of the summative assessment, only around 60% of grade IX students managed to achieve the Minimum Completion Criteria (KKM). Therefore, this problem becomes crucial to overcome. Based on the theoretical studies and the problems described above, this study aims to determine the effect of the PBL and PjBL and motivation on students' learning outcome.

Method

This study used an experimental method with a 2x2 factorial design, involving two independent variables, one moderator variable, and one dependent variable. The first independent variable is the PBL and PjBL learning models; the second independent variable is students' learning motivation classified into high and low motivation categories. The moderator variable is learning motivation that functions to influence the relationship between learning models and science learning outcomes. The variables that are affected are the dependent variables. This study used an experimental method with a 2x2 factorial design, involving two independent variables, one moderator variable, and one dependent variable. The first independent variable is the PBL and PjBL learning models; the second independent variable is students' learning motivation classified into high and low motivation categories.

The explanation of the research method is presented in the following Table 1.

Table 1. 2x2 Factorial Design

	Learning Model (A)	PBL	PjBL
Learning motivation (B)			
High motivation		A ₁ B ₂	A ₂ B ₂
Low motivation		A ₁ B ₂	A ₂ B ₂

Description:

- A₁B₁ = Learning outcomes taught using the PjBL learning model for students with high learning motivation
- A₁B₂ = Learning outcomes taught using PBL learning model for students with high learning motivation
- A₂B₁ = Learning outcomes taught using PjBL learning model for students with low learning motivation
- A₂B₂ = Learning outcomes taught using PBL learning model for students with low learning motivation

The moderator variable is learning motivation that functions to influence the relationship between learning models and science learning outcomes. The dependent variable is students' science learning outcomes.

Table 2. Diagram of the 2x2 Factorial Experiment Plan

Teaching model	High Motivation (B ₁)	Low Motivation (B ₂)
PBL (A ₁)	A ₁ B ₁	A ₁ B ₂
PjBL (A ₂)	A ₂ B ₁	A ₂ B ₂

This study aims to analyze the influence of learning models, namely PBL and PjBL as well as learning motivation, on the science learning outcomes of grade IX students at SMPN 1 Pacet. Independent variables included teaching models and learning motivation as moderator variables. The dependent variable is science learning outcomes, which are measured through multiple-choice tests. The PBL model is implemented through problem-solving activities while emphasizing the completion of projects based on their context. A questionnaire that has been tested for validity and reliability with high and low motivation categories was used to measure learning motivation. The learning outcomes were obtained from pretest and posttest scores with a minimum completeness limit of 78.

Population and Sample

The study population was 210 ninth-grade students at SMPN 1 Pacet. The sample consisted of two randomly selected classes of 30 students each. The study samples were divided into two, one class for the PBL model and the other for the PjBL class. Random selection aimed to avoid bias and ensure representative results. The study population was 210 ninth-grade students at SMPN 1 Pacet.

Data Collection

To measure learning outcomes, the data were collected through pre-tests and post-tests and a motivation questionnaire that had been tested for validity and reliability. The data collection process was carried out systematically and in a standardized manner. Data were collected through pre-tests and post-tests to measure learning outcomes, as well as a motivation questionnaire that had been tested for validity and reliability. The data collection process was carried out systematically and in a standardized manner.

Instruments

The instruments were first tested for validity and reliability. Data normality and homogeneity were then tested. Data were analyzed using a two-way ANOVA to examine the effect of the learning model, motivation,

and their interaction on learning outcomes, with a significance level of 0.05 as the decision limit.

Result and Discussion

Question Validity Test

Validity testing demonstrates the level of accuracy of a test instrument in measuring learning outcomes. A test is considered valid if it measures what it is supposed to measure and meets certain criteria. The following are the results of the validity test:

Table 3. Knowledge of the History of Aceh Historical Sites

Question Items	Correlations		
	Person Correlation	Sig. (2-tiled)	Information
1	0.585	0.001	Valid
2	0.627	0.000	Valid
3	0.404	0.002	Valid
4	0.562	0.001	Valid
5	0.406	0.026	Valid
6	0.419	0.021	Valid
7	0.545	0.002	Valid
8	0.406	0.026	Valid
9	0.419	0.021	Valid
10	0.406	0.026	Valid
11	0.429	0.018	Valid
12	0.500	0.005	Valid
13	0.519	0.003	Valid
14	0.584	0.001	Valid
15	0.458	0.011	Valid
16	0.476	0.008	Valid
17	0.406	0.026	Valid
18	0.477	0.008	Valid
19	0.432	0.017	Valid
20	0.411	0.024	Valid

Based on Table 3, the results of the item validity analysis using the Pearson correlation method with a two-tailed significance level indicate that validity measures the extent to which the items represent the construction being tested. The correlation values for each item ranged from 0.404 to 0.627, with the highest value for item 2 (r = 0.627) and the lowest values for several items, such as items 3, 5, 8, 10, and 17 (r = 0.406). However, they still showed a fairly good positive correlation. All items had significant values below 0.05 (between 0.000 and 0.027), indicating that the correlation was statistically significant and not a coincidence. Therefore, all items were declared valid because they met the criteria for positive correlation and sufficient significance, making this test instrument reliable for measuring the intended construct.

Item Reliability

Reliability testing is a test conducted to evaluate or understand the object being measured. The following are the results of the reliability test:

Reliability Statistics

Based on Table 4, the reliability test results using Cronbach's Alpha of 0.728 for 20 items indicate that the test instrument has adequate internal consistency. The value indicates that the measuring instrument is stable enough to be trusted to produce consistent data in repeated measurements with similar conditions. Therefore, the instrument can be considered reliable and

suitable for further analyses, such as validity and hypothesis testing.

Table 4. Reliability Test Results

Reliability Statistics	
Cronbach's Alpha	N of Items
.728	20

Normality Test

The normality test aims to determine whether the collected data are normally distributed or derived from a normal population. The following are the results of the normality test:

Table 5. Normality Test

Result	Group	Tests of Normality					
		Kolmogorov-Smirnova			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
	Pretest PBL	.187	30	.009	.940	30	.092
	Posttest PBL	.195	30	.005	.942	30	.100
	Pretest PjBL	.115	30	.200*	.967	30	.470
	Posttest PjBL	.198	30	.004	.940	30	.094

*This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Based on the results of the Shapiro-Wilk normality test, which is more appropriate for small samples (n=30), the pre-test and post-test data from both groups, the PBL and PjBL classes, can be considered normally distributed. The significance value obtained for the PBL class pre-test was 0.092 and the PBL class post-test was 0.100. Meanwhile, for the PjBL class, the pre-test was 0.470 and the post-test was 0.094, all greater than the 0.05 significance limit. Thus, all analyzed data met the

assumption of normality, allowing the use of parametric statistical methods in further analysis of this study.

Homogeneity Test

The homogeneity test aims to determine whether the variances of two or more groups are similar or homogeneous. Homogeneity of variance is a crucial assumption in parametric statistical analysis, such as the t-test or ANOVA. Data are considered homogeneous if the significance value (Sig.) is greater than 0.05.

Table 6. Homogeneity Test

Learning outcome	Test of Homogeneity of Variance				
		Levene Statistic	df1	df2	Sig.
	Based on Mean	.019	1	58	.892
	Based on Median	.021	1	58	.885
	Based on Median and with adjusted df	.021	1	57.991	.885
	Based on trimmed mean	.026	1	58	.872

Based on the homogeneity test results shown in Table 6, the significance value (Sig.) of Levene's test for the variance between the two groups was 0.892. It is significantly greater than the threshold of 0.05. This indicates that the variance of learning outcome data between groups is homogeneous. The assumption of homogeneity of variance is met, and the data are ready for further analysis using parametric statistics such as the t-test or ANOVA.

Hypothesis Testing

The hypothesis testing analysis was aimed to assess the impact of the learning model, student motivation, and the interaction between the two variables on science learning achievement. The data are presented in Table 7.

The results of the hypothesis test analysis show that there is a significant influence of the learning model on students' science learning outcomes, with a significance value of 0.000 which is smaller than 0.05, so the hypothesis is not rejected, and the alternative hypothesis is accepted. This means that there is a significant difference in learning outcomes between students

taught using the PBL and PjBL models. Furthermore, student learning motivation also has a significant influence on science learning outcomes, with a significance value of 0.000 which is very small compared to 0.05, indicating that student motivation has an important role in achieving science learning outcomes. In addition, there is a significant interaction between the learning model and student motivation on science

learning outcomes with a significance of 0.016, which means that the influence of the learning model on science learning outcomes is influenced by the level of student motivation, and vice versa. Thus, both the learning model and motivation as well as the combination of the two have a real impact on the achievement of students' science learning outcomes.

Table 7. Hypothesis Testing

Tests of Between-Subjects Effects					
Dependent Variable: Learning outcomes					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	35148.333a	3	11716.111	67.500	.000
Intercept	221880.000	1	221880.000	1278.321	.000
Teaching Model	1333.333	1	1333.333	7.682	.000
Motives	33333.333	1	33333.333	192.044	.000
Teaching Model * Motivation	1080.000	1	1080.000	6.222	.016
Error	9720.000	56	173.571		
Total	363150.000	60			
Corrected Total	44868.333	59			

a. R Squared = ,783 (Adjusted R Squared = ,772)

Discussion

The validity and reliability results of the instrument demonstrated adequate measuring quality. This study also successfully met all statistical assumptions required for further analysis. Normality and homogeneity of variance tests indicated that the data obtained were suitable for analysis using a parametric approach, thus confirming the validity of the statistical methods used in hypothesis testing.

The findings show that both learning models have a significant effect on students' science learning outcomes. This is in line with constructivist learning theory, which emphasizes active student involvement in the learning process, thereby improving conceptual understanding and critical thinking skills (Piaget, 1973; Vygotsky, 1978). The PBL and PjBL models, which place students at the center of learning through problem solving and project work, are in line with the demands of 21st century learning. PBL and PjBL position learners to be more active, providing opportunities for students to take responsibility for defining, investigating, and completing authentic tasks. This approach emphasizes choice for learners, relevance, social collaboration, and teacher facilitation, with learning leading to the direct transmission of information. Forms of responsibility Learners diagnose problems or plan projects and direct inquiry and decision-making, placing learners at the center of the learning process (Saad et al., 2024). The other research results in terms of evidence of outcomes and effectiveness showed a meta-analysis of grades 6–12 found that PBL/PjBL students outperformed traditionally instructed peers with a mean effect size $g = 0.54$, and a bias-adjusted effect of $g = 0.50$ (Chang et al.,

2022). Furthermore, according to Awamleh (2024), Peng et al. (2024), Tirado-Morueta et al. (2024) there is significant positive effects of both problem-based and project-based instruction on students' achievement motivation, with differences between the two approaches in that sample. In short, both approaches place students at the center by making learners responsible for inquiry, choice, collaboration, and reflection, with PBL oriented toward solving ill-structured problems and PjBL toward producing sustained, public artifacts both requiring strong facilitation and carefully designed scaffolds for best outcomes.

Furthermore, the significant role of learning motivation in this study emphasizes the importance of internal factors in determining academic success. High learning motivation increases engagement, focus, and perseverance in learning, thereby positively impacting learning outcomes. These findings back up prior research that found that high motivation focuses behavior on learning goals and increases the salience of academic tasks, which raises time-on-task and active participation; school-context effects on engagement operate largely through students' achievement motivation (Chang et al., 2022; Muliyadi et al., 2023; Munandar et al., 2024). In addition, the significant interaction between learning models and motivation indicates that the effectiveness of these models may vary depending on students' motivation levels, which requires teachers and curriculum developers to pay attention to motivational aspects when designing learning strategies. When students are intrinsically motivated, they are more likely to engage deeply with

the material, leading to better learning outcomes where active learning strategies are more effective, the relationship between intrinsic motivation and learning strategies is very important for learners because it affects their academic performance and engagement. Understanding this relationship can help in designing teacher training programs that foster intrinsic motivation (J. Chen et al., 2025).

These study results provide practical implications for educators to adopt or engage in innovative learning models and strengthen student motivation. Because of the limitations of the study, the researchers suggest further research to expand the sample and context and explore other factors that may influence science learning outcomes, such as learning styles, environmental support, and learning technology.

The success of PBL and PjBL learning models can be highlighted as being related to their ability to develop students' metacognitive skills to improve science learning outcomes. Research by Torgal et al. (2024) showed that learning models that require reflection and problem-solving increase students' awareness of their own thinking processes, which positively impacts learning effectiveness. In PBL and PjBL contexts, students not only acquire factual knowledge but also learn to manage their learning independently, increasing their sense of responsibility and initiative in learning (Pimdee et al., 2024).

In addition, learning motivation affects learning outcomes. As explained by Deci et al. (2017) Self-Determination Theory, which emphasizes the importance of intrinsic and extrinsic motivation in the learning process. Intrinsic motivation stems from students' internal desire to master the material. It has a more long-term impact than extrinsic motivation. Therefore, learning models that support the development of intrinsic motivation, such as PBL and PjB are highly relevant for application in science education (Leasa et al., 2025; Magaji et al., 2024).

The interaction found between learning models and motivation demonstrates the need for a learning approach that relies not only on methods but also optimizes students' psychological aspects. Teachers and educators are expected to create a conducive and motivating learning environment and adapt learning models to students' motivational characteristics. This research also highlights the importance of training teachers in classroom management and understanding students' motivational needs to maximize the implementation of learning models.

Furthermore, the limitations of this study, such as the relatively small sample size and data collection limited to one school, should be considered in future research. Further studies should involve more schools and consider other variables such as social support,

emotional intelligence, or the use of educational technology as additional factors that may influence science learning outcomes. Thus, this study provides a strong empirical basis for the development of problem-based and project-based learning methods combined with efforts to increase motivation to improve the quality of science learning at the secondary school. Overall, this study contributes theoretically and practically to science education by providing empirical evidence on the effectiveness of learning models and the importance of learning motivation in secondary schools. Student-centered approaches that pay attention to motivation can significantly improve the quality of learning and students' readiness to face global challenges

Conclusion

This study concludes that both instructional models and students' learning motivation have a significant influence on science learning outcomes at the junior secondary school level. In line with the summary presented in the abstract, the findings indicate that Project-Based Learning (PjBL) results in higher science learning outcomes than Problem-Based Learning (PBL). Learning motivation was also found to play a crucial role, as students with high learning motivation consistently achieved better science learning outcomes than those with low motivation. This result confirms that motivational factors are not merely supporting variables, but key determinants of students' academic performance in science learning. Moreover, the significant interaction between learning models and learning motivation demonstrates that the effectiveness of PBL and PjBL depends on students' motivational levels. This interaction suggests that instructional strategies and learner characteristics operate interdependently rather than independently in shaping learning outcomes. From a broader perspective, these findings can be generalized to indicate that student-centered learning models such as PBL and PjBL are effective approaches for improving science learning outcomes, particularly when students' motivational characteristics are considered. This reinforces constructivist learning principles emphasizing active engagement, problem solving, and project-based activities. In practical terms, this study implies that science teachers should not only adopt innovative learning models but also deliberately foster students' learning motivation through meaningful tasks, collaborative learning, and supportive classroom environments. Schools and curriculum developers are encouraged to integrate PBL and PjBL systematically into science instruction and provide professional

development programs that strengthen teachers' capacity to address students' motivational needs

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Author Contributions

AZ: Conceptualization, methodology, data collection, and drafting. Rf: Data analysis, interpretation, supervision, and manuscript revision. RDR: Literature review, documentation, and reference management.

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Conflicts of Interest

This research is a manifestation of the institution's commitment to strengthening academic capacity. There is no conflict of interest in the academic field.

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