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Analysis of the Relationship Between Learning Motivation and Critical Thinking Skills using The Problem-based Learning Model

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Abstract: The learning of Basic Natural Sciences is still dominated by conventional discussion methods and one-way communication. The aim of this study is to fill a gap in the literature by examining the relationship between learning motivation and students' critical thinking skills in Basic Natural Sciences courses using the Problem-Based Learning (PBL) method. The study employs a correlational research method. Learning motivation is measured using the Attention, Relevance, Confidence, Satisfaction (ARCS) motivation questionnaire. Critical thinking skills are assessed through a test with indicators such as evaluating evidence, analyzing arguments, understanding implications and consequences, developing sound arguments, and understanding causation. Data analysis used in this research includes correlation analysis and regression analysis. The research results indicate a relationship between learning motivation and critical thinking skills. The correlation coefficient (r) value between learning motivation and critical thinking skills is 0.823, indicating a strong/high correlation. The relationship between learning motivation and critical thinking skills is positive. The coefficient of determination (r^2) is 0.677 (67.7%), which means that 67.7% of the variability in critical thinking skills can be explained by learning motivation. The regression significance value confirms that the regression line equation can be used for predictions. The regression line equation for the relationship between learning motivation and critical thinking skills within the PBL model is $\hat{Y} = 24.258 + 0.746X$.

Keywords: Learning Motivation, Critical Thinking Skills, Problem Based Learning, Basic Science.

Introduction

Basic Sciences is a foundational course in higher education designed to provide students with insights into the fundamental concepts of natural sciences and their applications in life. This course covers discussions on the universe, the Earth, biodiversity, ecosystems, natural resources, and the interrelationship between science, technology, and society. Basic Sciences also serves to develop students' critical, systemic, and scientific thinking skills while fostering environmental awareness and promoting sustainable technological development (Sodiq, 2017).

In the scope of physics, students will study the laws of motion, energy, forces, and electrical and magnetic phenomena, which are foundational for understanding many natural events. In the field of chemistry, topics include atomic structure, properties of substances, chemical reactions, and other chemical processes that are essential for understanding the materials around us. Meanwhile, in biology, the focus is on cells as the unit of life, ecology, environmental conservation, and human organ systems that support life sustainability.

In addition to the three main fields mentioned, this course often includes other branches of science,

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such as geology, which studies the structure and processes of Earth's formation, and astronomy, which explores the universe. Not only does it provide scientific information and facts, but it also equips students with skills in scientific methods, including the ability to conduct observations and analyze data. This approach provides a solid foundation for understanding advanced scientific concepts and their applications in technology and everyday life.

However, Basic Sciences learning is still dominated by conventional discussion methods and one-way delivery using media such as PowerPoint. These discussions are primarily focused on transferring information about the concepts being taught without considering students' learning motivation during the process. The material often involves understanding complex concepts and abstract thinking, making it crucial to empower students' critical thinking skills in learning Basic Sciences.

The abilities of students, including motivation and critical thinking skills, are interrelated. One of the factors determining the strength of this relationship is the learning model used when studying the material, such as the Problem-Based Learning (PBL) model.

Problem-Based Learning (PBL) is an approach increasingly utilized in higher education to encourage active student engagement and enhance critical thinking skills. This approach places students in real-life situations that require analysis, problem-solving, and decision-making based on a deep understanding of concepts (Freeman et al., 2018). In the context of Basic Natural Science courses, critical thinking skills are crucial as these courses demand students to understand and analyze natural phenomena scientifically.

Learning motivation is one of the key factors influencing students' success in their studies. Students with high motivation tend to be more actively engaged in the learning process, demonstrate greater curiosity, and delve deeper into knowledge, ultimately supporting the development of their critical thinking skills (Deci & Ryan, 2017; Huber & Kuncel, 2020).

However, research examining the relationship between students' learning motivation and critical thinking skills in the context of case-based learning in Basic Natural Science courses remains limited. Therefore, this study aims to explore the relationship between learning motivation and students' critical thinking skills, with the hope of providing new insights to enhance the quality of higher education learning.

Problem-Based Learning (PBL) is an innovative approach designed to improve students' critical thinking skills through the analysis of real-world cases (Anazifa & Djukri, 2020). In the context of higher education, particularly in Basic Natural Science courses, critical thinking skills are essential because students are expected to comprehend, analyze, and evaluate natural phenomena logically and scientifically.

This learning approach provides students with opportunities to engage with complex real-world situations, stimulating their abilities to solve problems, make decisions, and formulate solutions based on the knowledge they have acquired (Ihsani et al., 2020).

Learning motivation, both intrinsic and extrinsic, serves as a key driver in enhancing student engagement in learning. Highly motivated students tend to be more active in discussions, demonstrate deep curiosity, and maintain focus on learning tasks (Lovens et al., 2019; Zimmerman, 2020). Conversely, a lack of motivation can hinder active student engagement, thereby reducing the effectiveness of case-based learning. This indicates that learning motivation not only contributes to academic outcomes but also directly influences the development of critical thinking skills (Liu et al., 2019).

Learning motivation and critical thinking skills are crucial elements for the success of the learning process, particularly in Basic Natural Science courses. Learning motivation, which encompasses both internal and external drives, plays a pivotal role in enhancing students' activeness, analytical abilities, and awareness of the material being studied. Highly motivated students are more likely to actively participate in learning, seek solutions to problems, and achieve better learning outcomes.

Nevertheless, empirical research on the relationship between students' learning motivation and critical thinking skills in case-based learning, particularly in the Basic Natural Sciences course, remains limited. Previous studies have primarily focused on evaluating the general effectiveness of teaching methods without considering internal student factors, such as learning motivation, which can influence learning outcomes. In fact, such research is crucial to providing a more comprehensive understanding of how learning motivation can be leveraged as a key supporting factor in enhancing students' critical thinking skills.

Moreover, case-based learning facilitates the integration of various cognitive skills, including analysis, synthesis, and evaluation, which are essential components of critical thinking. Throughout the process, students are encouraged to explore diverse perspectives, identify core issues, and develop solutions supported by logical arguments and relevant data.

Thus, this study aims to address the gap in the literature by examining the relationship between learning motivation and students' critical thinking skills

in the Basic Natural Sciences course employing a problem-based learning approach. The findings of this research are expected to make a significant contribution to the development of more effective teaching strategies in higher education, particularly in fostering 21st-century skills development.

Method

The study employs a correlational research method. Correlational research is used to describe the relationships between variables (Cresswell & Cresswell, 2017; Coe, et al., 2021; Adams & McGuire, 2022; Leavy, 2022; Johnson & Cristensen, 2024; Privitera, 2024). The relationship examined in this study focuses on the connection between learning motivation and critical thinking skills in learning activities using the Problem-Based Learning (PBL) model.

The sample in this research consists of students enrolled in the Basic Natural Sciences (IKD) course. Learning motivation is measured using the ARCS (Attention, Relevance, Confidence, Satisfaction) motivation questionnaire (Keller & Suzuki, 1990). Critical thinking skills are assessed through a essay test with indicators such as evaluating evidence, analyzing arguments, understanding implications and consequences, developing sound arguments, and understanding causation (Braun et al., 2020).

The data analysis methods used in this study include correlation and regression analyses. Correlation analysis employs the Pearson Product-Moment method to determine the strength and direction of the relationships between variables (Miles & Shevlin, 2000; Sedgwick, 2012; Puth et al., 2014). The strength of the relationship is expressed as the correlation coefficient (r), which is calculated using the Pearson Product-Moment formula as follows:

$$r = \frac{n\sum x_i y_i - \sum x_i \sum y_i}{\sqrt{\{n\sum x_i^2 - (\sum x_i)^2\}\ \{n\sum y_i^2 - (\sum y_i)^2\}}}$$

The direction of the relationship describes whether the relationship between two variables is positive, negative, or there is no relationship at all. Correlation measures the extent to which a change in one variable is followed by a change in another variable, and the direction of this relationship is determined by the sign of the correlation coefficient (r). To determine the contribution of the independent variable to the dependent variable, the coefficient of determination is then calculated. The coefficient of determination (r^2) is calculated by squaring the correlation coefficient (r) and then multiplying by 100%. Regression analysis is used to make predictions using the predictor variable (learning motivation) and the response variable (critical thinking skills) (Pandey, 2020; Montgomery, et al., 2021; Arkes, 2023).

To determine the regression coefficient and the regression line equation, a regression analysis is performed using simple linear regression. Regression analysis is a statistical technique used to investigate and model the relationship between variables (Pandey, 2020; Arkes, 2023; James, et al., 2023). Since it only uses one predictor variable and one response variable, the regression equation used is:

$$\hat{Y} = a + bX$$

Before being analyzed using simple linear regression analysis, the data were first analyzed for normal distribution and linear relationship patterns as part of the classical assumption tests for simple linear regression analysis. The normality test of the data was performed using the One-sample Kolmogorov-Smirnov test (Razali & Wah, 2011). The One-sample Kolmogorov-Smirnov normality test examines how well the research data distribution fits a normal curve when the sample size is greater than 50 (González-Estrada & Cosmes, 2019; Khatun, 2021; Demir, 2022). The linearity test was conducted to determine the relationship pattern between learning motivation and critical thinking skills. One linearity test that can be used is the F-test (Montgomery, et.al, 2021; Kusuma & Nurmawanti, 2023).

Result and Discussion

The data obtained from the research consists of scores for learning motivation and critical thinking skills. The first step is to conduct classical assumption tests to ensure that hypothesis testing using Pearson correlation and simple linear regression can proceed. The first assumption test conducted is the normality test using the One-sample Kolmogorov-Smirnov test. A summary of the normality test results can be seen in Table 1 below.

Table 1. Summary of the Normality Test for Learning Motivation and Critical Thinking Skills Data

Tests of Normality				
Variable		Kolmogorov-Smirnov[a]		
		Statistic	df	Sig.
Score	Learning Motivation	.096	76	.081
	Critical Thinking Skills	.101	76	.053

Based on the normality test using the One-sample Kolmogorov-Smirnov test in Table 1, it is found that the significance value for the learning motivation data is 0.081 > 0.050, so it can be concluded that the learning motivation data is normally distributed. The significance value for critical thinking skills data is 0.053 > 0.050, so it can be concluded that the critical thinking skills data is normally distributed. After the normality test is conducted and the data from the two variables are normally distributed, the next step is the linearity test. The summary results of the linearity test for the data using the F test can be seen in Table 2 below.

Table 2. Summary of the Data Linearity Test for Learning Motivation and Critical Thinking Skills Data

ANOVA Table

			Sum of Squares	df	Mean Square	F	Sig.
Critical_Thinking_Skills * Learning Motivation	Between Groups	(Combined)	3485.722	22	158.442	7.913	.000
		Linearity	3078.793	1	3078.793	153.762	.000
		Deviation from Linearity	406.929	21	19.378	.968	.514
	Within Groups		1061.225	53	20.023		
	Total		4546.947	75			

Based on the results of the linearity test, it is known that the significance value of the linearity of learning motivation data and critical thinking skills is 0.00 < 0.05, so it can be concluded that the relationship pattern between of learning motivation data and critical thinking skills has a linear relationship. The linear relationship pattern can also be seen from the significance value of deviation from linearity. If the significance value of deviation from linearity is greater than the significance level, then the relationship pattern between two variables is said to be linear. Based on the results of the analysis, it is known that the significance value of deviation from linearity is 0.514 > 0.05, so it can be concluded that the pattern of the relationship between of learning motivation data and critical thinking skills has a linear relationship. The pattern of the relationship between of learning motivation data and critical thinking skills based on scatterplot analysis can be seen in Figure 1 below,

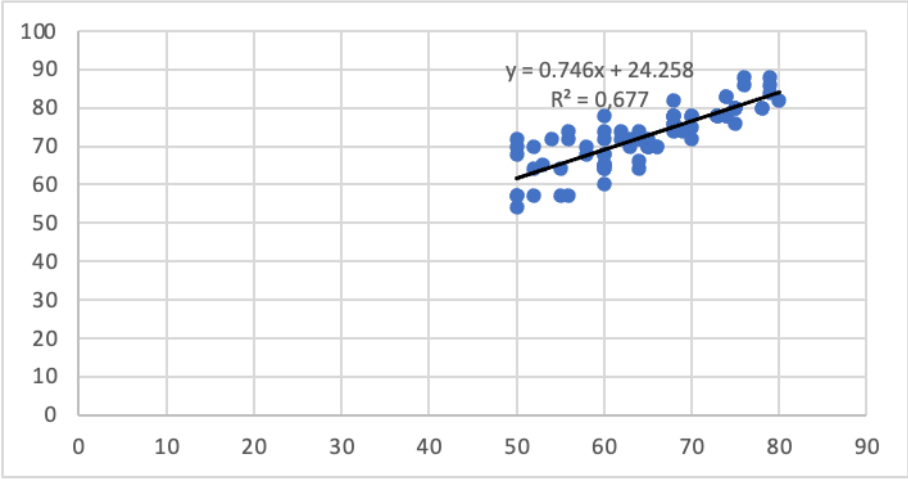

Figure 1. The scatterplot of the relationship between of learning motivation data and critical thinking skills

Based on Figure 1, the relationship between learning motivation data and critical thinking skills forms a linear positive relationship. The next results explain the regression coefficient values, which can be seen in Table 3.

Tabel 3. Summary of the Regression Coefficient Analysis.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3078.793	1	3078.793	155.182	.000[b]
	Residual	1468.154	74	19.840		
	Total	4546.947	75			

Based on the results of the analysis in Table 3, it can be seen that the regression significance value is 0.00 < 0.05 so, H_0 states that there is no relationship between learning motivation data and critical thinking skills of students using the *Problem Base Learning* (PBL) model was rejected, and Ha, who stated that there was a relationship between learning motivation data and critical thinking skills using the *Problem Based Learning* (PBL) model, was accepted. This regression significance value is also used to determine whether the regression line equation can be used for prediction or not. If the regression significance value is < the specified significance level, then the regression line equation can be used for prediction. Based on the analysis results, the regression significance value is 0.00 < 0.05, so it can also be concluded that the regression line equation can be used for prediction. The correlation coefficient value (r), which explains the close relationship between learning motivation data and critical thinking skills, and the coefficient of determination (r^2), which explains the magnitude of the influence of predictor variables on response variables, can be seen in Table 4.

Table 4. Correlation Coefficient and Determination Coefficient Values of Learning Motivation and Critical Thinking Skills

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.823[a]	.677	.673	4.45420

Based on Table 4, the correlation coefficient (r) value of learning motivation data and critical thinking skills is 0.823 (good/high). The direction of the relationship between learning motivation data and critical thinking skills is a positive. The coefficient of determination (r^2) is 0.677 (67,7%), so it can be explained that the variability in critical thinking skills is determined by 67.7% of learning motivation.

Tabel 5. Regression line equation for the relationship between between learning motivation and critical thinking skills.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	24.258	3.908		6.207	.000
	Learning Motivation	.746	.060	.823	12.457	.000

Based on Table 5, the intercept of the regression line equation is 24.256. The slope value (slope of the line) is 0.746. This slope value means that for every 1 increase in the learning motivation variable, the value of the critical thinking skills variable will increase by 24.258. The regression line equation for the relationship between learning motivation and critical thinking skills using the Problem Based Learning (PBL) model is $\hat{Y} = 24.258 + 0.746X$.

Based on the research results, it is known that there is a significant relationship between learning motivation and students' critical thinking skills in learning using the Problem-Based Learning (PBL) model, as indicated by a correlation coefficient of 0.823. This correlation coefficient falls within the high correlation interval, showing a strong positive relationship between the two variables. This means that when students' learning motivation increases, their critical thinking skills tend to improve as well.

Learning motivation, which includes internal drive to achieve academic goals, curiosity, and willingness to face challenges, is a key factor in encouraging students to think critically (Purwanto & Widodo, 2021; Setiawan & Kusuma, 2022). Critical thinking skills involve the ability to analyze problems in depth, evaluate evidence, and generate logical and relevant solutions (Rahmawati & Subekti, 2023). High learning motivation often triggers students to be more actively engaged in the learning process, seek additional information, and develop better analytical abilities (Sari & Pratama, 2019; Hasanah & Fadilah, 2020).

Recent research has also shown that motivated students tend to be more proactive in exploring complex issues, questioning assumptions, and making data-driven decisions. Therefore, learning strategies designed to enhance students' learning motivation, such as problem-based learning, can be an effective way to improve critical thinking skills, which are crucial in today's work environment and global society (Sari & Pratama, 2019).

The relationship between students' learning motivation and critical thinking skills in the Basic Natural Science course with the Problem-Based Learning (PBL) approach shows significant dynamics. High learning motivation plays a key role in encouraging students to actively engage in exploration and problem-solving, which is the core of the PBL method (Nurfathurrahmah, et al., 2019). On the other hand, students' critical thinking skills tend to improve because this method requires them to analyze problems, evaluate data, and develop logical solutions (Freeman, et al., 2018; Huber & Kuncel, 2020; Ihsani, et al., 2020). Several studies show that PBL is effective in enhancing critical thinking skills because this model is oriented toward contextual learning relevant to real-life situations (Nurfathurrahmah, et al., 2019; Ihsani, et al., 2020; Maharani & Sukardi, 2022).

Moreover, PBL provides opportunities for students to work collaboratively, engage in self-directed learning, and participate in discussions that promote in-depth analysis (Roviati & Widodo, 2019). High learning motivation in this context helps students persevere in facing challenges and motivates them to achieve optimal learning outcomes (Mustaghfirin, 2020).

The ARCS motivation model focuses on four main elements: 1) Attention, which draws students' focus through engaging and relevant learning materials connected to their experiences, fostering the initial interest crucial for critical analysis; 2) Relevance, linking the material to real-world contexts, helping students see the relevance of learning to their daily lives, thereby encouraging reflective thinking skills; 3) Confidence, boosting students' self-confidence by providing gradual challenges, motivating them to argue and solve problems logically; 4) Satisfaction, ensuring fulfillment through rewards and positive feedback, reinforcing students' desire to develop deep thinking skills (Deci & Ryan, 2017; Ramadani & Sulisworo, 2022; Lovens et al., 2019; Mulyana et al., 2020).

Other studies also reveal that attention stimulates students' curiosity and focus, encouraging them to explore information more deeply. Relevance ensures that learning feels meaningful and connected to students' experiences or goals, motivating them to analyze and evaluate information reflectively. Confidence builds students' belief in their ability to solve problems, which is critical for effective critical thinking. Satisfaction guarantees that learning outcomes are valued, promoting the application of critical thinking skills in real-world situations (e.g., decision-making or solving complex problems) (Lie & Keller, 2018; Zubaidah, 2017; Adip, 2021; Facione, 2021; Ma & Lee, 2021).

Empowering learning motivation through the Problem-Based Learning (PBL) model is an effective approach to enhancing student engagement in learning (Wijnia et al., 2024). PBL encourages students to solve real-world problems, integrating learning experiences with daily life (Yu & Zin, 2023). This process helps students develop critical, creative, and collaborative thinking skills. In PBL, students are positioned as active participants in learning, providing intrinsic motivation as they feel a sense of control over their learning process (Lovens et al., 2022; Rivas, 2022).

The implementation of problem-based learning strategies, such as PBL, demonstrates that motivation can be integrated to develop critical thinking skills. In this model, students are encouraged to identify real problems, organize ideas, conduct research, and present solutions. These activities train students to think systematically and critically, fostering confidence in solving complex problems (Lovens et al., 2022; Rivas, 2022; Al-Bahadli et al., 2023).

According to recent studies, PBL has also been proven to increase students' interest in learning by providing an interactive environment relevant to their contexts. Moreover, this model motivates students to explore information more deeply and maintain long-term learning (Yu & Zin, 2023; Loyens et al., 2019).

In practice, teachers act as facilitators, providing necessary guidance and ensuring learning objectives are met without compromising students' autonomy in the learning process. Therefore, PBL is not just a teaching method but a strategy that empowers students to become more enthusiastic and motivated in exploring new knowledge (Anazifa & Djukri, 2020).

The strong correlation between learning motivation and critical thinking skills reflects the interconnectedness of these aspects in supporting the learning process (Saputra et al., 2020). Learning motivation, encompassing internal and external drives, is a vital foundation for fostering enthusiasm and commitment to acquiring and understanding new information (Julia & Sumaryoto, 2024). With high motivation, students are more driven to actively engage in the learning process, ask questions, and analyze and evaluate learning materials, which are essential elements of critical thinking skills (Julia & Sumaryoto, 2024).

Research shows that learning motivation acts as a driving force that helps students face challenges in understanding and solving problems (Sulistiarini, et al., 2020; Wahyuni, et al., 2021). This happens because motivation encourages students not only to passively receive information but also to seek, validate, and critically evaluate it. Motivated students tend to be more independent, brave in expressing opinions, and highly curious, all of which support the development of critical thinking skills (Sulistiarini, et al., 2020; Wahyuni, et al., 2021).

Motivation plays a significant role in encouraging students not just to passively accept information but also to actively search for, validate, and critically evaluate it (Chengjun & Mustakim, 2022). With motivation, students are more likely to be independent in learning, confident in expressing their opinions, and exhibit a high level of curiosity (Julia & Sumaryoto, 2024). These traits directly support the development of critical thinking skills, which are crucial in helping students understand and analyze problems deeply as well as make sound decisions. Strong motivation serves as a foundation for meaningful learning that is focused on building long-term competencies.

Motivation drives students to seek additional information from various sources, validate the accuracy of the information obtained, and critically evaluate it by comparing different perspectives (Cahyani, 2020; Nurfathurrahmah, 2021). Motivated students tend to exhibit learning independence, express opinions with logical arguments, and have a strong curiosity to explore topics in greater depth (Lie & Keller, 2018; Zubaidah, 2017; Adip, 2021). This enables them not only to understand material superficially but also to master it deeply through analytical and reflective approaches. Furthermore, strong motivation helps students develop essential skills such as problem-solving, creative thinking, and decision-making based on thoughtful considerations.

All these aspects contribute to the formation of critical thinking skills, which are essential for addressing real-world challenges and preparing students to become competent and adaptable individuals in various situations (Monica, 2023).

Motivation plays a vital role in fostering the development of students' critical thinking skills. It not only helps students become more proactive in seeking information but also enhances their ability to evaluate and analyze information independently (Lie & Keller, 2018; Sulistiarini, et al., 2020; Wahyuni, et al., 2021; Fascione, 2020). Motivated students are more actively engaged in learning, whether through discussions, explorations, or collaboration with peers. This active engagement helps them formulate and critically solve problems (Cahyani, 2020; Nurfathurrahmah, 2021).

Conclusion

The research results show that there is a relationship between learning motivation and critical thinking skills using the Problem Based Learning (PBL) model. The correlation coefficient (r) value of learning motivation data and critical thinking skills is 0.823 (good/high). The direction of the relationship between learning motivation data and critical thinking skills is a positive. The coefficient of determination (r^2) is 0.677 (67,7%), so it can be explained that the variability in critical thinking skills is determined by 67.7% of learning motivation. The direction of the relationship between learning motivation data and critical thinking skills is a positive relationship. The regression significance value proves that the regression

line equation can be used for predictions. The regression line equation for the relationship between learning motivation data and critical thinking skills the Problem Based Learning (PBL) model is $\hat{Y} = 24.258 + 0.746X$.

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