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The Influence of Group Investigation and Problem-Based Learning Models on Students' Critical Thinking Skills and Learning Motivation in Biology Learning

Margaretha Apriana Wanda[1*], Muh. Amir Masruhim[1], Evie Palenewan[1], Daniel[1], Taufan Purwokusumaning Daru[1], Elsje Theodora Maasawer[1]

[1] Program Studi Magister Pendidikan Biologi, Fakultas Keguruan Dan Ilmu Pendidikan, Universitas Mulawarman, Samarinda, Indonesia.

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Corresponding Author:
Margaretha Apriana Wanda
margarethaaprianaw@gmail.com

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Abstract: This study aimed to analyze the effects of the Group Investigation (GI) and Problem-Based Learning (PBL) models on students' critical thinking skills and learning motivation in biology learning. A quantitative approach with a quasi-experimental design was employed, involving two experimental classes and one control class at SMA Negeri 1 Muara Wahau. The first experimental class implemented the PBL model, the second applied the GI model, while the control class received conventional instruction. Data on students' critical thinking skills and learning motivation were collected using achievement tests and questionnaires and were analyzed using two-way ANOVA followed by the Least Significant Difference (LSD) post hoc test. The results revealed that the learning model had a significant effect on both critical thinking skills and learning motivation ($p < 0.05$). Students taught using the PBL model demonstrated the highest improvement in critical thinking skills and learning motivation, followed by those taught using the GI model, while the conventional learning group showed the lowest outcomes. These results indicate that student-centered learning models encourage active engagement, problem-solving, and collaborative learning, which contribute to enhanced cognitive and motivational outcomes in biology learning. In conclusion, both PBL and GI models positively influence students' critical thinking skills and learning motivation; however, the PBL model is the most effective. Therefore, the implementation of problem-oriented and collaborative learning models is recommended to improve the quality of biology learning processes and outcomes.

Keywords: Biology; Critical thinking; Group investigation; Learning motivation; Problem based learning

Introduction

Education in Indonesia in the 21st century is positioned within an era of openness and globalization that brings fundamental changes to various aspects of life. Rapid developments in science and technology require the availability of human resources who possess analytical, creative, and collaborative thinking skills. Consequently, learning in the 21st century should encourage students to actively seek information from diverse sources, formulate problems, collaborate with others, and solve problems critically and creatively. The primary expectation of 21st-century education is to produce high-quality human resources capable of competing globally; therefore, education must equip students with competencies that prepare them for future challenges (Jariah et al., 2022). This condition implies that learning processes can no longer focus solely on content delivery. Instead, learning must provide opportunities for students to develop literacy skills, attitudes, knowledge, and higher-order thinking skills. In line with this view, 21st-century learning emphasizes

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students' ability to formulate problems, not merely to solve them, while highlighting cooperation and collaboration as essential elements in overcoming challenges (Agustiawan, 2021; Muliyadi et al., 2023). Education thus becomes the primary means of equipping individuals with the knowledge, abilities, and skills required by modern society (Hidayatullah et al., 2021).

Critical thinking skills and learning motivation are among the most essential competencies in 21st-century education. However, these competencies have not yet been optimally developed at SMA Negeri 1 Muara Wahau. Based on observations, questionnaires, and interviews, classroom learning remains dominated by teacher-centered conventional approaches. This situation results in low student engagement, where learners tend to be passive, lack confidence in asking questions or expressing opinions, and are not accustomed to reading or completing tasks that promote higher-order thinking. Students' abilities to identify problems, construct arguments, and draw conclusions are also underdeveloped, leading to relatively low critical thinking skills.

Critical thinking skills are crucial to cultivate so that students become accustomed to responding to problems using logical and reflective reasoning. These skills are increasingly important in the current era, characterized by rapid change and intense competition driven by technological advancement (Doyan et al., 2022; Sianturi et al., 2020). Nevertheless, learning practices still tend to emphasize routine academic activities rather than the development of higher-order thinking skills (Kirana et al., 2025). As a result, students' critical thinking skills remain low because they are rarely trained (Halim et al., 2025; Hidayatullah et al., 2024). Moreover, students demonstrate a strong dependence on teachers as the sole source of information, making learning monotonous and limiting opportunities for critical thinking development (Insyasiska et al., 2017).

In addition to critical thinking skills, students' learning motivation also emerges as a significant concern. Many students display low interest at the beginning of lessons, show a lack of focus during learning activities, and rarely respond to teachers' instructions. Several students report that biology lessons are difficult to understand when delivered solely through one-way lecturing. Learning motivation remains low because instructional approaches continue to prioritize direct information transmission, causing students to become passive and disengaged. Furthermore, learning activities rarely provide opportunities for problem solving, which could support deeper conceptual understanding (Kusumawati, 2024).

These conditions indicate a clear gap between the demands of 21st-century learning—which emphasize creativity, collaboration, and higher-order thinking skills—and current classroom practices. The low levels of motivation and critical thinking skills underline the urgent need for instructional strategies that actively engage students and provide space for the development of higher-order thinking. In reality, learning activities remain largely conventional and have not been able to optimally stimulate students' critical thinking skills. Students are also not accustomed to initiating learning through problem-solving or independently discovering concepts. This situation hinders the development of students' critical thinking potential and leads to decreased motivation to actively participate in learning (Wulan et al., 2017). Therefore, the selection of appropriate learning models by teachers plays a crucial role in improving students' critical thinking skills (Fithriyah et al., 2025).

Among various instructional approaches, Group Investigation (GI) and Problem-Based Learning (PBL) are considered effective models for fostering higher-order thinking skills. The GI model emphasizes collaborative group investigation, in which students formulate topics, plan inquiries, gather information, analyze data, and present findings together (Solihah et al., 2017; A. Supriyanto et al., 2025). Through these activities, students engage directly in scientific inquiry processes, allowing critical thinking skills to develop through questioning, evidence gathering, and conclusion drawing. GI is also recognized as a cooperative learning model that encourages active student participation in independently seeking information from various resources (Aiman et al., 2023; Subudi, 2021). Moreover, GI allows students to select topics or subtopics based on their interests, which can enhance learning motivation by fostering a sense of ownership and control over the learning process.

In contrast, the PBL model offers a different learning experience by placing authentic problems at the center of instruction. PBL has been shown to enhance critical thinking skills, foster student initiative, increase intrinsic motivation, and develop interpersonal skills through group collaboration (Kono et al., 2016). Several studies indicate that PBL effectively habituates students to critical thinking through structured investigative activities (Alamha et al., 2025; Astra et al., 2024; Widayati et al., 2025). In PBL, problems are used to stimulate curiosity and encourage students to investigate relevant issues. During the investigation process, students apply critical thinking skills such as evaluating evidence and drawing conclusions from findings (Adhelacahya et al., 2023). The use of real-world problems enhances relevance, which increases student engagement and motivation. Consequently, PBL not only improves critical thinking skills but also motivates students to actively participate in learning activities (Darmawati et al., 2025).

Although both Group Investigation (GI) and Problem-Based Learning (PBL) are designed to enhance critical thinking skills and learning motivation, they differ in their instructional approaches. GI emphasizes collaborative group dynamics and student-selected investigative processes, fostering greater autonomy and a sense of ownership in learning, whereas PBL applies a more structured framework centered on authentic problems and systematic problem-solving guidance. Previous studies indicate that GI can improve critical thinking and motivation through in-depth investigative activities, while PBL is effective in developing problem-solving abilities, creativity, and higher-order thinking skills by stimulating curiosity and intrinsic motivation. However, research findings comparing the two models remain inconsistent, with some studies favoring GI for motivation, others highlighting PBL for critical thinking, and some reporting no significant differences, suggesting that variations may depend on learning context, student characteristics, biology content, and implementation quality.

Therefore, this study aims to provide empirical evidence regarding which learning model—GI or PBL—is more effective in improving students' critical thinking skills and learning motivation in biology learning. Learning motivation is a crucial factor because it significantly influences learning outcomes (Putri et al., 2021). Motivated students are more likely to succeed in the learning process, as increased motivation positively affects attitudes and behaviors (Rahmi et al., 2021). Motivation serves as a driving force that initiates, directs, and sustains learning behavior (Susanti et al., 2022).

Overall, this study is expected to contribute valuable insights for biology teachers in selecting appropriate learning models based on student needs and material characteristics. The findings may also support the development of more innovative instructional strategies aimed at improving learning quality. Thus, this research holds strong urgency in providing a comprehensive understanding of the comparative effects of the Group Investigation and Problem-Based Learning models in enhancing students' critical thinking skills and learning motivation.

Method

This study employed a quasi-experimental design using a pretest–posttest control group structure. This design was selected because the research was conducted in pre-existing classes, making it impossible to randomly assign participants. The design consisted of two experimental groups and one control group. Experimental Group 1 received instruction using the Problem Based Learning (PBL) model, while Experimental Group 2 was taught using the Group Investigation (GI) model. The control group participated in biology learning through the conventional instructional approach typically implemented by the teacher in the classroom.

The study was conducted from May to July 2025, coinciding with the even semester of the 2024/2025 academic year. The research took place at SMA Negeri 1 Muara Wahau and focused on Grade XI students. The selection of research subjects was carried out using purposive sampling, based on considerations of curriculum equivalence, uniformity of biology learning materials, and the availability of class schedules that allowed the treatments to be implemented consistently. The study population consisted of three classes with a total of 97 students, all of whom were included as research subjects. Data were collected through two primary techniques: surveys and tests. The survey instrument was used to measure students' learning motivation, while the test was employed to assess their critical thinking skills. Tests were administered in the form of pretests and posttests to identify changes in student performance before and after the treatments. This two-measurement design enabled the researchers to evaluate the effect of each instructional model on the improvement of student learning outcomes.

The research instruments consisted of a learning motivation questionnaire developed based on established motivation indicators and measured using a Likert scale. The questionnaire underwent content validation by experts in biology education and learning assessment to ensure that each item was aligned with the motivation construct. Another instrument used in this study was a set of pretest and posttest questions designed to measure students' critical thinking skills, covering indicators such as analyzing, evaluating, interpreting, and providing scientific reasoning. The test items were subjected to empirical validation and reliability testing to ensure their appropriateness and measurement accuracy.

The research data were analyzed through several stages of statistical testing. The analysis began with a normality test to ensure that the data were drawn from a normally distributed population, followed by a homogeneity test to examine the equality of variances across groups. After the statistical assumptions were met, an independent t-test was conducted to determine the differences in the effects of the PBL and GI models on the improvement of students' critical thinking skills and learning motivation. All statistical analyses were performed using IBM SPSS Statistics version 22 for Windows to ensure precision and accuracy in data processing.

Result and Discussion

Result

This study is quasi-experimental research that describes students' critical thinking skills using three different classes, namely the Problem Based Learning class, the Group Investigation class, and the conventional class. The research was conducted on eleventh-grade students at SMA Negeri 1 Muara Wahau to determine the influence of the Problem Based Learning (PBL) and Group Investigation (GI) models on students' critical thinking skills and learning motivation in biology learning, specifically on the topic of the growth and development of living organisms.

The research instruments used were a pretest, posttest, and a motivation questionnaire. The pretest was administered to measure students' initial abilities, while the posttest was used to assess students' abilities after receiving treatment. The learning motivation questionnaire was used to determine students' interest in biology, especially in the topic of the growth and development of living organisms. The data obtained consisted of quantitative and qualitative data. Data from the pretest, posttest, and questionnaire were analyzed to determine the results of students' critical thinking skills and learning motivation using SPSS Version 22 with a 95% significance level. The pretest was given to measure students' initial abilities before the learning intervention, with questions related to the material to be taught through the predetermined learning models.

Table 1. Pretest Results of Students' Critical Thinking Skills and Learning Motivation

Group	Class	N (Number of students)	Average critical thinking	Average learning motivation
	XI IPA1	30	80.3	80.6
PBL Model	XI IPA2	31	76.9	77.0
	XI IPA3	36	71.7	72.0
	XI IPA1	30	75.8	74.8
GI Model	XI IPA2	31	74.1	70.0
	XI IPA3	36	68.5	65.0
	XI IPA 3	30	62.2	55.8
Conventional	XI IPA 2	31	61.1	54.1
	XI IPA 3	36	50.3	54.0

Table 1 presents the pretest results of students' critical thinking skills and learning motivation across three learning models, namely Problem Based Learning (PBL), Group Investigation (GI), and conventional learning. The results show that the class using the PBL model obtained the highest initial (pretest) scores on both variables. The average critical thinking score in the PBL group ranges from 71.7 to 80.3, while the average learning motivation ranges from 72.0 to 80.6. This indicates that students in the PBL class possessed stronger initial analytical abilities and learning motivation. In the GI model, the average critical thinking scores range from 68.5 to 75.8, while learning motivation ranges from 65.0 to 74.8. These results reflect a good initial readiness, although it is still lower than the PBL group's performance.

Conversely, the group receiving conventional learning demonstrated the lowest initial scores. Their average critical thinking abilities ranged only from 50.3 to 62.1, while their learning motivation ranged between 54.0 and 55.8. These findings indicate that students in the conventional group had lower initial critical thinking skills and learning motivation compared to the other two learning models. Furthermore, the data on students' critical thinking skills and learning motivation in the experimental groups, each of which used the three learning models, namely Problem Based Learning, Group Investigation, and conventional learning, are presented for the topic of growth and development in living organisms.

Based on Table 2, the average scores of students' critical thinking skills who used the Problem Based Learning (PBL) model ranged from 82.7 to 88.4, with the highest score found in class XI IPA 1 at 88.4, which is far above the minimum mastery criterion (KKM) of 75. Meanwhile, the group that used the Group Investigation (GI) model obtained average scores ranging from 79.0 to 84.3, with the highest score being 84.3. The class that used conventional learning obtained average scores between 73.0 and 78.0, still below the two innovative learning models. Overall, all models showed an increase in critical thinking skills from pretest to posttest, but the PBL model produced the highest improvement.

The superiority of the PBL model in producing the highest posttest scores is influenced by its characteristics, which encourage students to actively construct knowledge through real-world problem solving. PBL also increases learning activity, helps students understand concepts more deeply, provides responsibility for the learning process, encourages self-evaluation, and trains critical thinking and adaptability to new knowledge. In addition, PBL provides opportunities for students to connect learning with real-life experiences, thereby fostering continuous learning interest.

Table 2. Posttest Results of Students' Critical Thinking Skills

Group	Class	N (Number of students)	Average critical thinking	Average learning motivation
	XI IPA1	30	88.4	88.2
PBL Model	XI IPA2	31	85.2	83.0
	XI IPA3	36	82.7	80.0
	XI IPA1	30	84.3	81.0
GI Model	XI IPA2	31	79.8	78.5
	XI IPA3	36	79.0	75.9
	XI IPA1	30	78.0	77.0
Conventional	XI IPA2	31	75.0	75.2
	XI IPA 3	36	73.0	72.3

Based on the learning motivation data in Table 2, the PBL group again showed the highest value, namely 88.2 in class XI IPA 1, which is also above the KKM of 75. The GI group obtained motivation scores ranging from 75.9 to 81.0, while the conventional group ranged between 72.3 and 77.0. Similar to the critical thinking variable, all groups experienced an increase in learning motivation from pretest to posttest, but PBL remained the model with the most significant improvement.

The advantage of PBL in increasing learning motivation is influenced by its challenging and real-world-relevant learning process, which provides space for students to explore, discuss, and find solutions independently. This model also helps students understand lessons through critical thinking activities, build new knowledge, and maintain continuous learning interest, especially in the topic of growth and development in plants.

Before analysing the influence of the learning models used, the research data had to undergo several prerequisite tests. For the critical thinking variable, the prerequisite tests included validity, reliability, and normality tests. The validity test was conducted to determine the accuracy of the instrument in measuring the intended aspects, and the analysis results showed that all items in the critical thinking instrument had item–total correlation values smaller than the 0.05 significance level, indicating that all 12 items were valid. Furthermore, the reliability test was conducted to ensure the consistency of the instrument as a measurement tool and based on the Shapiro–Wilk test on nine statements, values greater than 0.6 were obtained, indicating that the instrument met the reliability criteria. The normality test was then conducted to determine whether the critical thinking data were normally distributed, which is an important requirement before further statistical analysis. The results of the normality test are presented in the following table as the basis for the feasibility of inferential analysis.

Table 3. Normality Test of Critical Thinking Based on Learning Model Factors

Learning Model		Kolmogorov-Smirnov			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Critical Thinking	PBL	0.203	3	.	0.994	3	0.848
	GI	0.326	3	.	0.873	3	0.304
	Conventional	0.219	3	.	0.987	3	0.780

Table 3 presents the results of the normality test for critical thinking skills based on the learning model using the Shapiro–Wilk test. Based on the Shapiro–Wilk significance values (Sig.), the three learning model groups, Problem Based Learning (PBL), Group Investigation (GI), and conventional learning, have significance values of 0.848, 0.304, and 0.780, respectively. All these values are greater than the significance level of 0.05. Therefore, the critical thinking skill data in all three learning models are normally distributed, allowing the analysis to proceed to parametric statistical tests.

Table 4 shows the results of the normality test for critical thinking skills based on class groups, namely XI IPA 1, XI IPA 2, and XI IPA 3. The Shapiro–Wilk significance values obtained are 0.780 for IPA 1, 0.957 for IPA 2, and 0.740 for IPA 3. All these significance values are above 0.05, indicating that the critical thinking skill data in all classes meet the normality assumption. This shows that the distribution of data in each class does not deviate significantly from a normal distribution. Next, a homogeneity test was conducted to determine whether the data obtained were homogeneous or not. This homogeneity test uses the Levene test with a significance level of 5%. The results of the homogeneity test are presented in the table 5.

Table 4. Normality Test of Critical Thinking Based on Class Factors

Class		Kolmogorov-Smirnov			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Critical Thinking	IPA1	0.219	3	.	0.987	3	0.780
	IPA2	0.178	3	.	0.999	3	0.957
	IPA3	0.229	3	.	0.982	3	0.740

Table 5. Homogeneity Test of Critical Thinking Scores Based on Learning Model Factors

Levene Statistic	df1	df2	Sig.
0.666	2	6	0.937

Table 6. Homogeneity Test of Critical Thinking Scores Based on Class Factors

Levene Statistic	df1	df2	Sig.
0.010	2	6	0.990

Table 5 shows the Levene test results for critical thinking scores based on the learning model factor. The significance value (Sig.) is 0.937 (> 0.05), which means that the variances among the learning model groups are homogeneous. Thus, the data meet the homogeneity assumption, allowing further analyses such as ANOVA to be conducted without violating assumptions.

In Table 6, the Levene test results show a significant value of 0.990 (> 0.05). This indicates that the variance of critical thinking scores based on class factors is also homogeneous. In other words, there is no significant difference in variance among the class groups.

Table 7. Normality Test of Learning Motivation Based on Learning Model Factors

Learning Model		Kolmogorov-Smirnov			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Learning Motivation	PBL	0.239	3	.	0.975	3	0.698
	GI	0.175	3	.	1.000	3	0.989
	Conventional	0.227	3	.	0.983	3	0.749

The normal analysis of learning motivation data is divided into two main factors. In Table 7, the results of the normality test for learning motivation data grouped by learning model (PBL, GI, and Conventional) show that the data are normally distributed in all groups. This is indicated by the Shapiro–Wilk significance (Sig.) values, all of which are well above the 0.05 threshold (PBL: 0.698; GI: 0.989; Conventional: 0.749).

Table 8. Normality Test of Learning Motivation Based on Class Factors

Class		Kolmogorov-Smirnov			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Learning Motivation	IPA1	0.241	3	.	0.974	3	0.688
	IPA2	0.207	3	.	0.992	3	0.831
	IPA3	0.183	3	.	0.999	3	0.931

Table 8 presents the results of the normality test based on class factors (IPA1, IPA2, and IPA3). Similar to the learning model factor, the data in these class groups also show a normal distribution, with Sig. values consistently exceeding 0.05 (IPA1: 0.688; IPA2: 0.831; IPA3: 0.931). Overall, because all Sig. values are greater than 0.05, the assumption of normality is met, and the data are suitable for processing using parametric statistical tests.

Table 9. Homogeneity Test of Learning Motivation Scores Based on Learning Model Factors

Levene Statistic	df1	df2	Sig.
0.682	2	6	0.541

The results of the homogeneity test of variance for learning motivation scores based on the learning model factor (consisting of PBL, GI, and Conventional) are presented in Table 9. The Levene's Statistic test produced a value of 0.682 with degrees of freedom df1 = 2 and df2 = 6. The significance value (Sig.) obtained is 0.541. Since the Sig. value (0.541) is greater than 0.05, it can be concluded that there is no significant difference in the variance of learning motivation among the three learning model groups. In other words, the variance of learning motivation scores across the learning model groups is homogeneous (equal).

Table 10. Homogeneity Test of Learning Motivation Scores Based on Class Factors

Levene Statistic	df1	df2	Sig.
0.378	2	6	0.701

The results of the homogeneity test of variance for learning motivation scores grouped by class factors (IPA1, IPA2, and IPA3) are presented in Table 10. The Levene's Statistic test produced a value of 0.378 with degrees of freedom df1 = 2 and df2 = 6. The significance value (Sig.) obtained is 0.701. Since the Sig. value (0.701) is also greater than 0.05, it can be concluded that there is no significant difference in the variance of learning motivation scores among the three class groups. Therefore, the variance of learning motivation scores across the class groups is declared homogeneous. The next step is hypothesis testing using two-way ANOVA.

Table 11. Results of the Two-Way ANOVA Analysis on Critical Thinking Skills Data

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	199.678[a]	4	49.919	217.567	0.000
Intercept	58499.484	1	58499.484	254961.433	0.000
Learning Model	154.916	2	77.458	337.588	0.000
Class	44.762	2	22.381	97.545	0.000
Error	0.918	4	0.229		
Total	58700.080	9			
Corrected Total	200.596	8			

Based on the table above, which represents the results of the statistical test, the calculated F value for critical thinking skills has a probability value smaller than 0.05. Therefore, it can be concluded that in this study there is an effect of the learning model factor and the class factor on critical thinking skills. Thus, the analysis can be continued with a Post Hoc test.

Table 12. Post Hoc Test for the Learning Model Factor

Learning Model		Mean Difference	Std.error	Sig.	95% Confidence interval	
					Lower Bound	Upper Bound
PBL	GI	4.4000	0.39110	0.000	3.3141	5.4859
	Conventional	10.1333	0.39110	0.000	9.0475	11.2192
GI	PBL	-4.4000	0.39110	0.000	-5.4859	-3.3141
	Conventional	5.7333	0.39110	0.000	4.6475	6.8192
Conventional	PBL	-10.1333	0.39110	0.000	-11.2192	-9.0475
	GI	-5.7333	0.39110	0.000	-6.8192	-4.6475

The PostHoc test results for the dependent variable Critical Thinking Scores across different learning model groups show a highly significant difference in the means among all group pairs. All comparisons namely PBL vs GI, PBL vs Conventional, and GI vs Conventional yielded a Significance (Sig.) value of 0.000. This indicates that each learning model has a significantly different impact on critical thinking ability. Specifically, the PBL model was proven to produce the highest results, significantly outperforming GI (Mean Difference 4.4000) and Conventional (Mean Difference 10.1333). The GI model also showed a significant advantage over the Conventional model (Mean Difference 5.7333). Overall, the effectiveness ranking of learning models in enhancing critical thinking is PBL > GI > Conventional.

Table 13. Post Hoc Test of Class Factor

Class		Mean Difference	Std.error	Sig.	95% Confidence interval	
					Lower Bound	Upper Bound
IPA1	IPA2	3.5667	0.39110	0.001	2.4808	4.6525
	IPA3	5.3667	0.39110	0.000	4.2808	6.4525
IPA2	IPA1	-3.5667	0.39110	0.001	-4.6525	-2.4808
	IPA3	1.8000	0.39110	0.010	0.7141	2.8859
IPA3	IPA1	-5.3667	0.39110	0.000	-6.4525	-4.2808
	IPA2	-1.8000	0.39110	0.010	-2.8859	-0.7141

The PostHoc test results indicate that Critical Thinking Scores are significantly influenced by the class factor. Meanwhile, comparisons among classes (IPA1, IPA2, and IPA3) also show significant differences (Sig. ≤ 0.010) for all pairs, with the ranking from highest to lowest being IPA1, IPA2, and IPA3.

Table 14. Two-way ANOVA Analysis Results on Student Learning Motivation Data

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	173.610[a]	4	43.030	37.674	0.002
Intercept	56205.346	1	56205.346	48787.481	0.000
Learning Model	120.316	2	60.158	52.219	0.001
Class	53.294	2	26.647	23.130	0.006
Error	4.608	4	1.152		
Total	56383.564	9			
Corrected Total	178.218	8			

Based on the table above, which presents the statistical test results, the F-value for learning motivation has a probability value less than 0.05. Therefore, it can be concluded that in this study, there is an effect of both the learning model factor and the class factor on learning motivation. This is then followed by a Post Hoc test. The Post Hoc test using the LSD method aims to determine where the differences lie among the three experimental classes. The results of the Post Hoc test using LSD are presented in the following table. The Post Hoc test is also used to identify the differences resulting from the use of different learning models concerning learning motivation. The results of this Post Hoc test are presented in the following table.

Table 15. PostHoc Test on Student Learning Motivation Data by Learning Model Factor

Learning Model		Mean Difference	Std.error	Sig.	95% Confidence interval	
					Lower Bound	Upper Bound
PBL	GI	5.2667	0.87637	0.004	2.8335	7.6999
	Conventional	8.9067	0.87637	0.001	6.4735	11.3399
GI	PBL	-5.2667	0.87637	0.004	-7.6999	-2.8335
	Conventional	3.6400	0.87637	0.014	1.2068	6.0732
Conventional	PBL	-8.9067	0.87637	0.001	-11.3399	-6.4735
	GI	-3.6400	0.87637	0.014	-6.0732	-1.2068

Next, the results of the Multiple Comparison test (LSD) indicate significant differences in learning motivation. For Critical Thinking Scores, all comparisons among learning models (PBL, GI, and Conventional) yielded Sig. 0.000, with the effectiveness ranking being PBL > GI > Conventional. Comparisons among classes (IPA1, IPA2, IPA3) were also significant (Sig. ≤ 0.010), with the ranking from highest to lowest being IPA1 > IPA2 > IPA3. Similarly, for Learning Motivation Scores, all comparisons among learning models were significant (Sig. ≤ 0.014), reaffirming that PBL and GI are significantly more effective than the Conventional model in enhancing learning motivation.

Table 16. PostHoc test on Student Learning Motivation Data by Class Factor

Class		Mean Difference	Std.error	Sig.	95% Confidence interval	
					Lower Bound	Upper Bound
IPA1	IPA2	3.1667	0.87637	0.022	0.7335	5.5999
	IPA3	5.9567	0.87637	0.002	3.5235	8.3899
IPA2	IPA1	-3.1667	0.87637	0.022	-5.5999	-0.7335
	IPA3	2.7900	0.87637	0.033	0.3568	5.2232
IPA3	IPA1	-5.9567	0.87637	0.002	-8.3899	-3.5235
	IPA2	-2.7900	0.87637	0.033	-5.2232	-0.3568

Discussions

The study conducted at SMA Negeri 1 Muara Wahau involved three classes: two experimental classes and one control class, aiming to analyze the effect of Problem-Based Learning (PBL), Group Investigation (GI), and conventional learning on students' critical thinking skills and learning motivation in biology. The first experimental class implemented the PBL model, the second experimental class used the GI model, while the control class followed a teacher-centered conventional approach. Statistical analysis showed that the learning model had a significant effect on both research variables.

The corrected model value of 0.99 for critical thinking indicates that 99% of the variation in students' critical thinking skills was influenced by the learning model used. These results provide strong evidence that different instructional strategies produce different effects on students' thinking quality. PBL emerged as the most effective model in enhancing critical thinking compared to GI and conventional learning.

The advantage of PBL in this study can be understood through its fundamental characteristics. PBL facilitates active student engagement in identifying problems, collecting information, analyzing data, and formulating solutions based on their own understanding. This process trains students in higher-order thinking because they directly confront situations that require logical reasoning, in-depth analysis, and reflection on various possible solutions. In biology learning, contextual problems related to natural phenomena or everyday life issues are highly effective in stimulating critical thinking skills. Students are not merely asked to memorize concepts but to interpret them in real-world contexts. As a result, the knowledge they acquire becomes more meaningful and applicable. These findings support Ejin (2016), who demonstrated that PBL-based instructional tools can significantly enhance student activity while developing both conceptual mastery and critical thinking skills.

Meanwhile, the GI model also has a positive impact, although not as strong as PBL. GI is a cooperative learning model that emphasizes group investigation of specific topics chosen by students based on their interests. This process involves topic identification, group assignments, independent investigation, data collection, report preparation, and presentation of learning outcomes. Through these stages, students theoretically can develop critical thinking, communication, and collaboration skills. GI has been proven to enhance students' critical thinking skills across various educational levels. For example, the study by Supriyanto & Mawardi (2020), conducted on elementary school students showed a significant improvement after the implementation of GI. Furthermore, applying GI to the topic of the classification of living things in junior high school students drastically increased their critical thinking scores (Nadiya et al., 2016; Naili, 2016). The implementation of GI with supporting media such as Plickers has even been combined to strengthen its positive effect on critical thinking (Setiyani et al., 2019). Moreover, the success of GI is influenced by moderating variables such as students' learning styles (Iskandar et al., 2023).

Conventional learning, on the other hand, showed the lowest achievement in critical thinking skills among the three models. This can be explained by the characteristics of conventional learning, which is teacher-centered, one-way, and emphasizes direct information delivery. In such a situation, students tend to be passive recipients and are less engaged in higher-order cognitive processes. Therefore, it is understandable that conventional learning produces lower critical thinking outcomes compared to active learning models such as PBL and GI.

Regarding learning motivation, the study showed a similar pattern. The corrected model value of 0.97 indicates that the learning model has a significant effect on students' learning motivation. Once again, PBL emerged as the model with the greatest impact. The characteristics of PBL, which place students at the center of learning, provide challenges through real-world problem-solving, and involve independent investigation, have been shown to enhance students' interest and curiosity. PBL successfully increased students' learning motivation. This was evident from the improvement in motivation scores from the pre-cycle to the second cycle (Kurniawan et al., 2022). The implementation of PBL in science learning also significantly enhanced students' motivation based on questionnaire data and classroom observations (Fitri et al., 2024).

The GI model also enhances learning motivation, although not as much as PBL. In GI, students are given the freedom to choose topics and conduct group investigations, which makes them feel responsible for the learning process. This condition fosters a sense of ownership and increases intrinsic motivation. GI can enhance motivation through collaborative and investigative activities. However, differences in students' abilities to work independently and manage group dynamics result in learning motivation in the GI class being lower than that achieved by students in the PBL class (Budiani et al., 2014).

In contrast, conventional learning produced the lowest learning motivation. Students who are not actively engaged tend to become quickly bored, lack curiosity, and have difficulty concentrating because learning does not present meaningful challenges. The absence of interaction, discussion, and investigative activities limits the development of students' intrinsic motivation, causing them to participate in learning without enthusiasm.

Overall, the results of this study indicate that both PBL and GI are effective learning models for enhancing students' critical thinking skills and learning motivation in biology. However, PBL has a stronger effect than GI because its structured approach systematically guides students to think critically and solve real-world problems. Both models are far more effective than conventional learning, which provides limited opportunities for students to develop higher-order cognitive processes and intrinsic motivation.

Conclusion

The Group Investigation (GI) learning model has been shown to influence students' critical thinking skills and learning motivation on the topic of growth and development of living organisms among Grade XI Science students at SMA Negeri 1 Muara Wahau. Likewise, the Problem-Based Learning (PBL) model affects students' critical thinking skills and motivation within the same subject and grade level. When comparing the effectiveness of the two models, PBL demonstrates a stronger positive impact on students' learning motivation and is significantly more effective in enhancing critical thinking skills than the Group Investigation model.

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Conflicts of Interest

The authors declare no conflict of interest.

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