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The Influence of Learning Models and Physics Learning Motivation on Students' Critical Thinking Skills

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Abstract: This research is an experimental study with a 2×2 factorial design, examining the interaction between learning models and physics learning motivation on students' critical thinking skills, both overall and in terms of high and low levels of learning motivation. In addition, this study also aims to test the interaction between learning models and physics learning motivation on critical thinking skills. The study population consisted of all grade XI students at Madrasah Aliyah Allu Jeneponto in the 2024/2025 Academic Year. The research sample consisted of 64 students, selected through a cluster random sampling technique with a lottery method to determine which classes would serve as the experimental and control groups. To minimize disruption to the ongoing learning process, randomization was conducted at the class level, rather than the individual level. Based on the lottery results, it was determined that class XI.1 was designated as the experimental class, taught using the guided inquiry learning model. In contrast, class XI.3 was designated as the control class, taught using the conventional learning model. Each class consisted of 32 students. Data analysis employed descriptive and inferential statistics, including a two-way ANOVA test with a significance level of 5%. The results showed that the experimental group had an average critical thinking ability 12.81 points higher, with a standard deviation of 2.16, compared to the control group, which had an average of 11.09 points, with a standard deviation of 2.13. Inferential analysis confirmed a significant difference in students' overall critical thinking ability between the two learning models, both in the high-motivation and low-motivation groups. However, no influence was found between the learning model and physics learning motivation on the critical thinking ability of students at Madrasah Aliyah Allu. This shows that the influence of the guided inquiry learning model on critical thinking ability is consistent at all levels of learning motivation. Thus, the application of the guided inquiry learning model has been proven effective in improving students' critical thinking abilities, and learning motivation also plays an important role as an independent factor that supports the improvement of this ability.

Keywords: guided inquiry, learning motivation, critical thinking skills.

▪ INTRODUCTION

Quality human resources capable of facing the challenges of the 21st century depend heavily on education. As science and technology advance, students must possess not only factual knowledge but also higher-order thinking skills. Within the 21st-century competency framework, these skills are organized into the 6Cs: Character, Citizenship, Critical Thinking, Creativity, Collaboration, and Communication. Students need these six skills to think creatively, adapt to change, and compete effectively in a global context (Kain et al., 2024; Kocak et al., 2021).

Critical thinking is one of the six most important 21st-century skills. However, research has shown that students in Indonesia still lack critical thinking skills. Results from the Program for International Student Assessment (PISA) and the Trends in International Mathematics and Science Study (TIMSS), released by the OECD in 2023, show that Indonesia ranks low in science, reading, and mathematics literacy, which are closely correlated with higher-order thinking skills, among the 80 countries registered in

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PISA 2022. Indonesia ranked 69th. Critical thinking skills are essential for adapting to the global challenges and complexities of the 21st century. However, the findings suggest that physics education in secondary schools places more emphasis on mastering concepts than on developing higher-order thinking skills (Akpur, 2025).

According to Facione (2011), critical thinking is defined in terms of interpretation, analysis, evaluation, inference, explanation, and self-regulation. With such skills in place, students can do more than simply passively absorb information; they can devise alternative solutions, evaluate arguments, and arrive at reasoned decisions (Dwyer et al., 2014). Critical thinking is essential for students learning physics, as it enables them to gain a deep understanding of concepts and solve scientific phenomena, or apply these concepts in daily life (Maknun, 2020). Critical thinking is also important for students' personal development. Learners who think critically will reason more independently, be more receptive to accepting new ideas, and solve problems effectively in terms of the scientific as well as personal life (Kaynar & Kurnaz, 2024). According to Paulsen & Kolstø (2022), it is unrealistic to expect any one person to be able to assimilate all new knowledge and information. However, they can learn to better identify relevant information, assess its credibility, and draw reasonable conclusions about what should be believed or done. Some didactic models of teaching could be used to train critical thinking skills in order to teach critical thinking. Multiple learning models can be employed to enhance critical thinking skills, such as inquiry-based learning models, project-based mastery models, and enterprise-based learning models (Anggraeni et al., 2023). One of the suggested theoretical approaches to addressing low critical thinking skills among students is the use of the guided inquiry learning model. This model does not enable students to participate actively in the investigation process, such as posing problems, designing experiments, analyzing data, and drawing conclusions (Wang et al., 2015). Inquiry-based learning can enhance critical thinking skills, particularly when accompanied by reflection on the scientific process (Prayogi et al., 2025). Nisa, Koestiari, Habibbulloh, & Jatmiko (2018) also demonstrated that the guided inquiry model has a significant effect on increasing high school students' critical thinking skills in physics learning. Another systematic review study, conducted by Anggraeni, Prahani, Suprapto, Shofiyah & Jatmiko (2023), suggested that the inquiry-based teaching approach would be a common strategy to foster ITCC skills across different science education settings.

This model positions the teacher as a guide who provides minimal direction, allowing students to engage in an active construction of knowledge through multiple scientific inquiry tasks. This model is based on promoting student activity to undertake scientific investigations covering the following systematic processes: problem orientation, hypothesis forming, experimental designing, data collection, and result analysis & drawing a conclusion. Indicators of critical thinking can apply to stages in guided inquiry. For example, the hypothesis formulation stage promotes analysis and inference, while the conclusion drawing and presenting stages promote evaluation, explanation, and self-regulation (Facione, 2011; Maknun, 2020).

However, the implementation of the guided inquiry model is not only concerning the learning strategy but also with internal student factors such as learning motivation. Motivation is a key factor in effective physics learning. motivated students are more likely to attain higher academic performance. They become more invested in the subject, which leads to better study habits and better test-taking skills (Rizki et al., 2025). Physics motivation can be classified into two categories: intrinsic and extrinsic. Inherent motivation is the driving force that sparks students' interest in learning, fueled by curiosity and a passion for the subject matter. Technically, intrinsic motivation refers to behavior that is performed "for its own sake" or out of interest and enjoyment (Ryan & Deci, 2020). Extrinsic motivation refers to the external rewards, such as grades, treats, or recognition (Bøe et al., 2025; Lin et al., 2003). Meulenbroeks, van Rijn & Reijerkerk (2024) found that inquiry-based learning has a positive effect on enhancing students' intrinsic motivation towards science, which in turn leads to an increase in critical thinking abilities. That is to say, implementing inquiry-based learning strategies with high learning motivation plays an important role in developing critical, reflective, and self-regulated students. It is well-known that when inquiry-based teaching is used in a supportive learning environment, students' conceptual understanding and literacy in science improve, as do their motivation and skills to reason scientifically. High-motivation students are very likely to explore concepts, ask “what-if” questions, and persevere in solving problems. By contrast, low motivation is perceived to result in passive behaviour even if novel learning models are implemented (Dah et al, 2024).

However, in reality, physics learning in secondary schools in Indonesia, including at the Allu Bangkala Private Islamic Senior High School, is still dominated by conventional, teacher-centered models. Students tend to memorize formulas without understanding the concepts, and have difficulty interpreting graphs, analyzing relationships between variables, or drawing conclusions from experimental results. Learning outcome data in grade XI shows that only around 55% of students achieve the Minimum Completion Criteria, and interview results indicate low motivation to learn physics. This condition indicates the need for more innovative learning strategies to foster motivation and improve students' critical thinking skills.

Several previous studies have demonstrated the effectiveness of guided inquiry models in developing critical thinking skills (Anggraeni et al., 2023; Prayogi et al., 2025), but most were conducted outside the Indonesian context or focused on science subjects in general. Furthermore, research examining the influence of learning models on critical thinking rarely integrates learning motivation factors, despite both intrinsic and extrinsic motivation being shown to influence success in science learning (Bøe et al., 2025; Meulenbroeks et al., 2024). Studies on the interaction between guided inquiry learning models and learning motivation in relation to critical thinking skills in physics are still limited, especially at the high school level. Furthermore, observations at the Allu Bangkala Private Islamic Senior High School, which showed low achievement of minimum completion criteria and weak learning motivation, have never been empirically studied in relation to the application of guided inquiry learning models.

Thus, this study attempts to fill this gap by examining the influence of guided inquiry learning models and physics learning motivation (intrinsic and extrinsic) on students' critical thinking skills at Allu Private Islamic Senior High School, while also examining their interaction. This study aims to make theoretical and practical contributions to the development of effective physics learning strategies that enhance students' critical thinking skills. Based on the above problems, the following research questions can be formulated:

1. Overall, are critical thinking skills among students taught using the guided inquiry learning model higher than those taught using the conventional learning model?
2. Considering high learning motivation for physics, are critical thinking skills among students taught using the guided inquiry learning model higher than those taught using the conventional learning model?
3. Considering low learning motivation for physics, are critical thinking skills among students taught using the guided inquiry learning model higher than those taught using the conventional learning model?
4. Is there an influence between the learning model and the learning motivation on critical thinking skills among students at Madrasah Aliyah Allu Bangkala?

▪ METHOD

Participants

The population in this study consisted of all 11th-grade students at Madrasah Aliyah Swasta (Private Islamic High School) Allu in the 2024/2025 academic year. The sample was selected using cluster random sampling, a sampling technique that is based on existing groups or classes. Class selection was conducted randomly using a simple lottery method to determine which classes would serve as the experimental and control groups. To minimize disruption to the ongoing learning process, randomization was conducted at the class level, rather than at the individual level. Based on the lottery results, it was determined that class XI.1 was designated as the experimental class, taught using the guided inquiry learning model. In contrast, class XI.3 was designated as the control class, taught using the conventional learning model. Each class consisted of 32 students.

Grouping of students based on their learning motivation level was carried out using the median split approach, which divides students into two large groups based on the median value of their learning motivation score. This approach was chosen to obtain a more adequate and representative sample size in each motivation category. The grouping process was carried out stratified within each class, ensuring that the distribution of students with high and low motivation remained balanced between the experimental and control classes. The learning motivation scores in each class were sorted from highest to lowest. Then, 50% of the students with the highest scores were categorized as the high-motivation group, while 50% of the students with the lowest scores were categorized as the low-motivation group. Since each class had 32 students, each class produced 16 students with high motivation and 16 students with low motivation. Thus, four cells were obtained in the 2 × 2 factorial design, namely: (1) the experimental class with high motivation, (2) the experimental class with low motivation, (3) the control class with high motivation, and (4) the control class with low motivation. This approach enables a more balanced distribution of students in each group, allowing for a more valid and reliable analysis of the main influence and interaction between learning models (guided inquiry vs. conventional) and learning motivation (high vs. low) on critical thinking skills.

Table 1. Sample distribution based on learning motivation

Learning Motivation (B)	Learning Model (A)		Total
	Guided Inquiry (A_1)	Conventional (A_2)	
High (B_1)	$50\% \times 32 = 16$	$50\% \times 32 = 16$	32
Low (B_2)	$50\% \times 32 = 16$	$50\% \times 32 = 16$	32
Σ	**32**	**32**	**64**

Research Design and Procedures

This research employs a treatment-by-level experimental design with a 2 × 2 factorial structure. This research was conducted in the even semester of the 2024/2025 academic year. This research was conducted at Madrasah Aliyah Allu, located on Jl. Andi Hindi No. 01, Benteng, Bangkala District, Jeneponto Regency, South Sulawesi. The intervention consisted of six meetings, each lasting 2×45 minutes. The material discussed focused on Thermodynamics, including: The First and Second Laws of Thermodynamics, Heat and Energy Changes, Heat Transfer and Thermal Equilibrium, and Practical Applications in Daily Life and Simple Experiments.

In this study, the independent variable (Independent Variable) is divided into two classes, namely the experimental class and the control class. In the experimental class, the guided inquiry learning model was used, while in the control class, the conventional learning model was used. The dependent variable is the critical thinking ability of students, and the moderator variable is learning motivation, which is divided into two groups, namely, students with high learning motivation and students with low learning motivation. The research design is presented in Table 2.

Table 2. Factorial design 2 × 2

Learning Motivation (B)	**Learning Model (A)**	
	Guided Inquiry (A_1)	**Conventional (A_2)**
High (B_1)	A1B1	A2B1
Low (B_2)	A1B2	A2B2
Σ	A1B1 + A1B2	A2B1 + A2B2

Information:

A1 : Group of students was taught using the Guided Inquiry learning model.
A2 : Group of students was taught using the conventional learning model.
B1 : Group of students who have high learning motivation
B2 : Group of students who have low learning motivation
A1B1 : Group of students who learn using the Guided Inquiry learning model with high learning motivation
A1B2 : Group of students who learn using the Guided Inquiry learning model with low learning motivation
A2B1 : Group of students who learn using conventional learning models with high learning motivation
A2B2 : Group of students who learn using conventional learning models with low learning motivation

This research consisted of three main stages: preparation, implementation, and finalization. During the preparation stage, researchers conducted initial observations at Madrasah Aliyah Allu, Jeneponto, South Sulawesi, to obtain an overview of the physics learning conditions and determine the sample classes for the study. Next, learning materials were developed, consisting of a guided inquiry-based teaching module and student worksheets on thermodynamics. Instruments: The Motivation for Learning Questionnaire and the Critical Thinking Ability Test were used as research tools. The instruments were field-tested and subjected to face validation by experts, including assessment of content, relevance to the study's objective, level of difficulty, and item discrimination.

The actual testing phase involved testing, interventions, and data gathering. The operation aspect comprised empirical observations, learning interventions, and data collection. Following the determination of instrument feeling, students were classified into two groups based on their learning motivation: high-motivated and low-motivated. These groups were compared in the experimental class (guided inquiry model) and the control class (conventional model). Learning was then implemented according to the validated materials, with Class XI.1 serving as the experimental class and Class XI.3 as the control class.

The third stage focused on measuring outcomes and analyzing data. All the students completed a critical thinking skills test after the lesson to determine how the learning model and learning motivation influence learning achievement. The data from this research were analyzed to identify the differences in critical thinking skills between the experimental class and the control class, as well as between the learning model types and learning motivation. The results of this analysis served as the basis for compiling a report containing a discussion, conclusions, and implications of the research.

Instrument

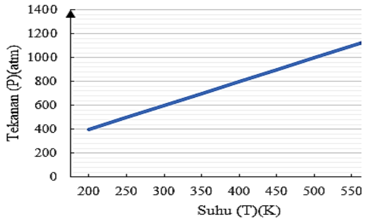
This study used two types of research instruments: a test instrument and a non-test instrument. Data on students' critical thinking skills were collected using a test instrument, while data on learning motivation were collected using a non-test instrument. The research instruments used in this study are as follows.

Critical Thinking Skills Instrument

The critical thinking skills test used in this study was a multiple-choice test. The questions used in the critical thinking skills test instrument were based on three critical thinking indicators: interpretation, analysis, and inference. These were selected from six aspects according to Facione (2011) because they are considered the most relevant and measurable in the context of high school physics learning. Interpretation is necessary for students to understand and interpret data, phenomena, or physics concepts, which is the first step in scientific critical thinking. Analysis emphasizes students' ability to solve problems, identify relationships between variables, and evaluate arguments, in line with experimental activities and conceptual discussions in physics. Meanwhile, inference trains students to draw conclusions or predictions based on experimental data and observations. The other three indicators: evaluation, explanation, and self-regulation, are more reflective and challenging to measure directly through multiple-choice tests. Therefore, focusing on these three indicators allows the research instrument to be more valid, measurable, and aligned with the research objective, which is to operationally assess students' critical thinking skills through physics learning activities. There are 5 (five) answer choices in the questions with the choice symbols A, B, C, D, and E, where each question item only has one correct answer choice. If the student answers correctly, they receive a score of 1 (one); if they answer incorrectly, they receive a score of 0 (zero).

Table 3. Critical thinking skills instrument grid

Critical Thinking Skills Aspect	Question Indicator	Question	Question Item Number	Number of Questions
Interpretation	Students can	1. The graph below shows the	1. 2. 3. 4.	8

<table>
<tr>
<td></td>
<td>interpret data presented in the form of graphs/tables.</td>
<td>relationship between pressure (P) and temperature (T) of an ideal gas with a constant volume.

The graph below illustrates the relationship between pressure (P) and temperature (T) of an ideal gas at constant volume. Based on the graph, the correct statement is...
A. The volume of the gas remains constant throughout the process.
B. The graph shows an isobaric process.
C. The internal energy of the gas remains constant throughout the process.
D. The graph shows that pressure is inversely proportional to temperature.
E. The graph depicts an isothermal process.</td>
<td>5. 6. 7. 8.</td>
<td></td>
</tr>
<tr>
<td>Analysis</td>
<td>Students can analyze an equation and determine the value of a variable based on the known values of other variables.</td>
<td>9. A car has an engine that operates at a high temperature of 800 K and a low temperature of 300 K. Based on the laws of thermodynamics, what is the maximum efficiency of this engine?
A. 37.5%
B. 45%
C. 50%
D. 62.5%
E. 75%</td>
<td>9. 10. 11. 12. 13. 14. 15.</td>
<td>7</td>
</tr>
<tr>
<td>Inference</td>
<td>Students can conclude data/ problems presented in the form of tables/graphs/ or pictures.</td>
<td>16. A gas experiences expansion at constant pressure, and changes in temperature and volume are presented in the following table:
<table><tr><th>Condition</th><th>Temperature (K)</th><th>Volume (L)</th></tr><tr><td>A</td><td>300</td><td>6</td></tr><tr><td>B</td><td>600</td><td>....</td></tr></table>
The correct conclusion regarding the volume of gas in state B is...</td>
<td>16. 17. 18. 19. 20. 21</td>
<td>6</td>
</tr>
</table>

	A. The volume remains constant because the pressure remains constant B. The volume becomes 9 L because the temperature doubles C. The volume becomes 12 L because the temperature doubles D. The volume becomes 18 L because the temperature doubles E. Cannot be determined because the mass of the gas is unknown		
Total Question Items		**21**	**21**

Learning Motivation Instrument

Learning motivation is the drive that arises from within the student (intrinsic) or from external factors (extrinsic) to engage in a learning activity. The indicators in the learning motivation instrument used in this study, as referenced by Uno (2016), are compiled into a questionnaire to measure the level of student learning motivation prior to the learning process or intervention. The questionnaire was developed based on several learning motivation indicators, including:

Table 4. Learning motivation instrument outline

Dimensions	**Indicator**	**Statement**		**Total**
		Positive	**Negative**	
Intrinsic Motivation	Having a passion and a desire to succeed	1. 2. 4. 5. 7. 8. 9	3 dan 6	9
	Having a drive and a need to learn	10. 11. 12. 13. 15. 16. 17	14	8
	Having hopes and aspirations for the future	18. 20. 21. 22. 23. 24	19	7
Extrinsic Motivation	Having an appreciation for learning	25. 26. 27. 28. 30. 31	29	7
	Having interesting learning activities	32. 33. 34. 36. 37	35	6
	Having a conducive learning environment	38. 39. 41. 42. 43	40	6
Total		**36**	**7**	**43**

The learning motivation instrument on the questionnaire sheet consists of positive questions (+) and negative questions (-) where the answer choice format is based on the Linkert model scale which consists of 5 (five) alternative answer choices: Strongly Agree (SA), Agree (A), Less Agree (LA), Disagree (DA), Strongly Disagree (SDA) each answer will be given a score of 5, 4, 3, 2, and 1 for positive statements, while for negative questions with answer choices: Strongly Agree (SA), Agree (A), Less Agree (LA), Disagree (DA), Strongly Disagree (SDA) each answer will be given a score of 1, 2, 3, 4, and 5.

Data Analysis

The data analysis in this study was divided into two parts: data analysis related to the instruments used in the study and analysis of data obtained during the study (descriptive and inferential). The research instruments, which used a learning motivation questionnaire and a critical thinking ability test, were first assessed for content validity, criterion validity, and reliability. Based on the results of the validity test involving three experts, all learning tools and research instruments were declared valid because Aiken's V index values were above 0.4, the minimum validity limit. The learning module obtained a V index of 0.830, the learning materials 0.826, the student worksheet 0.822, the learning motivation questionnaire 0.824, and the critical thinking ability test 0.811. All these values were in the range of ≥ 0.8, which is considered high validity. Therefore, it can be concluded that the developed research tools and instruments meet the criteria for validity and are suitable for use, proceeding to the trial phase.

Next, the validity of the critical thinking ability test items was calculated using point biserial correlation, resulting in 21 valid and nine invalid items from a total of 31 trial participants. Meanwhile, the validity of the learning motivation questionnaire items was assessed using product-moment correlation, and out of 50 statements, 43 were deemed valid and seven were deemed invalid. Reliability testing was then conducted after establishing item validity. The reliability of the critical thinking ability test instrument was analyzed using the Kuder-Richardson-20 (KR-20) formula, yielding a value of 0.841, which indicates that the instrument is reliable. The reliability of the learning motivation questionnaire was assessed using Cronbach's Alpha, yielding a value of 0.923, which exceeds the recommended threshold of 0.70, indicating that the questionnaire is reliable. Thus, both the learning device and research instrument used in this study were proven valid and reliable, making them suitable for use as measurement tools in the research.

After all instruments met the instrument testing requirements, they were administered to the research sample to obtain raw data for subsequent processing. The data were then analyzed using both descriptive and inferential statistics in SPSS version 29. Before conducting the two-way ANOVA test, a prerequisite analysis was performed, consisting of two stages in this study: a normality test and a test for homogeneity of variance. The normality test aims to determine whether the data studied comes from a normally distributed population. The normality test was conducted using the Lilliefors test. Meanwhile, the homogeneity test of variance was conducted to determine whether the two samples being compared have the same variance, indicating homogeneity of variance. The homogeneity test was conducted in this study using the Bartlett test. After the two-way ANOVA analysis was conducted and the hypothesis results obtained were H_0 rejected or H_1 accepted, a further ANOVA test was conducted as a follow-up to the analysis of variance. This further test aims to check the average of each pair of columns, pairs of rows, and pairs of cells. So it is known which parts have significant or insignificant averages. If the sample size for each group is the same (i.e., the number of cells is the same), the Tukey test can be used. Before conducting the Turkey test, we first conduct a t-test. The t-test was conducted to see if there were any differences in the scores of the experimental group and the control class.

▪ RESULT AND DISSCUSSION

Descriptive data analysis in this study describes students' critical thinking ability scores in physics, which are influenced by two factors: the first factor is the learning model, and the second factor is learning motivation. The results of the descriptive analysis obtained for each class are described as follows:

Descriptive Analysis

Results of Descriptive Analysis of Critical Thinking Ability

Descriptive analysis aims to describe the variation of data collected through a research instrument in the form of a test of students' critical thinking skills. The data to be analyzed include information on the implementation of learning with a guided inquiry learning model, learning motivation towards students' critical thinking skills during the learning process, and students' responses to the learning. Based on the results of the descriptive analysis of students' critical thinking skills in the experimental and control classes, data were obtained that showed differences in achievement in three indicators: interpretation, analysis, and inference. In the experimental class, the average scores for students' critical thinking skills were 42.9 for the interpretation indicator, 32.4 for analysis, and 24.7 for inference. Meanwhile, in the control class, the average scores were 41.0, 31.8, and 27.2, respectively. These results indicate that students in the experimental class had higher achievement in the two initial indicators, namely interpretation and analysis. In contrast, the control class showed a slight superiority in the inference indicator.

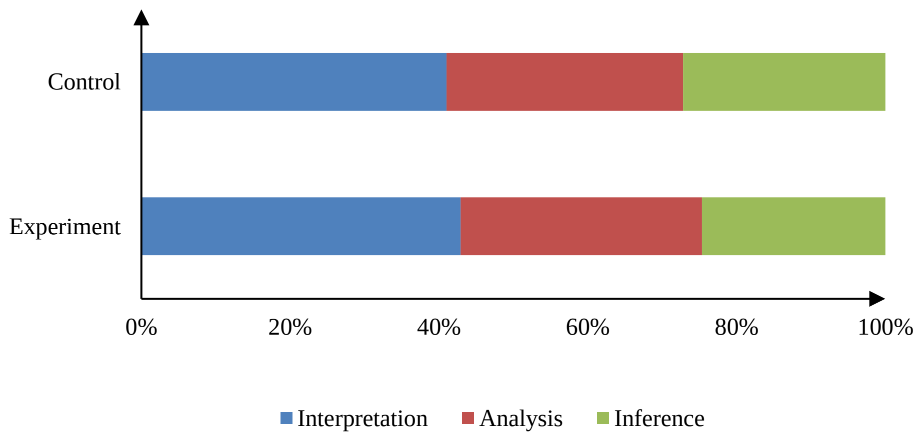


Figure 1. Critical thinking ability diagram based on indicators

As indicated in the figure above, critical thinking skills in interpretation had the highest ratio for the two groups; meanwhile, analysis and inference followed. For the experimental group, interpretation accounted for approximately 43%, analysis for 32%, and inference for 25% of the whole set of critical thinking skills. Count-wise, in the control class, the fall-out rates were 41%, 32%, and 27%, respectively. This pattern indicates that the experimental class had an advantage in the two initial indicators of critical thinking, indicating that the applied learning model was able to encourage students to more actively understand and analyze information logically.

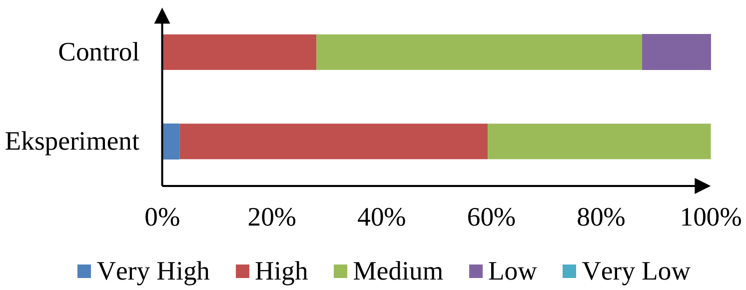


Figure 2. Distribution diagram of critical thinking ability categories in experimental and control classes

Furthermore, based on the distribution of critical thinking ability categories in Figure 2, it was found that in the experimental class, out of a total of 32 students, one student (3.1%) was in the very high category, 18 students (56.3%) were in the high category, and 13 students (40.6%) were in the medium category. No students were found in the low or very low categories. The diagram above shows that the majority of students in the experimental class were in the high category, accounting for more than half of the total number of students, while the remainder were in the medium category. The absence of students in the low or very low categories suggests that the learning experience in the experimental class had a positive impact on improving students' critical thinking skills overall.

Meanwhile, in the control class, also with 32 students, no students were found in the very high category. Nine students (28.1%) were in the high category, 19 students (59.4%) were in the medium category, and four students (12.5%) were in the low category. Based on the diagram above, it can be seen that the majority of students in the control class fall into the moderate category, with a small number falling into the high and low categories. The absence of students in the very high category indicates that the conventional learning approach used was less than optimal in fostering high-level critical thinking skills.

Overall, the results of this descriptive analysis indicate that the experimental class achieved better/higher levels of critical thinking skills than the control class. The most significant improvement was in the interpretation and analysis indicators, while the inference indicator still needs strengthening. The proportion of students in the high-ability category was also significantly greater in the experimental class than in the control class. Therefore, it can be concluded that the learning model used in the experimental class contributed positively to improving students' overall critical thinking skills. The learning process, which emphasized exploration, discussion, and concept discovery through teacher guidance, encouraged students to be more active, analytical, and reflective in understanding the material. Furthermore, this learning approach proved effective in creating a learning environment that stimulated higher-level thinking and fostered students' confidence in expressing ideas logically and argumentatively.

Results of Descriptive Analysis of Physics Learning Motivation

Based on the results of data analysis from the six learning motivation indicators, it was found that students in the experimental class, which was taught using the guided inquiry learning model, showed higher learning motivation compared to those in the control class, which used the conventional learning model. The following figure shows student learning motivation.

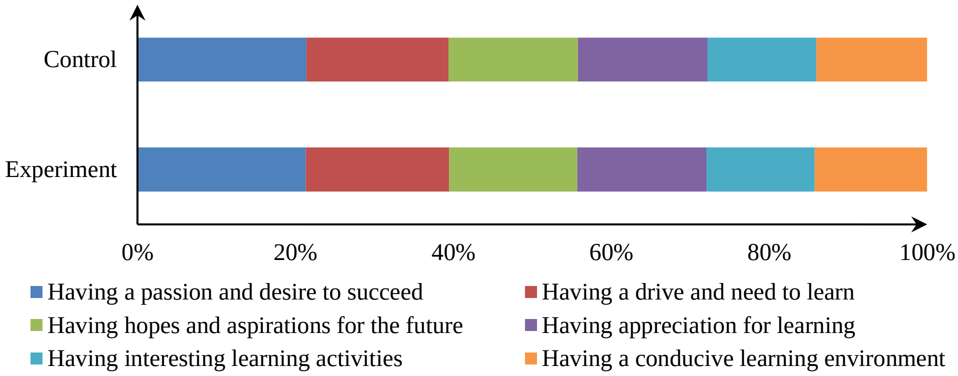


Figure 3. Learning motivation diagram of students in the experimental and control classes

On the passion and desire to succeed indicator, the experimental class achieved an average score of 36.5, while the control class achieved 35.9. This indicates that the implementation of the guided inquiry model fosters enthusiasm and a strong drive for success in students.

The motivation and need for learning indicator also showed a difference, with a score of 31.1 in the experimental class and 30.3 in the control class. Through the independent inquiry and exploration process characteristic of guided inquiry, students felt more motivated to actively fulfill their learning needs. Furthermore, on the hope and future aspirations indicator, the experimental class achieved a score of 27.8, slightly higher than the control class's score of 27.5. This suggests that the guided inquiry model enables students to connect learning activities with their long-term goals and personal aspirations. On the reward for learning indicator, the experimental class scored 28.1, while the control class scored 27.6. This reflects that active, discovery-based learning experiences provide stronger intrinsic rewards for students in the experimental class. For the indicator of engaging learning activities, the experimental class scored 23.5, while the control class scored 23.2. Experiment-based learning and collaborative discussions, as implemented in the guided inquiry model, have been shown to make learning activities more engaging and meaningful for students. Finally, for the indicator of a conducive learning environment, the experimental class scored 24.4, while the control class scored 23.6. This indicates that guided inquiry learning can create a more comfortable, open learning atmosphere and support collaboration among students.

Overall, the guided inquiry learning model increased student learning motivation across all indicators compared to the conventional model. Students became more active, had a stronger drive to learn, and showed greater interest in the learning process.

Inferential Analysis

Prerequisite Test

Before conducting the two-way ANOVA test, prerequisite analysis tests were performed, including normality tests and tests for homogeneity of variance. The normality test was conducted to ensure that the critical thinking ability data of students in the experimental and control classes were normally distributed. Based on the results of the Kolmogorov–Smirnov (KS) and Shapiro–Wilk (SW) normality tests, the data in the experimental class using the guided inquiry learning model showed a KS value of 0.12 (df = 18, p = 0.20) and SW = 0.96 (df = 18, p = 0.58). Meanwhile, the control class using the conventional learning model obtained a KS value of 0.15 (df = 18, p = 0.20) and SW = 0.96 (df = 18, p = 0.63). Since all p-values were higher than 0.05, it can be concluded that the critical thinking ability data in both groups were normally distributed. Thus, the normality assumption is met, so that the data is suitable for use in further parametric statistical analysis.

Next, a homogeneity of variance test was conducted to determine whether the two groups had the same variance. The test was conducted using the Bartlett test, and the analysis results showed that the χ^2 value was 0.04 with a p-value of 0.84 ($p > 0.05$). This indicates that the variance between the experimental class and the control class is homogeneous. By fulfilling the assumptions of normality and homogeneity, the data on students' critical thinking skills meet the requirements for further analysis using the two-way ANOVA test.

Hypothesis Testing

Next, a two-way ANOVA was used to test the hypothesis to determine the influence of the independent variable (learning model used) and learning motivation on the dependent variable (critical thinking skills). The hypothesis testing in this study aimed to determine whether there were differences in the influence of learning models and learning motivation on students' critical thinking skills and their interactions with these models.

Table 5. Basic statistical results of two-way ANOVA

Learning Motivation (B)	**Statistics**	**Learning Model (A)**		**∑B**
		Guided Inquiry (A1)	**Conventional (A2)**	
High (B1)	N	16	16	32
	$\sum Y$	219	195	414
	$\sum Y^2$	3071	2437	5508
	S	2.21	2.01	2.21
	S^2	4.90	4.03	4.90
	$\bar{Y}$	13.69	12.19	12.94
Low (B2)	N	16	16	32
	$\sum X$	191	160	351
	$\sum X^2$	2327	1642	3969
	S	1.77	1.67	1.96
	S^2	3.13	2.80	3.84
	$\bar{X}$	11.94	10.00	10.97
∑K	N_t	32	32	64
	$\sum X_t$	410	355	765
	$\sum X^2$	5398	4079	9477
	S	2.16	2.13	2.30
	S^2	4.67	4.54	5.28
	X_t	12.81	11.09	11.95

Hypothesis testing employs a two-way analysis of variance with an F-test at a significance level of α = 0.05. If the F-calculated value of the data obtained is greater than or equal to the F-table value, then H0 is rejected, as shown in Table 6.

Table 6. Summary of manual analysis of variance (ANOVA) test results

Source of Variance	Sum of Squares (SQ)	Degrees of Freedom (df)	Mean Square (SQ)	F_{count}	F_{table}	Test Decision
A	47.27	1	47.27	12.73	4.00	H_0 rejected
B	62.02	1	62.02	16.70	4.00	H_0 rejected
Interaction AB	0.77	1	0.77	0.21	4.00	H_0 accepted
In Cell	222.81	60	3.71	-	-	-
Total	332.86	63		-	-	-

Table 6 above presents several conclusions regarding the hypothesis, which can be explained in detail as follows.

Overall, the Critical Thinking Skills of Students Taught Using the Guided Inquiry Learning Model are Higher than Those of Students Taught Using the Conventional Learning Model

The results of the two-way analysis of variance showed that the calculated F_count= 12.73 > F_table= 4.00, with the decision H_0 being rejected. This indicates a significant difference in the critical thinking skills of students taught using the guided inquiry learning model compared to those taught using the conventional learning model.

Descriptively, the experimental class using the guided inquiry model achieved higher average scores than the control class on almost all critical thinking indicators, namely interpretation (42.9 vs. 41.0), analysis (32.4 vs. 31.8), and inference (24.7 vs. 27.2). This difference indicates that the guided inquiry model is effective in developing students' critical thinking skills. This is because the inquiry approach requires students to ask questions, formulate hypotheses, collect data, and draw conclusions independently with teacher guidance. This process stimulates higher-order thinking skills (HOTS), which include interpretation, analysis, and inference (Facione, 2011).

Furthermore, active interaction between teachers and students in scientific inquiry activities improves conceptual understanding and logical reasoning. This finding aligns with research by Sari et al. (2023), which found that guided inquiry significantly improves critical thinking skills compared to direct learning. Similarly, Arends (2021) stated that guided inquiry provides ample opportunities for students to develop analytical skills through discovery-based learning experiences.

The study's findings also align with various findings showing that guided inquiry learning models can improve students' critical thinking skills in physics. For example, research conducted by Prayogi et al (2025) found that the implementation of guided inquiry significantly improved critical thinking skills. An ANCOVA analysis showed a significant difference between the experimental and control classes, with the group taught through guided inquiry achieving higher average scores than those taught conventionally.

This finding is consistent with research by Harjilah et al. (2019), which revealed that students taught using guided inquiry achieved significantly higher critical thinking scores compared to the control group. The statistical test result yielded a significant t-value ($p = 0.94$), indicating that this model has a significant effect on students' critical thinking abilities. Similarly, de Jong et al. (2024) report an experimental study that resulted in higher scores of critical thinking in the IBL group compared to the conventional one.

The above research findings support the assumption that providing the appropriate treatment (learning model) can impact the measured variable (critical thinking skills). Based on these results, it can be concluded that, overall, the critical thinking skills of students taught using guided inquiry are higher than those of students taught using conventional learning models. Thus, the results of this study align with previous research, indicating that the implementation of guided inquiry is more effective in developing critical thinking skills than conventional learning.

Considering High Learning Motivation for Physics, are Critical Thinking Skills Among Students Taught Using the Guided Inquiry Learning Model Higher Than Those Taught Using the Conventional Learning Model

The results of the Tukey test between students who have high learning motivation towards physics taught using the guided inquiry learning model, with an average score = 13.69 (cell I), and students who have high learning motivation towards physics taught using the conventional learning model, with an average score = 12.19 (cell II). According to the data in Table 6, a two-way ANOVA yielded an average of 3.71. To obtain stronger analysis results for testing hypothesis 2, a Tukey test was conducted between the two groups (B1 and B2). Based on the results of the Tukey test analysis, $Q_{count} = 3.11 \geq Q_{table} = 2.89$, so H_0 is rejected and H_1 is accepted, meaning that for students who have high learning motivation towards physics, there is a difference in the critical thinking abilities of students taught using the guided inquiry learning model which is significantly higher than students taught using the conventional learning model (cell I is superior to cell II) at a significance level of 0.05. The results of this study align with previous findings, such as research by Arafah et al (2020), which showed an interaction between learning models and learning motivation on physics learning outcomes. In that study, highly motivated students taught through guided inquiry achieved better critical thinking skills than those taught through conventional learning. This evidence supports the conclusion that high motivation is a crucial factor in the effectiveness of guided inquiry.

Furthermore, research by Meulenbroeks et al. (2024) highlighted that the intrinsic motivation of learners was one of the most important factors for success within IBL. Highly motivated students are more likely to become fully engaged in all aspects of the search and refine their critical thinking skills.

Therefore, the findings of this study confirm and strengthen the empirical evidence from previous studies that the application of guided inquiry models is more effective in improving critical thinking skills, especially in students with high learning motivation. This means that strong learning motivation strengthens the potential of guided inquiry learning as a means of developing students' higher-order thinking skills.

Considering Low Learning Motivation for Physics, are Critical Thinking Skills Among Students Taught Using the Guided Inquiry Learning Model Higher Than Those Taught Using the Conventional Learning Model

The Tukey test results show a difference between students with low learning motivation for physics taught using the guided inquiry learning model, with a mean score of 11.94 (cell III), and students with high learning motivation for physics taught using the conventional learning model, with a mean score of 10.00 (cell IV). The data in Table 6 demonstrates a two-way ANOVA with a mean squared error of 2.493. To obtain stronger analysis results for testing Hypothesis 3, a Tukey test was conducted between the two groups (B1 and B2). Based on the Tukey test analysis, Q_count= 4.02 ≥ Q_table= 2.89, thus H_0 zeros rejected and H_1 is accepted. This means that for students with low learning motivation for physics, there is a significantly higher critical thinking ability in students taught using the guided inquiry learning model than in students taught using the conventional learning model (cell III is superior to cell IV) at a significance level of 0.05.

This finding aligns with the research of Nisa, Koestiari, Habibbulloh, & Jatmiko (2018) showed that the implementation of guided inquiry can improve students' learning motivation and critical thinking skills. Although some students initially had low motivation, the systematic implementation of inquiry stages (observing, formulating problems, designing experiments, analyzing data, and concluding) made them more engaged and encouraged to think critically.

Thus, it can be concluded that guided inquiry learning has superior potential compared to conventional learning in improving critical thinking skills, in both highly and low-motivated students. This is because guided inquiry provides students with opportunities to be active in the learning process. Therefore, even with low initial motivation, critical thinking skills can still develop through direct learning experiences. In the low-motivation group, this success is significantly influenced by the teacher's role in providing guidance and scaffolding at each stage of learning, ensuring that students remain actively engaged and develop critical thinking skills despite their relatively low initial motivation.

There is no Influence Between the Learning Model and Learning Motivation on the Critical Thinking Abilities of Students at Madrasah Aliyah Allu

Based on the results of the two-way ANOVA, F_{count}= 0.21 < F_{table}= 4.00 was obtained, with the decision H_0 being accepted, indicating no influence between the learning model and learning motivation on critical thinking skills. Therefore, there is no influence between the learning model and learning motivation on the critical thinking skills of students at Madrasah Aliyah Allu. This is because there is no significant interaction between the two variables in terms of students' critical thinking skills. This finding indicates that the influence of the learning model on students' critical thinking skills is independent of their level of learning motivation. Both students with high and low motivation achieved relatively similar improvements in critical thinking skills when taught using the guided inquiry learning model and the conventional model.

Theoretically, these results can be attributed to the inherent characteristics of the guided inquiry model itself. This model is designed to provide gradual guidance (scaffolding) to students in the scientific inquiry process, allowing them to remain actively involved even with low levels of learning motivation. The teacher plays a significant role as a facilitator, directing the course of inquiry activities through the use of trigger questions, discussions, and reflections. With this kind of pedagogical support, students with initially low motivation still have the opportunity to think critically and develop their cognitive abilities. This condition reduces the differences between motivation levels, resulting in a statistically insignificant interaction effect between learning model and learning motivation. This finding aligns with the results of a meta-analysis conducted by Kim et al (2018), which showed that scaffolding and direct teacher guidance in science learning can overcome differences in student readiness and motivation. Thus, the guided inquiry model is inclusive and effective for a wide range of student characteristics, including those with low learning motivation.

Furthermore, the learning context and student characteristics also contributed to the lack of interaction. In this study, most students demonstrated relatively homogeneous levels of learning motivation, and the learning environment at Madrasah Aliyah Allu Bangkala was sufficiently conducive to supporting student engagement in learning. Consequently, variations in learning motivation were insufficient to moderate the effect of the learning model on critical thinking skills. Furthermore, the relatively short duration of the guided inquiry model may have also limited the interaction. Arifin, Sukarmin, Saputro, and Kamari (2025) conducted a meta-analysis showing that the effect of inquiry-based learning on critical thinking skills is highly dependent on the implementation context, guidance intensity, and duration of the learning intervention.

The findings of this study also support the results of a study conducted by Antonio and Prudente (2024), which found that the effectiveness of inquiry-based learning on critical thinking skills is consistent across various motivation levels, provided teachers offer adequate facilitation during the learning process. Similar results were also reported by Kurniawati et al. (2022), who found that implementing a guided inquiry model can improve critical thinking skills without significantly affecting students' learning motivation. However, the results of this study differ from those of Afrida et al. (2019), who reported an interaction between the learning model and learning motivation on learning outcomes. This difference is likely due to variations in context, student characteristics, and the field of study.

Therefore, the absence of an effect between the learning model and learning motivation on students' critical thinking skills indicates that the effectiveness of the guided inquiry model on critical thinking skills is stable and consistent across various levels of learning motivation. This model provides an inquiry-based learning experience that enables all students to think scientifically and reflectively, so that learning motivation is not the primary factor determining the success of developing critical thinking skills. This reinforces the view that guided inquiry learning is not only effective but also pedagogically inclusive, as it balances learning opportunities for students with diverse motivational backgrounds. The graphical form of the interaction between the learning model and learning motivation on critical thinking skills is presented in the following figure

Figure 4 above illustrates the interaction between learning model treatments and physics learning motivation. Figure 4 illustrates that the red line represents the guided inquiry learning model, while the purple line represents the conventional learning model. The graph shows that both lines are parallel, indicating that there is no intersection point between the two lines in Figure 4, which suggests that there is no real interaction between

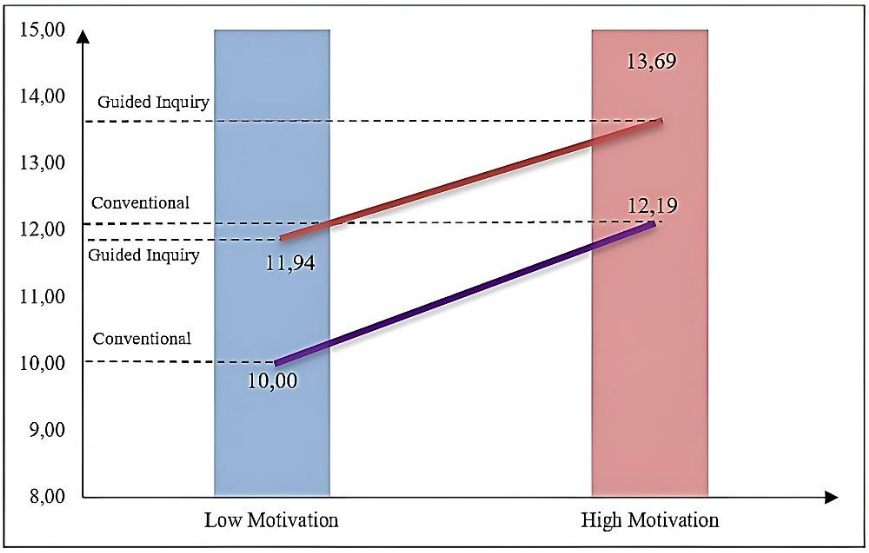


Figure 4. Interaction pattern of learning models and learning motivation on critical thinking skills

the two factors. By observing Figure 4, it is evident that the average value of students' critical thinking skills is consistently higher when taught using the guided inquiry learning model compared to the conventional learning model. In addition, critical thinking skills tend to be more closely related to cognitive aspects than to affective ones, so that learning motivation, as an affective factor, does not significantly influence the relationship between learning models and critical thinking skills. The differences in learning motivation are also likely not large enough to produce a significant effect, so the results do not show a statistically significant difference. On the other hand, external factors such as initial abilities, learning habits, and the learning environment may play a greater role in influencing the development of critical thinking than the interaction between learning models and learning motivation. According to Figure 4, the application of the guided inquiry learning model has proven effective in improving students' critical thinking skills. Additionally, learning motivation plays an important role as an independent factor that supports the improvement of these skills.

▪ CONCLUSION

Based on the research results, descriptive and inferential data analysis, and the discussion presented, it can be concluded that the overall critical thinking skills of students taught using the guided inquiry learning model are higher than those taught using the conventional learning model. In terms of learning motivation, both among students with high and low motivation for physics, the guided inquiry model consistently demonstrated superior results in improving critical thinking skills. Thus, the guided inquiry model has proven effective in physics learning across various levels of student motivation. Meanwhile, the inferential analysis results indicate no interaction effect between the learning model and learning motivation on students' critical thinking skills at Madrasah Aliyah Allu. Theoretically, these results can be attributed to the inherent characteristics of the guided inquiry model itself. This model is designed to provide gradual guidance (scaffolding) to students throughout the scientific investigation process, enabling them to remain actively involved, even with low levels of learning motivation. The teacher plays a significant role as a facilitator, guiding inquiry activities through the use of prompting questions, discussion, and reflection. With this kind of pedagogical support, students with initially low motivation still have the opportunity to think critically and develop their cognitive abilities. This condition reduces the differences between motivation levels, so the interaction effect between the learning model and learning motivation does not appear statistically significant. Thus, the lack of an effect between the learning model and learning motivation on students' critical thinking skills indicates that the effectiveness of the guided inquiry model is stable across different levels of learning motivation. This model provides an inquiry-based learning experience that enables all students to think scientifically and reflectively, so learning motivation is not the primary factor in improving critical thinking skills.

This study suggests that physics teachers may consider adopting the guided inquiry learning model more widely, as it has been demonstrated to enhance students' critical thinking skills independently of their learning motivation. This means that the guided inquiry model can be an effective alternative for improving the quality of physics learning, particularly in developing critical and independent thinking in students. Limitations: The subjects in this study were only from one madrasah (Islamic school), and it is possible that the learning motivation variables adopted do not fully reflect other affective factors. Therefore, additional studies that include a larger sample of schools with diverse backgrounds and more variables, such as learning styles or creativity, are encouraged to gain a more comprehensive understanding of the factors influencing students' critical thinking abilities.

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