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Enhancing Students' Scientific Argumentation Skills through Nearpod-Assisted Guided Inquiry Learning on the Topic of Heat Transfer

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Abstract
Difficulties in constructing scientific arguments remain a persistent challenge in science learning, particularly in linking evidence with appropriate reasoning. This study aimed to examine the effect of a Nearpod-assisted Guided Inquiry Learning model on students' scientific argumentation skills based on Toulmin's Argumentation Pattern (TAP), which includes the components of claim, evidence, and warrant. The research was conducted at MTsN 3 Surabaya with 31 seventh-grade students during the 2025/2026 academic year on the topic of heat and heat transfer. A quasi-experimental one-group pretest–posttest design was employed to investigate changes in students' scientific argumentation skills before and after the implementation of the learning model. Data were collected through essay-based pretests and posttests and were analyzed according to the scientific argumentation components proposed in TAP. The results indicated a statistically significant improvement in students' scientific argumentation skills ($p < .001$) with an average N-gain of 0.65 (medium category). These findings suggest that integrating Nearpod within guided inquiry learning can enhance students' engagement and support the development of scientific argumentation in science learning contexts.

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INTRODUCTION

Educational institutions today are preparing human resources with 21st-century skills who aim not only to develop competencies but also to shape students' character (Shandra & Movitaria, 2022). To achieve these objectives, an educational system is required that does not merely focus on learning outcomes but also develops thinking skills and attitudes (Yusnidar et al., 2024). Students are no longer positioned solely as recipients of information; rather, they are active subjects directly involved in the learning process (Inayah et al., 2022). The main components of the learning process involve engagement in various essential aspects, including formulating questions, describing mechanisms, and constructing arguments.

Although conventional learning is generally considered efficient, it tends to focus primarily on learning outcomes. The learning process often moves in a one-way direction, offering limited opportunities for students to actively participate. As a result, this approach has not fully supported the development of higher-order thinking skills necessary to improve the quality of students' reasoning processes. Consequently, students' thinking skills tend to develop inadequately (Novanda et al., 2024).

Indonesian Students' argumentation skills are still considered relatively low. Evidence shows that when students are asked questions or requested to express their opinions, they are generally able to provide claims, but the supporting evidence and reasoning are often irrelevant

or insufficient (Ula et al., 2025a). This condition is supported by the results of the PISA 2022 survey. This program evaluates students worldwide not only in terms of literacy but also their reasoning abilities and their skills in using scientific evidence to support statements in the development of argumentation skills. In 2023, according to the Ministry of Education and Culture (Kemendikbud), Indonesia ranked 68th with a science literacy score of 398 (OECD, 2024). The foundation of this study is further strengthened by the results of an argumentation skills test conducted among students at MTs Negeri 3 Surabaya, which indicated that their argumentation abilities remain at a low level. Students tend to generate simple argumentative ideas, but are not yet capable of constructing arguments supported by logical data and reasoning (Budinarianti & Susiyawati, 2024). Consequently, students' critical and argumentative thinking skills have not yet developed optimally.

Based on these conditions, a learning theory framework is required to systematically address these issues. One relevant learning theory that aligns with these needs is constructivism, which views learning as an active process in which students construct knowledge through experience, interaction, and reflection (Subarjo et al., 2023). According to Vygotsky's social constructivism, learning is a process of knowledge construction that occurs through social interaction among learners. In this learning approach, argumentation skills enable students to present claims, evidence, and reasoning in dialogue with peers, in both written and oral forms. Students do not merely receive information but actively build their own knowledge, ideas, and scientific concepts (Wibowo et al., 2025). Therefore, innovative and effective learning strategies are needed to facilitate students' argumentation skills and enhance their engagement in communicating arguments during the learning process (Arifuddin et al., 2024).

One learning model that improves argumentation skills is the Guided Inquiry Learning model. This model actively involves students as creators of knowledge and provides an environment that supports thinking processes through activities such as observation, hypothesis formulation, data collection, data analysis, and conclusion. Teachers play an important role in facilitating the process without dominating students' involvement (Nurita et al., 2023). First, teachers present questions about phenomena in everyday life that are related to science learning concepts. This technique creates an environment that encourages students to think collaboratively and to design investigations to verify assumptions and find answers to the discussed phenomena. During the investigation process, teachers provide opportunities for students to conduct experiments in order to cultivate habits of careful observation and analytical thinking. Students collaborate to solve the problems presented. Finally, teachers guide students in analyzing and presenting the evidence from their experiments to refine their previous theories and assumptions (Idris et al., 2022).

The implementation of the Guided Inquiry Learning model supports students' ability to interpret knowledge gained through the inquiry process. Research indicates that students who previously could only formulate claims become more systematic in constructing arguments that include scientific evidence and reasoning (Sosial et al., 2025). However, in practice, inquiry activities often fail to fully engage students. Some students still feel shy and lack confidence when expressing statements or arguments. As a result, improvements in argumentation skills are not observed evenly among all students. This condition, therefore, requires an appropriate approach to address the issue so that improvements in argumentation skills can occur more evenly.

One approach that can be combined with Guided Inquiry Learning to improve argumentation skills is the use of learning media such as Nearpod. Nearpod is an online application accessible on mobile devices that offers various features to support interactive learning (Ami, 2021). Through Guided Inquiry Learning supported by Nearpod, students are invited to investigate heat transfer influenced by factors such as temperature, energy, and others, which are connected to the phenomenon of global warming occurring in East Java, particularly

Surabaya. The topic of heat transfer aligns with the issue of global warming in Surabaya, which frequently occurs during the dry season and affects almost all students at MTsN 3 Surabaya. This issue becomes an appropriate topic for active discussion through the implementation of Guided Inquiry Learning. In practice, the topic of heat transfer often leads to misconceptions regarding its scientific mechanisms. Moreover, many students still experience difficulties in connecting these three components with real-life phenomena (Nistilawati & Satriawan, 2025). Global phenomena are closely related to heat transfer processes. Students often assume that conduction occurs only in solids and that convection occurs only in boiling water. These misconceptions lead students to lack a comprehensive understanding of the mechanisms and processes involved in heat distribution, including those related to global warming.

Although the Guided Inquiry Learning model has the potential to develop students' scientific reasoning, its implementation remains limited. Teachers often rely solely on student worksheets without applying specific approaches that provide opportunities for students to actively engage in learning. Meanwhile, the use of digital learning media is still not widely implemented in schools. Therefore, this study integrates the Guided Inquiry Learning model with Nearpod learning media to create an interactive learning environment and support students' development of argumentation skills. Nearpod functions as an interactive learning tool that connects teachers with students and students with one another. Students work in groups to discuss problems under the teacher's guidance. Features such as quizzes, polls, open-ended questions, and simulations allow students to express opinions and assumptions, analyze data, and actively respond to the discussed problems. Thus, these features help students connect the results of investigations on temperature and heat transfer with arguments that are communicated more clearly and systematically, thereby enabling a more even improvement in argumentation skills (Farhan Sagara et al., 2023).

This study aims to describe the effect of the Guided Inquiry Learning model assisted by Nearpod on students' argumentation skills. Therefore, this research is expected to provide a clear description of the effectiveness of the implemented learning model in enhancing students' argumentation skills.

METHOD

Research Design Justification

This study employs a quantitative approach using a quasi-experimental design of the One-Group Pre-test-Post-test type. This design was chosen as it allows the researcher to measure changes in the dependent variable (argumentation skills) following the intervention without the need for complex subject randomisation, which is often difficult to achieve in formal educational settings (Denny et al., 2023). In this design, a single group of subjects was administered a pre-test before the intervention, followed by a Guided Inquiry Learning intervention supported by Nearpod, and concluded with a post-test to assess the impact of the intervention (Anantasia et al., 2025).

The research subjects were selected using purposive sampling, namely 31 Year 7 pupils at MTs Negeri 3 Surabaya for the 2025/2026 academic year. This technique was used to ensure the sample possessed characteristics relevant to the research objectives, namely, pupils at a transitional cognitive stage who had not previously received specific instruction on scientific argumentation patterns (Rachman et al., 2024).

Validity of Argumentation Instruments

The primary instrument used is a scientific argumentation skills test developed based on Toulmin's Argumentation Pattern (TAP) framework. This instrument is designed to measure the components of argumentation, which include the claim (position statement), data (empirical

evidence), warrant (the link connecting the data to the claim), and backing (theoretical support) (Muslim et al., 2024; M. J. Ramadhan et al., 2026).. The use of TAP in science education assessment has proven effective for mapping students' levels of critical thinking ability and the validity of their arguments in a structured manner (Andriani et al., 2025).

Before implementation, the instrument was validated by subject matter experts and evaluation experts to ensure content and construct validity. The validation results showed that the instrument achieved an Aiken's V coefficient of 0.85, which falls within the high validity category, thus making it suitable for use in research (Ningdyah et al., 2021). This process is crucial to ensure that the essay questions used genuinely measure students' ability to construct scientific arguments, rather than merely testing factual recall (J. M. Ramadhan et al., 2026)

The assessment of students' arguments was conducted using a scoring rubric on a scale of 0–3 for each component of the argument. A score of 0 indicates that the student did not respond; a score of 1 indicates that the claim is unsupported; a score of 2 indicates that the claim is supported by data; and a score of 3 indicates that the claim is supported by data, including analogies and analysis of the data. As the instrument took the form of subjective essay questions, an inter-rater reliability test was conducted. The assessment was carried out by two assessors using a rubric based on Toulmin's Argumentation Pattern with a 0–3 scale for each component of the argument. The results of the analysis showed an inter-rater reliability coefficient of 0.80, which falls within the high category, indicating that the assessments provided by both assessors demonstrated a good level of consistency (Cole, 2024).

Data Analysis Techniques

Data analysis was carried out quantitatively using SPSS statistical software. The stages of data analysis included:

1. Paired Sample T-Test

This test is used to measure the significance of the difference in mean scores between the pre-test and post-test. This test is based on the assumption that the data are normally distributed. If the p-value obtained is less than 0.05 ($p < 0.05$), it is concluded that there is a significant effect of the implementation of the learning model on the improvement of students' argumentation skills (Zin et al., 2025). This method is considered the most accurate for repeated-measures designs on the same sample group (Denny et al., 2023).

In addition to testing statistical significance, this study also used Cohen's d to measure the magnitude of the impact of the learning model's implementation on the improvement of students' argumentation skills. Cohen classifies effect sizes as small ($d = 0.2$), moderate ($d = 0.5$), and large ($d > 0.8$) (Sullivan & Feinn, 2023).

2. N-Gain Test (Normalized Gain)

Improvements in argumentation skills can be assessed more specifically through Normalised Gain (N-Gain) analysis. N-Gain is a measure used to determine the extent of improvement in students' learning abilities following instruction (Sugiyono, 2013), calculated by dividing the difference between the post-test and pre-test scores by the difference between the maximum ideal score and the pre-test score (Gustanti et al., 2025). The formula used is as follows (Sukarelawan et al., 2024):

$$N_{Gain} = \frac{\text{Posttest Score} - \text{Pretest Score}}{\text{Ideal Score} - \text{Pretest Score}}$$

N-Gain scores are categorised as: High ($0.70 \leq g \leq 1.00$), Moderate ($0.30 \leq g \leq 0.70$), and Low ($0.00 \leq g \leq 0.30$). This analysis provides a clear picture of the extent of improvement in students' conceptual understanding following the intervention (Sukarelawan et al., 2024).

3. Analysis of student responses

Student responses to the learning process were analysed using the percentage of questionnaire scores. This technique measures the level of student acceptance and engagement with the Nearpod platform and the inquiry-based model implemented, with interpretation categories ranging from "Very Poor" to "Very Good." (Norahim et al., 2025). Before its use in the study, the questionnaire was validated by validators and demonstrated valid categories, thereby rendering it suitable for use in the study

RESULT AND DISCUSSION

Students' scientific argumentation skills were measured using pretest and posttest scores obtained before and after the learning process. The measurement results indicate a difference in students' scientific argumentation abilities between the initial condition and after the learning process was implemented. The changes in pretest and posttest scores suggest an improvement in students' scientific argumentation skills in the components of claim, data, and warrant, as shown in the following graph.

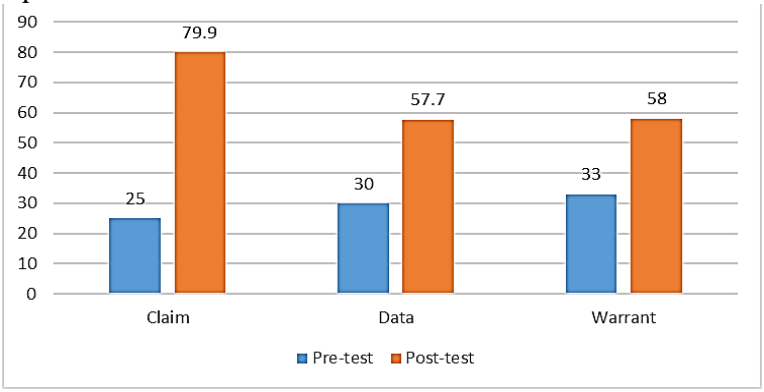

Figure 2. Students' N-gain Scores for Each Indicator

The results showed that students' average score on scientific argumentation skills increased significantly following the implementation of Guided Inquiry using Nearpod. The substance of this increase is reflected not only in numerical scores but also in a shift in students' thinking from reliance on factual answers to the skill of systematically structuring claims, data, and warrants. Research by (Ula et al., 2025b), found that Guided Inquiry directly improved students' argumentative skills in science learning, especially in knowledge interpretation and evidence-supported claims. This shows that, through the inquiry process, students not only gain conceptual knowledge but are also trained to assemble more logical, data-based arguments (Telenius et al., 2020). The improvement in students' scientific argumentation skills is more evident when analyzed using N-gain scores, which indicate the change in students' ability after learning relative to the initial condition.

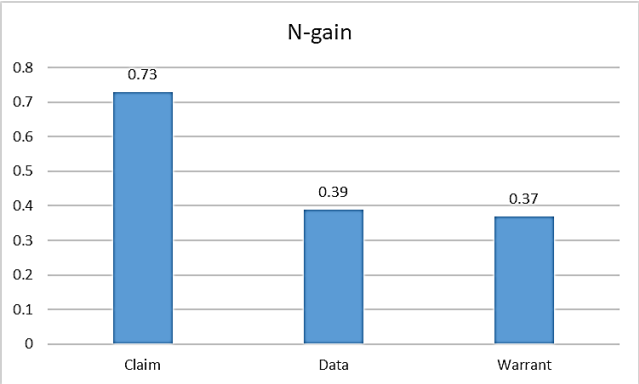

Figure 2. Student N-gain Score of each Indicator

The analysis of N-gain for each argumentation skill indicator revealed differences among the indicators. Overall, the average N-gain class was 0.65 (medium). The claim indicator shows a relatively high increase in N-gain, meaning that students experience significant development in expressing their opinions or initial conclusions about a problem. The skill of making claims is the first step in argumentative thinking. This shows that, through Guided Inquiry, students become more confident and are better at formulating main ideas (Indriana, 2025). Previous research has also confirmed that inquiry-based learning encourages students to be more courageous and skilled in making their initial claims (Clevenger et al., 2023; Salsabila et al., 2025). According to Erduran et al (2004). The skill of stating claims is the initial capital of argumentative thinking and a crucial phase that needs to be developed early in science learning. In the second indicator, students can present evidence or data to support the previous statement. Despite an increase in learners' ability to search, select, and use evidence, growth in this aspect is not as high as claimed. This can happen because compiling data as scientific evidence requires more complex information processing and interpretation skills. Research by Asriyani et al. (2023), shows that learners often have difficulty linking the data to their claims, even though they can structure claims well. The third indicator is warrants. Students can provide supporting reasons that connect claims to data. The increase in this indicator has also increased, but it is not as high as claimed. A warrant is a reasoning that connects claims to data, which is often considered the most difficult component of an argumentative structure (Toulmin, 2003). This skill requires learners not only to convey opinions and evidence, but also to understand the logical relationship between the two.

According to Zairina & Hidayati (2022) , scientific reasoning (warrant) is a high-level thinking skill that often poses a major challenge for many students, as it requires abstract thinking and deep reflection. This is in line with the findings of other research that show that inquiry-based learning models allow students to develop their ideas with evidence, process data, and actively construct and present arguments rather than just passively answering questions (Hasanah et al., 2022; Nazidah et al., 2022; Salsabila et al., 2025). The paired t-test results ($p < 0.001$) reported by Ula et al. (2025b) not only indicate statistical effectiveness but also align with previous studies demonstrating that Guided Inquiry and other argumentation-based models consistently enhance students' argumentation skills. As shown in Table 1, the t-test results on the evidence and warrant indicators reveal significant differences between the groups studied.

Table 1. Paired Sample t-Test Results

Argumentation Test	N	t	df	Mean	SD	Normality Test		Paired Sample t-Test	
						Sig.	Conclusion	Sig.	Conclusion
Pretest	31	-35.36	30	40.65	4.95	0.251	Normal Distribution	<0.001	Significant Differences
Posttest				79.06	4.21	0.130	Normal Distribution		

A significant increase in argumentation skills goes beyond just higher grades; it means students no longer merely create information but construct their own knowledge through a series of arguments (Hasanah et al., 2022). The Guided Inquiry model provides a systematic learning stage and focuses on students' cognitive activities, thereby encouraging the gradual development of scientific argumentation (Santri et al., 2023). At the problem orientation stage, students encounter contextual problems that challenge their thinking, prompting the emergence of initial claims as their first response to the situation or problem (Sampson et al., 2021). Furthermore, at the stage of formulating problems and hypotheses, students are trained to formulate basic assumptions and reasons that will be tested through the learning process, so that they begin to

get used to formulating logical reasons before obtaining data. The data collection and analysis stage then provides concrete experience in selecting, processing, and validating information as evidence to support claims, reinforcing the structure of the developed argument (Sampson et al., 2013). Finally, at the conclusion-drawing stage, students are required to synthesize all the information obtained and maintain a logical warrant for the claims they make, so that argumentation skills are not only improved in theory but also reflected in the practice of scientific thinking as a whole. Research studies show that this kind of structure is effective in building the quality of students' argumentation (Salsabila et al., 2025; Ula et al., 2025b). In line with the constructivist theory of learning, where learning is the process of building knowledge. This knowledge is transferred and acquired based on students' understanding of the process they go through (Wibowo et al., 2025). This stage helps students build their understanding of heat transfer material, which is introduced with an overview of argumentation indicators: claims, evidence, and warrants.

Nearpod is an interactive digital learning platform that facilitates active student engagement and provides scaffolding through interactive features in Guided Inquiry learning. These features support data collection, evidence analysis, and student reasoning in building scientific arguments that include claims, evidence, and warrants (Violita & Irawan, 2025). Research by Ahmed & Elmubark (2022) on polling and real-time collaboration, which enables teachers to monitor and adjust the learning process in real time according to student needs. This aligns with findings that Nearpod can improve student engagement and learning outcomes when combined with a learning approach that supports active engagement (interactive learning) and students' reflection on the subject matter (Astrini et al., 2024).

In addition, the study by Apriana et al., (2025), shows that Nearpod is effective for formative assessment and for developing collaborative activities necessary for learning scientific argumentation centered on claims, evidence, and warrants. The use of Nearpod allows teachers to provide instant feedback on students' answers and to use that data to adjust learning scaffolding, so students can gradually structure, assess, and revise their arguments with the teacher's guidance (Ahmed & Elmubark, 2022). This feature also reinforces aspects of social interaction and collaborative learning, as students can see each other's ideas and responses in real time and discuss them in an active classroom context (Pramesti & Camellia, 2024).

CONCLUSION

Based on the research that has been conducted on the application of the Guided Inquiry Learning learning model assisted by Nearpod in students in grades VII-I MTs Negeri 3 Surabaya, there is an increase in scientific argumentation skills in learning heat materials and their displacement. The results showed an increase in the ability of students to prepare scientific arguments that included claims, data, and *warrants* in a more structured manner after treatment. Statistical tests using *paired sample t-tests* showed a significant difference between *pretest* and *posttest scores* ($p < 0.001$), and the average value of N-gain was in the medium category. The percentage of implementation at the time of the meeting was in the very good category. These findings indicate that *Guided Inquiry Learning* is able to encourage students' active involvement in the process of inquiry, data analysis, and scientific reasoning. The use of Nearpod is able to help students formulate initial claims from observations, explore students' initial ideas, and encourage the giving of reasons for students' answers, strengthen students' understanding in the preparation of scientific arguments, and facilitate discussions to relate data to claims through scientific argumentation. Thus, the integration of inquiry learning and digital technology can be an effective learning strategy to improve the quality of science learning and develop students' scientific argumentation skills.

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