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The Effect of Inquiry Learning Model with STEM Approach on Students' Critical Thinking Skills in Science Learning

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Abstract

Critical thinking is a skill needed to solve problems in the 21st century. However, the critical thinking skills of Indonesian students are still considered low, as confirmed by PISA research results. This low critical thinking ability is due to students' limited understanding of factual and conceptual information when solving problems. One learning model that can serve as an alternative to improving students' critical thinking skills is the Inquiry model with a STEM approach. In this model, students are actively engaged in learning, as the process focuses on them. Additionally, the STEM approach enhances students' critical thinking abilities because it integrates various fields of knowledge, enabling students to think from multiple perspectives and become accustomed to critical thinking. The purpose of this research was to determine the effect of the Inquiry learning model with a STEM approach on students' critical thinking skills. This quantitative research was conducted at Mts 1 Jember during the even semester of the 2024/2025 academic year. The sample included class VIII B as the experimental group and class VIII D as the control group, selected through purposive sampling. Data collection techniques involved tests as the primary instrument, with supporting instruments such as observation, interviews, and documentation. Data analysis was conducted using the Independent Sample t-test, which showed a significance value (2-tailed) of 0.000 < 0.05. The results indicated a moderate increase in students' critical thinking skills, with a score of 0.68. From this analysis, it can be concluded that the use of the Inquiry learning model with a STEM approach has a significant positive impact on improving students' critical thinking skills.

Keywords: critical thinking; inquiry learning; scienace learning; STEM

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INTRODUCTION

Critical thinking is a skill required to solve problems encountered in the 21st century. It is closely related to learning activities that aim to prepare students to solve problems. In learning activities, the integration of critical thinking skills enables students to become strong problem-solvers, capable of making decisions, and analyzing information (Ash-showy et al., 2022; Misbah et al., 2022; Raj et al., 2022). The importance of possessing critical thinking skills allows students to address various

challenges, making it essential to integrate critical thinking into science learning. According to Azizah et al., (2023) students with critical thinking skills can face problems using logical reasoning, interpret and analyze information, and evaluate the data they receive to make decisions.

The critical thinking skills of Indonesian students are generally categorized as low. This has been confirmed by the results of the PISA study. PISA aims to facilitate equality in education systems and international education standards (Lestari & Annizar, 2020). Of the 79 countries that participated in the 2018 PISA study, Indonesia ranked 73rd and 71st in mathematics and science proficiency, respectively (Adawiyah et al., 2022). Meanwhile, in the 2022 PISA results, Indonesia's performance in mathematics and science showed a decline, partly due to the COVID-19 pandemic. Despite the drop in scores in 2022, Indonesia's ranking in PISA improved compared to 2018 (Kemendikbud, 2023). However, Indonesia's science scores have shown little improvement over the years. The low PISA scores are attributed to the lack of ability to solve high-level problems. Based on PISA results, it can be said that Indonesian students have relatively low critical thinking skills (Sa'adah et al., 2020).

The low critical thinking skills of students stem from a lack of understanding of information, such as facts, concepts, procedures, and concepts in problem-solving. Additionally, the focus of teaching is often not on students' thinking processes, leading to their inability to think critically. Many teachers tend to teach lower-level thinking skills, resulting in students' higher-order critical thinking skills not being developed (Febrianti et al., 2021). According to Jaya (2021) teachers still play a dominant role in learning activities, limiting the opportunities for students to develop their critical thinking skills. Learning often emphasizes memorization rather than cognitive application, which weakens students' ability to engage in higher-order critical thinking.

Various teaching methods can be used to develop critical thinking skills, and one of the most effective is the Inquiry-based learning model with a STEM approach. The Inquiry learning model with a STEM approach is believed to improve students' critical thinking skills because it encourages students to connect real-world problems by using mathematics, engineering, and technology, preparing them to compete in the 21st century (Misbah et al., 2020; Wastiti & Sulur., 2019). Through the Inquiry model, learning becomes student-centered, with educators functioning as facilitators, enabling students to enhance their critical thinking skills (Jaya, 2021; Misbah et al., 2018; Pahrudin et al., 2021). Inquiry-based learning fosters students' independent discovery of knowledge, which cultivates critical thinking skills and turns them into a routine practice (Arifuddin et al., 2020; Santoso & Arif, 2021; Yani et al., 2021). Through the STEM approach, students are taught to be active in problem-solving (Fitriansyah et al., 2021). The STEM approach is believed to help develop students' critical thinking skills because it integrates various disciplines, such as science, technology, engineering, and mathematics, allowing students to think from multiple perspectives and become accustomed to critical thinking (Ash-showy et al., 2022).

METHOD

This research was conducted at MTs Negeri 1 Jember during the Even Semester of the 2023/2024 Academic Year. It is a quasi-experimental study, using a nonequivalent control group design. The population for this study

consisted of 8th-grade students, selected using purposive sampling and tested for homogeneity. The homogeneity test resulted in class VIII B being chosen as the experimental class, and class VIII D as the control class. The sample analyzed in each class consisted of 31 students.

The instruments used included written tests, interviews, observations, and documentation. The written test was given to students in the form of pretest and posttest questions, covering critical thinking indicators. Interviews were conducted with the science teacher at MTs 1 Jember regarding the teaching methods typically used and the challenges faced during science lessons. Observations were made to evaluate the implementation of the applied learning model. Documentation consisted of photos and videos of the learning activities, the results of the pretest and posttest, observations, and other supporting data relevant to the research.
Data analysis was conducted using normality tests with the Kolmogorov-Smirnov method, supported by the SPSS 25 software application. If the data followed a normal distribution, the hypothesis would be tested using the Independent Sample t-test.

RESULTS AND DISCUSSION

This research examined how the application of the Inquiry learning model with a STEM approach affected the critical thinking skills of junior high school students in the topic of vibrations and waves. The results indicated that the implementation of the Inquiry learning model with a STEM approach had a positive impact on students' critical thinking skills. This is consistent with the findings of Santoso and Arif (2021) who stated that the Inquiry model with a STEM approach encourages students to actively solve problems, fostering creativity and critical thinking in addressing issues. Additionally, Wastiti dan Sulur (2019) demonstrated that the Inquiry learning model with a STEM approach improves students' critical thinking skills by encouraging them to connect real-world problems with mathematics, engineering, and science technology, preparing them to compete in the 21st century.

This experimental study aimed to investigate whether the Inquiry learning model with a STEM approach influenced the critical thinking abilities of junior high school students. Two classes were used as samples for this research: class VIII B was the experimental group, which received special treatment, while class VIII D was the control group, which did not receive any special treatment. The study was conducted over the course of one month, with eight sessions. A pretest was administered to both classes in the first session, and a posttest was conducted in the final session using 10 essay questions that applied critical thinking skill indicators. The results of the pretest and posttest of students' critical thinking skills are shown in Table 1.

Table 1 Pretest and posttest results of students' critical thinking skills

Main Part	**Experimental Group**		**Control Group**	
	Pretest	Posttest	Pretest	Posttest
Number of Students	31		31	
The Highest Score	58	94	46	76
Lowest Score	12	58	9	22
Average	35.68	80.65	25.16	46.77

The pretest and posttest results for the experimental and control groups were analyzed with a normality test. Since the data involved more than fifty students, the normality of the pretest and posttest data for both the experimental

and control groups was tested using the Kolmogorov-Smirnov test. According to the Kolmogorov-Smirnov test criteria, the data is considered to follow a normal distribution if the Sig value is greater than 0.05. The following Table 2 shows the normality test results for students' critical thinking skills.

Table 2 Normality test results of students' critical thinking skills

	Kolmogorov-Smirnov		
Group	**Statistic**	**Df**	**Sig.**
Experimental Pretest	0.135	31	0.159
Control Pretest	0.108	31	0.200
Experimental Posttest	0.132	31	0.182
Control Posttest	0.103	31	0.200

The next step was to conduct the independent sample t-test, which yielded a Sig value < 0.05. Based on the hypothesis guidelines, this indicates that H0 is rejected, and Ha is accepted, meaning there is a significant difference in the mean critical thinking skills between the experimental and control groups. The Table 3 showing the results of the independent sample t-test for the students' post-test critical thinking skills.

Table 3 Independent sample t-test of students' critical thinking skills

	Class	***Posttest* Avarage**	***Levene's Test for Equality of Variance***	**T**	**Df**	***t-test for Equality of Means Sig. (2-tailed)***
Critical Thinking Skills	Experimental	80.64	0.941	-17.402	60	0.000
	Control	46.77				

The higher critical thinking skills in the experimental group demonstrate the impact of the treatment used compared to the learning model applied in the control group. This finding aligns with research by Wastiti and Sulur (2019), which showed that students' critical thinking skills improved after receiving the Inquiry model with the STEM approach. This learning model received positive responses, was well-received, and favored by students.

The Inquiry learning model with a STEM approach had a positive impact on improving the critical thinking skills of students at MTs 1 Jember in science lessons. This is evidenced by students being able to build their understanding independently by identifying problems, forming questions about those problems, testing and analyzing the questions, and then communicating their findings. This finding is consistent with Furmanti et al. (2020) who noted that Inquiry learning is a way of learning that seeks knowledge, questions, and studies phenomena. According to Fitriansyah et al. (2021), through the STEM approach, students are taught to be active in solving problems.

The analysis of the improvement in critical thinking skills for each indicator was conducted using the N-Gain test. The Table 4 showing the N-Gain test results for the experimental class.

The experimental group obtained an N-Gain score categorized as moderate improvement for the interpretation indicator, while the control group showed a low improvement. According to Afifah (2023), the interference indicator in the experimental sample had a higher N-Gain score compared to the control sample. In the interpretation

indicator, students were able to accurately and completely solve problem questions, as shown by their ability to explain the phenomenon in the question, though some did not provide correct explanations. This type of question is familiar to students, so they are used to it.

Table 4 N-Gain test results for students' critical thinking skills

Indicator	*Pretest* Avarage	Posttest Avarage	*N-gain*	Criteria
Interpretation	55.64	87.58	0.72	Moderate
Analysis	39.03	78.81	0.65	Moderate
Evaluation	26.12	63.22	0.50	Moderate
Interference	27.25	88.38	0.84	Moderate
Explanation	23.22	86.45	0.82	Moderate
Self Regulation	24.51	68.38	0.58	Moderate
Avarage	32.63	78.80	0.68	Moderate

For the analysis indicator, the experimental sample scored a higher N-Gain than the control group. In this indicator, students mostly connected the concepts in the questions accurately and completely, although some students provided less accurate answers. This finding is consistent with research by Ramadhanti & Agustini (2021), which showed that the analysis indicator had a moderate N-Gain because students did not fully demonstrate the process of analyzing.

For the evaluation indicator, the experimental class scored a moderate N-Gain, while the control class showed a low improvement. In this indicator, students could connect the concepts in the questions, but some of their answers were incomplete. This result aligns with Agnafia's (2019) study, which found that students were able to draw conclusions in solving problems.

The experimental group had a high N-Gain score for the inference indicator, while the control group had a low improvement. In this indicator, students were required to draw conclusions. Most students were able to make correct conclusions, as shown by the high N-Gain score in the experimental group. However, some students still struggled with making conclusions, as shown by the N-Gain score in the control group. This finding aligns with Agnafia's (2019) research, which indicated that students had the ability to identify and solve problems, allowing them to make conclusions.

The experimental group obtained a high N-Gain score for the explanation indicator, while the control group showed a low improvement. This result is consistent with the study by Ramadhanti & Agustini (2021), which found that the explanation indicator had the highest N-Gain score. Students were able to answer questions by providing logical explanations and reasoning based on evidence. In this indicator, students performed very well, as most gave correct and complete explanations and reasoning, although some students provided incomplete answers.

The experimental group had a moderate N-Gain score for the self-regulation indicator, while the control group showed a low improvement. In this indicator, students performed well in answering, analyzing, and evaluating the questions, although some students did not correctly evaluate the questions. This statement aligns with the research conducted by Anjelina et al. (2023), where the experimental group had a higher N-Gain score than the control group.

The N-Gain test analysis for each indicator in the experimental group showed moderate results, while the control group showed low results. This means that the Inquiry learning model

with a STEM approach on the topic of vibrations and waves had a positive impact on the critical thinking skills of students, categorized as moderate. This finding is consistent with Santoso and Arif's (2021) conclusion that the use of the Inquiry learning model with a STEM approach positively impacts students' critical thinking skills.

CONCLUSION

Based on the data analysis and discussion, it can be concluded that the use of the Inquiry learning model with a STEM approach significantly affects students' critical thinking skills on the topic of vibrations and waves. This impact is demonstrated by the significance value from the independent sample t-test being less than 0.05, indicating a difference in the average critical thinking skills between the experimental and control classes. The use of the Inquiry learning model with the STEM approach can enhance students' critical thinking skills, as shown by the students' N-gain scores, which fall into the moderate or good category. This finding serves as an evaluation for future researchers that a continuous learning process is needed to further improve students' critical thinking skills. From the explanation above, it is evident that the use of the Inquiry learning model with the STEM approach aligns well with the Merdeka Curriculum, which aims to develop students' critical thinking skills.

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