



Argumentation in Science Learning: Strategies and Opportunities

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Article Info	Abstract
Article history: Received: March 4, 2025 Accepted: May 15, 2025 Published: May 31, 2025 Keywords: Argumentation Literature review Science Students This article is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License. © 2025 Journal of Mathematics, Science, and Computer Education	This study aims to determine trends in a research article that measures argumentation skills carried out by students in science learning. This is important to know because argumentation is an important skill to be mastered by students. This research was conducted using a meta-analysis approach of relevant research articles. The articles used as samples in this study are articles published in the range of 2022 to 2024. The analysis found that research measuring students' argumentation skills in science learning was mostly published in 2023 and conducted at the junior high school level. The learning model most applied by researchers is the conventional learning model, with the data collection instrument in the form of essay tests. The assessment instrument most widely used by researchers to measure students' argumentation skills is based on TAP indicators with quantitative data analysis techniques.
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INTRODUCTION

The field of education plays an important role in preparing quality human resources to face global competition ([Hasanah et al., 2022](#); [Mardhiyah et al., 2021](#)). In order to produce globally competitive human resources, educators are required to strive and support students to have skills that have been adapted to the demands of the 21st century, known as the 4Cs, namely, critical thinking, communication, collaboration, and creative thinking ([Hidayatullah et al., 2021](#)). One of the supporters of achieving these skills is honing and developing students' skills in argumentation ([Riwayani et al., 2019](#)). The importance of argumentation skills for students makes this skill one of the indicators measured in the PISA science literacy ([OECD, 2023](#)).

In learning activities, the curriculum is a reference and tool for educators to organize effective learning. The independent curriculum aims to prepare Indonesia's golden generation by providing freedom in determining learning activities and achieving and strengthening students' 21st-century skills ([Mongkau et al., 2024](#)). Therefore, argumentation skills are important in the Merdeka Curriculum because argumentation skills directly support the achievement of this goal. Learners' argument skills are a step in

implementing the independent curriculum to produce an Indonesian generation with strong thinking skills ([Firdaus et al., 2024](#)).

Argumentation skills cannot be separated from science learning, in which some concepts need to be proven correct ([Hasanah et al., 2022](#)). Argumentation skills are one of the important skills for students to master ([Sinambela et al., 2023](#)). Argumentation can be defined as the ability to express opinions, ideas, or ideas that are in their minds based on accurate concepts ([Miaturohmah & Fadly, 2020](#)). Argumentation encourages students to externalize and reflect on the results of their reasoning/thinking, so that by arguing, students can develop metacognition and higher-order thinking skills ([Haruna & Nahadi, 2021](#)). This skill involves defending claims, evaluating them, responding to counterarguments, and drawing conclusions ([Drymiotou et al., 2021](#); [Noroozi, 2022](#)). In science education, the ability of learners' argumentation to support claims with real evidence is an important point, where learners need to collect empirical data and then explain a scientific concept by observation or experiment ([Guilfoyle et al., 2021](#)).

Argumentation skills cannot be separated from science learning because science learning is about mastering knowledge in the form of facts, concepts, or principles, and a discovery process ([Hasanah et al., 2022](#)). Learners' ability to validate evidence of discovery in science concepts plays an important role in argumentation reasoning, which is critical for learners' concept mastery ([Miralda-Banda et al., 2021](#)). Based on this, argumentation skills in science learning are important to be explored and developed ([Tanfiziyyah & Rochintaniawati, 2021](#)). A learning model framework is needed to explore and develop students' argumentation skills in science learning. With various appropriate learning models, argumentation skills can be trained and developed properly ([Fatmawati et al., 2018](#)).

Many studies have raised the issue of argumentation skills in science learning. This shows that the topic triggers the curiosity of researchers to understand it more deeply. Although the topic of students' argumentation skills in science learning has been widely researched, the variety of research is very diverse, but the research that unites the various findings has not been carried out, so there is no complete and integrated understanding. This implies the need for further research to bring together various findings from previous research to provide a holistic understanding.

In exploring and developing argumentation skills, researchers consider several other variables, namely, the level of education, data collection instruments, and data analysis techniques from the sample of research articles used regarding students' argumentation in science learning. In addition to considering the variables of the learning model applied and its assessment instruments, researchers also consider several other variables.

Research that reviews articles about argumentation has been done; some of these studies were conducted by [Mulyani et al. \(2024\)](#). This research was conducted based on chemistry, physics, and biology lessons, with the research trends being the country of origin of the articles studied, research areas, research methods, research subjects, learning interventions, and types of argumentation. Then, research was conducted by [Bubikova-Moan and Sandvik \(2022\)](#) on early childhood to unify research and provide a theoretical explanation of the origin and early development of the human ability to argue.

The novelty of this research is that it focuses on reviewing argumentation in science learning with aspects of research trends that focus on variables of education level, learning models applied, data collection instruments, assessment instruments, and data analysis techniques from samples of research articles on student argumentation in science learning. In addition, this study includes the latest articles as samples in research that have not been used in previous studies.

METHODS

This study used a meta-analysis approach to review information about articles that discuss argumentation issues in science learning over the past three years, from 2022 to 2024. The articles that become samples in this study focus on topics that specifically discuss the issue of argumentation in the context of science learning, so articles that discuss argumentation in general or discuss science teaching without mentioning the argumentation skills of students are not used in this study. Samples from this study must also be published in research articles; other types of publications, such as books and non-research reports, cannot be used. The articles reviewed are indexed by Scopus, Google Scholar, and Science and Technology Index (SINTA). Articles that were used as samples in this study are articles that have gone through three stages, namely: (1) identification and screening, (2) eligibility, and (3) inclusion (Putri et al., 2022). The screening stage was carried out using the Publish or Perish (PoP) application to find relevant articles indexed by Google Scholar and Scopus. By limiting the article search to only SINTA-indexed articles, SINTA-indexed articles were identified on the Google Scholar website. The screening stage was carried out in accordance with the characteristics determined at each stage. The results of the screening stage can be seen in Table 1.

Table 1 Article screening

Stages	Characteristics	Number of Articles
Identification and Screening	a. The scope of research is argumentation conducted in Indonesia	974 <i>Google Scholar</i> 400 <i>Scopus</i>
	b. Publication year 2022-2024	338 SINTA
Eligibility	Discussing students' argumentation in learning	500 <i>Google Scholar</i> 47 <i>Scopus</i> 125 SINTA
Inclusion	Discussing the argumentation of students in science learning	51 <i>Google Scholar</i> 6 <i>Scopus</i> 14 SINTA

Based on Table 1, over the past three years, many research articles have discussed argumentation in general and research conducted within the scope of education. However, in this study, the articles used as research samples focus on discussing students' argumentation skills in science learning because science learning is one of the sciences that cannot be separated from argumentation skills (Hasanah et al., 2022). After going through the screening stage, it is known that 71 samples of articles indexed by Google Scholar, Scopus, and SINTA were analyzed based on several trends, namely the level of education, the learning model, the data collection instrument, the assessment instrument in the research, and the data analysis technique. The analysis was done manually by reading all article samples so that each variable and its percentage in each trend analyzed are known.

RESULTS AND DISCUSSION

The determination of the year limit of the article to be used as a sample in the study was adjusted to the time when the latest curriculum was implemented, namely, the independent curriculum. This is because in the independent curriculum, there are elements of science process skills in the learning outcomes in science subjects that require argumentation skills to support the realization of these science process skills (Triani et al., 2023).

The number of publications in the last three years is shown in Figure 1. Based on Figure 1, it can be seen that articles discussing students' argumentation skills in science learning were mostly conducted in 2023, with as many as 32 articles, and the least in 2022, with as few as 18 articles.

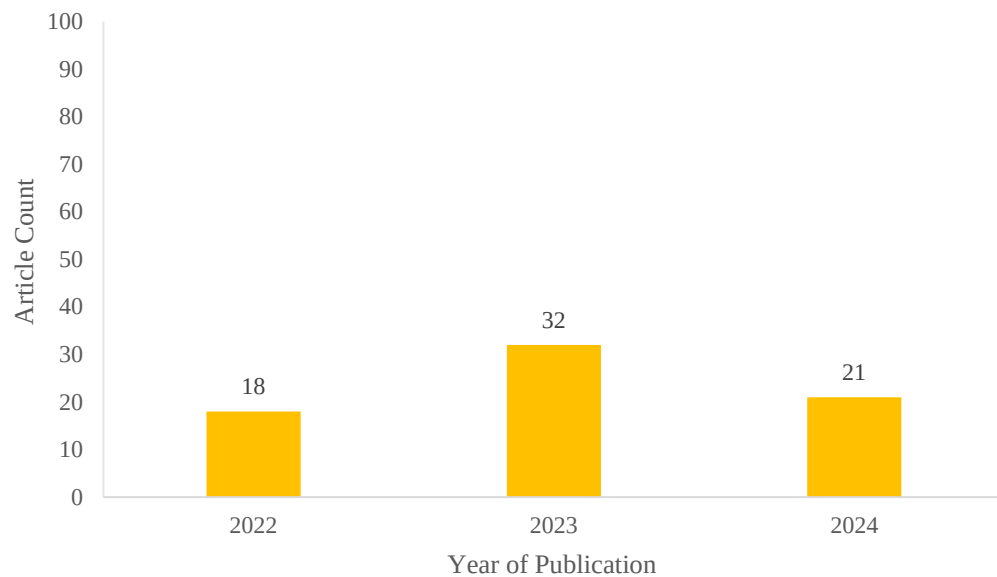


Figure 1 Number of publications in the last three years

Education Level Trends

Table 2 shows that junior high school is the most popular level of education for research on students' argumentation skills in science learning.

Table 2 Level of education in the study

Education Level	Number	Percentage
Elementary School	4	5.6%
Junior High School	39	54.9%
Senior High School	25	35.2%
Higher Education	3	4.2%
Total	71	100%

The number of studies conducted at the junior high school level can occur because, during junior high school, students enter the developmental stage of formal operations (formal operational). At this stage of development, learners think in a more abstract, logical, and idealized way. The junior high school period is important in students' cognitive development, so researchers assume that this junior high school period is the most appropriate period for growing and improving students' argumentation skills. Learners' argumentation skills show that learners can use logic and evidence to support their opinions.

Learning Model Trends

Researchers apply various learning models to measure students' argumentation skills. These learning models are shown in Table 3. Based on Table 3, the learning model widely used to support students in arguing in science learning for the last 4 years is the conventional learning model. The number of researchers using this learning model is in line with the number of educators who apply the conventional learning model in the classroom, so through the research conducted, it is able to provide an evaluation or reflection picture as material for improvement for educators ([Jemalu, 2021](#)).

Table 3 Learning model in research

Learning Models	Frequency	Percentage
Conventional Learning	16	22.5%
Socio Scientific Issues (SSI)	12	16.9%
Argument Driven Inquiry (ADI)	8	11.3%
Problem Based Learning (PBL)	8	11.3%
Discovery Learning	4	5.6%
Project Based Learning (PJBL)	3	4.2%
Cooperative Learning	2	2.8%
Engineering Design Process (EDP)	2	2.8%
Inquiry Learning	2	2.8%
Science, Technology, Engineering, and Mathematics (STEM)	2	2.8%
STEM-EDP	2	2.8%
Teams Games Tournament (TGT)	2	2.8%
Argument-Based Science Inquiry	1	1.4%
Collaborative Learning	1	1.4%
Cooperative Integrated Reading and Composition (CIRC)	1	1.4%
Etnoscience Learning	1	1.4%
Predict Observe Explain (POE)	1	1.4%
Problem Solving	1	1.4%
Real Time Streaming Protocol (RTSP)	1	1.4%
Science Argumentation Diagram	1	1.4%
Total	71	100%

After further analysis, unfortunately, some studies show that students' argumentation skills in science learning are of low quality. This happens because the conventional learning model is a learning model that is still teacher-centered, so the teacher is not optimal in providing a forum for students to develop their argumentation skills ([Hardini & Alberida, 2022](#)). This learning model makes students less able to pay attention to the meaning of the learning process, so they are less optimal in conveying their arguments ([Arfiany et al., 2021](#)).

Data Collection Instrument Trends

The types of instruments can be seen in Table 4.

Table 4 Data collection instrument in research

Data Collection Instruments	Number	Percentage
Essay	30	42.2%
Worksheet	8	11.3%
Interview	7	9.8%
Essay and Questionnaire	4	5.6%
Relevant Articles	3	4.2%
Essay and Observation Sheet	3	4.2%
Interview, Questionnaire, and Observation Sheet	3	4.2%
Interview and Essay	2	2.8%
Interview, Essay, and Observation Sheet	2	2.8%
Interview, Essay, and Questionnaire	2	2.8%
Observation Sheet	2	2.8%
Interview and Observation	1	1.4%
Interview and Questionnaire	1	1.4%
Learning Audio Recordings	1	1.4%
Observation Sheet, Video, Audio Recordings	1	1.4%
Science Practicum Report	1	1.4%
Total	71	100%

Based on Table 4, the data collection instrument most widely used by researchers is the essay task instrument, which is used without being accompanied by other instruments. The highest percentage value evidences this compared to the percentage of other instruments, namely 42.2%. Essay assignments help students convey their thinking arguments broadly ([Ahmad & Maysarah, 2023](#)). Essay assignments can also facilitate data analysis, considering argumentation can be written or oral. Through essay assignments, researchers will obtain samples of students' argumentation in writing, making it easier to assess than oral argumentation.

Assessment Instrument Trends

As part of science, argumentation learning requires assessment instruments, but these are still very limited ([Zaroh et al., 2022](#)). Based on this, argumentation assessment instruments still need to be developed. The model applied in learning will affect the determination of the argumentation assessment instrument used.

Based on the analysis, interesting results have been obtained regarding measuring students' argumentation skills in science learning. This is because only a few types of argumentation assessment instruments, compared to learning models and data collection instruments, are used by researchers to measure students' argumentation skills in science learning. The assessment instruments can be seen in Table 5.

Table 5 Assessment of the instrument in research

Assessment Instrument	Number	Percentage
TAP indicator	62	87.3%
Review the rubric argumentation	5	7.0%
Counterargumentation pattern	1	1.4%
Indicators of critical thinking	1	1.4%
Argumentation score criteria	1	1.4%
Indicators of science process skills and argumentation	1	1.4%
Total	71	100%

Based on Table 5, it can be seen that researchers mostly use Toulmin's Argument Pattern (TAP) indicators. This model analyzes students' argumentation skills ([Wisutama et al., 2024](#)). The large use of this model as an instrument for assessing argumentation can occur because TAP is a technique that has become the basis for previous researchers in examining argumentation ([Lobczowski et al., 2020](#)). This technique is considered a qualified and clear technique in analyzing an argument.

Data Analysis Techniques Trends

Table 6 shows the techniques used to analyze data on students' argumentation skills in science learning.

Table 6 Data analysis techniques in research

Data Analysis Techniques	Number	Percentage
Qualitative	10	14.1%
Quantitative	44	62.0%
Mixed methods	17	23.9%
Total	71	100%

Table 6 shows that researchers mostly analyze data using quantitative techniques. This happens because research that uses quantitative techniques can provide more measurable information in the presence of data that is used as the basis for producing information ([Rustamana et al., 2024](#)).

In research, quantitative research methods use data in the form of numbers to answer questions in research and play an important role because of their ability to produce objective and statistically measurable data ([Al-Qaisi, 2023](#); [Gnawali, 2022](#)). Quantitative research methods have been superior in various research fields since the 19th century and throughout the 20th century. The advantages of quantitative methods are that they have a high degree of objectivity because they are based on numerical data that can be measured objectively and avoid subjectivity bias, and data processing is faster because it can be done with the help of statistical software ([Waruwu et al., 2025](#)).

Most of the research results obtained from quantitative data analysis techniques are in the form of qualifications or level categories that show that students' argumentation skills in science learning are low, medium, high, or very poor, poor, sufficient, good, very good, and so on. This can be seen in research conducted by [Yahya et al. \(2022\)](#), [Yudistira and Fauziah \(2023\)](#), [Putri et al. \(2024\)](#), and other relevant research.

CONCLUSION

This study aims to analyze the variables trend in an article whose research aims to measure students' argumentation skills in science learning from 2022 to 2025. Based on the results of this analysis, it is known that research measuring students' argumentation skills in science learning over the past 4 years was published in 2023 and conducted at the junior high school level. The learning model most applied by researchers is the conventional learning model with the data collection instrument in the form of essay tests. The assessment instrument most widely used by researchers to measure students' argumentation skills is based on TAP indicators with quantitative data analysis techniques. Although this study has limitations in that the articles sampled in this study are only articles that discuss the issue of argumentation in science learning for the last 3 years, this study can provide a holistic understanding of argumentation skills in science learning and the results of this study can be a consideration for educators, especially in designing lessons that will improve students' argumentation skills in science learning.

CONFLICTS OF INTEREST

The authors declare that the research and data published in this article have no conflict of interest with any party.

AUTHOR CONTRIBUTIONS STATEMENT

The completion of writing this scientific article cannot be separated from the cooperation of the writing team, who carry out their respective duties responsibly. A.A. conducted the research, processed the data, drew conclusions, and wrote the manuscript with the help of SS, NF, AH, MS, and TT, who helped proofread the article's preparation and provided corrective feedback until the final manuscript was approved.

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