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ANALYSIS OF STUDENT RESPONSES TOWARDS THE IMPLEMENTATION OF STEM-BASED COOPERATIVE LEARNING IN SCIENCE EDUCATION

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ABSTRACT

The development of 21st-century skills such as critical thinking, collaboration, and problem-solving requires innovative learning approaches. STEM education, integrated with cooperative learning, is considered an effective strategy to enhance student engagement and understanding in science education. This study aims to analyze student responses to the implementation of STEM-based cooperative learning in science education. The research employed a descriptive quantitative approach using a survey method. A total of 31 junior high school students participated by completing a Likert-scale questionnaire consisting of ten statements. The results showed that students responded very positively, with an average score of 81.21%. The findings indicate that this learning approach enhances students' confidence in asking questions and expressing opinions, minimizes boredom, facilitates problem-solving, and improves understanding of the material. It is concluded that STEM-based cooperative learning is an effective and engaging strategy for science education. Further research is recommended to explore its long-term impact on academic achievement and to apply the approach across different subjects and educational levels.

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Introduction

The development of science and technology in the 21st century requires students to possess complex skills, such as critical thinking, communication, collaboration, and problem-solving abilities (Kennedy & Sundberg, 2020) . One learning approach believed to be relevant to achieving these goals is Science, Technology, Engineering, and Mathematics (STEM). STEM learning marks a shift from traditional models to inquiry-based, project-based, and problem-based learning models, which aim to provide meaningful learning experiences (Andrews et al., 2023).

STEM has the potential to develop principles that build knowledge through student experiences across all levels of education (Ragan). It integrates the four interconnected and inseparable disciplines of science, technology, engineering, and mathematics in effective science education (Zhan & Niu, 2023) . This integration can produce innovative discoveries and solutions to real-world problems. Through STEM-based learning, teachers can foster students' self-confidence, logical reasoning, technological literacy, and enhance critical and creative thinking skills, enabling students to solve problems, generate solutions, and become future innovators and inventors (Handayani, 2020) .

On the other hand, cooperative learning has long been recognized as an effective strategy for fostering collaboration and cooperation in achieving learning objectives (Sembiring, 2023) . Cooperative learning encourages students to express their opinions, fosters a sense of collective responsibility, and fosters emotional and social engagement (Sipayung, 2025) . When combined with a STEM approach, cooperative learning not only fosters collaboration but also integrates the practical application of science in real-life contexts (Bybee, 2013) .

Countries such as Australia (Fairhurst et al., 2023) and the United States (Gonsar et al., 2021; Roberts & Roberts, 2023) are actively developing STEM education, recognizing its potential to equip students with 21st-century skills. The characteristics of STEM education are believed to help students think critically about contextual issues. Design thinking embedded in STEM learning encourages students to observe, collect data, analyze information, and draw conclusions based on the problems presented.

Scientific reasoning in STEM learning aligns with the characteristics of integrated science education in junior high schools (SMP), which applies scientific methods to cognitive development (Ningrum & Rahmi, 2021) . Science learning materials relate to natural phenomena and systems, which are closely related to the focus on contextual and real-life problems in STEM education.

The primary goal of STEM-based education is to prepare students to develop their potential so they can contribute to innovative solutions to future challenges (Terzieva et al., 2024) . A STEM-oriented curriculum fosters the 21st-century skills of creativity, critical thinking, collaboration, and communication (the 4Cs).

Previous research has applied the STEM approach in science education at the secondary school level in Indonesia. One study showed that STEM-based learning can improve students' scientific literacy (Khaeroningtyas et al., 2016) . Another study by Suwarma et al., (2015) used a balloon-powered car as a STEM learning medium, which allowed students to better understand concepts such as uniform rectilinear motion. After implementing the learning process, students provided feedback through interviews, stating increased motivation and better understanding compared to conventional methods. Other studies also showed improved academic achievement thanks to STEM learning, especially in final assessments.

In conventional environments, science learning tends to be teacher-centered, with students passively memorizing answers. This can lead to boredom and reduced learning interest. Previous research has shown that STEM-based learning can enhance motivation and conceptual understanding (Hiğde & Aktamış, 2022) . However, student responses to this model, especially in cooperative settings, remain underexplored. Student responses, including attitudes, motivation, and perceptions, are key indicators of the effectiveness of a learning approach (Fraser, 1998) . Therefore, this study aims to analyze student responses to the implementation of STEM-based cooperative learning in science education.

Although prior research has demonstrated that STEM-based learning can enhance scientific literacy, motivation, and conceptual understanding compared to conventional methods, student responses to the STEM model when implemented in a cooperative setting (STEM-based cooperative learning) remain underexplored. Given that student responses including attitudes, motivation, and perceptions are key indicators of a learning approach's effectiveness. This study is necessary to bridge this gap by specifically analyzing students' perceptions of the integration of STEM and

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cooperative learning in science education. Therefore, this study aims to analyze student responses to the implementation of STEM-based cooperative learning in science education.

Research Methods

This study used a survey method with a descriptive quantitative approach. This approach was chosen to provide an overview of certain phenomena in the population studied. The sample of this study was the entire population in the study by Jati & Yuliansyah, (2017). The data collection instrument used in this survey was a Likert scale questionnaire. The questionnaire consisting of 10 items (5 positive statements and 5 negative statements) was used to collect students' perceptions.

The population in this study consisted of all students in classes VIIIA and VIIIB at SMP Kesatrian 1 Semarang. The sample for this research was selected from the eighth-grade students. The sampling technique used in this study was simple random sampling, which involves selecting samples from the population randomly without regard to the strata existing within the population, provided that the homogeneity of the two classes to be selected is first tested (Sugiyono, 2016).

The respondents of this study consisted of 31 eighth-grade students from SMP Kesatrian 1 Semarang who had experienced STEM-based cooperative learning. The learning implementation questionnaire was utilized to determine whether the STEM-based learning on the Optics theme had been successfully executed in the experimental class.

Prior to data collection, the questionnaire had undergone expert validation and was declared suitable for use in the research. Responses were processed by multiplying each option by its weight. Negative statements were converted to positive values to ensure consistency of scoring. The total score for each item was then calculated using the following formula:

Total Score = (Sum of item scores / Maximum possible score) × 100%
(Riduwan, 2015)

The scoring criteria for responses are shown below:

Table 1. Student Response Questionnaire Criteria

Response Options	Score
Strongly Agree (SA)	4
Agree (A)	3
Somewhat Agree (SA)	2
Disagree (D)	1

The percentage categories used for interpretation are:

Table 2. Percentage and Student Responses to the Questionnaire

Percentage (%)	Category
81–100%	Very good
61–80%	Good
41–60%	Fair
0–40%	Poor

Results and Discussion

Student responses to STEM-based cooperative learning in science education were collected after the learning session was completed through a questionnaire. The questionnaire aimed to identify and assess student responses to the learning approach. Students were asked to answer ten statements, consisting of five positive and five negative, regarding the learning experience.

Based on the indicators in the questionnaire, the results can be categorized into four main aspects: (1) STEM-based science learning encourages students to ask questions and express ideas or opinions; (2) facilitates students in solving problems and generating solutions; (3) increases student interest and reduces boredom; and (4) supports students' understanding of the subject matter.

The following table summarizes students' responses to STEM-based cooperative learning in science education:

No	Indicator	Average Student Response	Category
1	My science learning experiences have encouraged me to ask questions and express ideas.	80.65	Very good
2	I still have difficulty expressing my opinion.	81.45	Very good
3	The use of videos and practical activities makes it easier for me to express my ideas.	81.45	Very good
4	Learning science through discussion makes it increasingly difficult for me to convey my ideas.	81.45	Very good
5	The science lessons I experienced challenged me to solve problems.	80.65	Very good
6	Learning science through discussion	79.03	Good

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	trains me to find solutions to the problems given.		
7	Practical activities in the learning process increase my interest in learning.	81.45	Very good
8	Practical activities during lessons make me feel bored.	82.26	Very good
9	Learning through discussion helps me understand optics topics more easily.	83.06	Very good
10	Learning through discussion made me even more confused when studying the topic of optics.	80.65	Very good
	Average	81.21%.	Very good

Table 3 shows that the average student response score was 81.21%, which is categorized as "Very Good" This result indicates that STEM-based learning in science significantly improves student understanding. Students gave a positive perception of this approach and acknowledged its impact. This is in line with Mystakidis & Christopoulos, (2022), who argued that a learning method can be considered successful when it receives a good or very good response from students. Similar findings were reported by Saputri et al., (2024), who applied STEM-based learning to the topic of ecosystems and achieved an average response rate of 86%. This indicates that STEM-based learning generally receives a positive response from students.

It is important to acknowledge that these findings are based on a self-report questionnaire, which inherently carries the potential for social desirability bias. Students may be inclined to provide overly positive responses (resulting in the 'Very Good' category) to align with perceived expectations or the known objectives of the learning program. Future research should consider triangulation with observational data or teacher assessments to provide a more robust evaluation of the learning model's impact.

The first indicator, STEM-based science learning supports students' confidence in asking questions and sharing ideas, scored an average of above 80%, which is categorized as *"Very Good"* Statements in this indicator include: (1) *"Science learning encourages me to ask questions and share ideas"* which scored 80.65%; (2) *"I still struggle to express my opinion"* (reversed and scored positively) scored 81.45%; (3) *"Using videos and practice helps me express more ideas,"* scored 81.45%; and (4) *"Science learning through discussion makes it more difficult to express ideas"* (also reversed) scored 81.45%.

These results indicate that STEM-based learning increases students' confidence in expressing ideas and asking questions. This may be due to the nature of STEM learning, which requires students to engage in active inquiry, develop arguments, and evaluate data. Afriana et al., (2016) outlined the stages of STEM learning, which include formulating scientific questions, identifying problems, developing models, conducting investigations, interpreting data, applying mathematical and digital tools, constructing explanations, and communicating findings. These processes require active participation, which aligns with students' perceptions.

The second indicator, *"STEM-based learning helps students solve problems and develop solutions"* also scored highly. Statement (5) *"Science learning makes problem-solving difficult"* (reversed) scored 80.65%, and statement (6) *"Science learning through discussion helps me find solutions"* scored 79.03%, categorized as *"Good."*

The primary goal of STEM education is to train students to think critically and creatively using interdisciplinary knowledge to solve real-life problems (Mayasari et al., 2014; Widana & Septiari, 2021). This supports the findings of this study, which showed that students felt more capable of solving problems when engaged in STEM-based learning.

The third indicator, STEM learning increases interest and reduces boredom, also produces a *"Very Good"* response. Statement (7) *"Practical activities make me interested in learning"* obtained a score of 81.45%, and statement (8) *"Practical activities make me bored"* (reversed) obtained a score of 82.26%.

This supports the idea that STEM learning connects theory to real-world contexts, thereby increasing student engagement. As noted by Santoso & Arif (2021) and El-Deghaidy & Mansour (2015), STEM encourages inquiry-based, project-based, and problem-based learning, creating meaningful learning experiences. This motivates students and keeps them engaged throughout the learning process.

The final indicator, STEM-based learning improves understanding of the material, was also rated as *"Very Good"* Statement (9) *"Discussions*

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helped me understand topics about optics" scored 83.06%, and statement (10) *"Discussions confused me"* (reversed) scored 80.65%. This indicates that STEM-based instruction facilitates students' understanding of scientific content. According to Tamami, (2022), students generally become passive under classical learning methods. However, when actively involved through investigation and application, students become more engaged and able to understand complex topics. Abu Khurma et al., (2023) also emphasized that STEM-based teaching materials are clearly structured, making them easier to understand.

Although the overall response was highly positive, it should be noted that Item 6 *(Related to discussion aiding in finding solutions)* received the lowest score, at 79.03% (Good). This was the only item that did not achieve the *Very Good* category. This score variation indicates that while students generally felt capable of problem-solving (Item 5: 80.65%), the discussion aspect of finding solutions may still present a challenge. This could be due to group communication skills that are not fully matured, or some students may have perceived dominance by other group members during discussions, which warrants refinement in future cooperative implementations.

While this study provides strong evidence of effectiveness, it is necessary to acknowledge several limitations: (1) The small sample size, involving only 31 students from a single school, restricts the generalizability of the findings; and (2) The short implementation duration, which implies that the observed response might be a novelty effect rather than a sustained, long-term impact.

These findings recommend that the STEM-based cooperative learning model is not only effective in science education but also holds significant potential for broader application across the wider STEM curriculum, including the disciplines of Technology, Engineering, and Mathematics. Further research is recommended to explore its impact on long-term academic achievement and its applicability across different educational levels to validate this model as a relevant strategy for developing 21st Century Skills.

Conclusion

This study concluded that students responded very positively to the implementation of STEM-based cooperative learning in science education, with an average score of 81.21%. Their responses can be categorized into four areas: (1) increased confidence in asking questions and expressing ideas; (2) improved problem-solving skills; (3) greater interest and reduced boredom; and (4) increased understanding of the subject matter. All four indicators scored above 80%, which is classified as "*Very Good*" except for one item related to discussion-based problem-solving, which scored 79.03% and is classified as "Good." These findings indicate that STEM-based cooperative learning is an effective and engaging learning strategy in science education.

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