Jambura Journal of Educational Chemistry
Volume 8 Issue 2, August 2026
p-ISSN: 2655-7606, e-ISSN: 2656-6427
Journal Homepage: http://ejurnal.ung.ac.id/index.php/jjec

Students' Scientific Argumentation in Ethno-Thermochemistry: A Toulmin-Based Analysis Across Argumentation Levels

Nur Widia Ky. Martam[1], Lukman Abdul Rauf Laliyo[1]*, Thayban Thayban[1], Astin Lukum[1], Julhim S. Tangio[1]

[1]Department of Chemistry, Universitas Negeri Gorontalo, Gorontalo 96554, Indonesia

Article Info

Article history:
Received: 29-04-2026
Revised: 30-05-2026
Accepted: 31-05-2026
Available online: 01-08-2026

Keywords:
Scientific Argumentation; Toulmin Argument Pattern; Ethno-Thermochemistry; Argumentation Skills; Chemistry Education

***Corresponding author:**
lukman.laliyo@ung.ac.id

Abstract

Low students' scientific argumentation skills remain a concern in chemistry learning because students are required not only to understand concepts but also to explain phenomena logically, based on evidence, and in accordance with scientific principles. In thermochemistry learning, ethno-thermochemistry contexts can help students connect abstract energy transformation concepts with cultural phenomena closely related to their daily lives. However, studies investigating students' scientific argumentation skills within ethno-thermochemistry contexts, particularly based on the components of the Toulmin Argument Pattern (TAP), are still limited. Therefore, this study aims to analyze students' scientific argumentation skills in ethno-thermochemistry learning using TAP. This study employed a descriptive quantitative design involving 101 high school students. Data were collected through a multiple-choice test consisting of 36 items representing six ethno-thermochemistry phenomena. The instrument measured six argumentation components, namely claim, grounds, warrant, backing, qualifier, and rebuttal. The results revealed a consistent pattern in students' argumentation, with high achievement in lower-level components (claim: 65–77%) and moderate achievement in grounds and warrant, followed by a significant decline in higher-level components, particularly backing, qualifier, and rebuttal (25–40%). These findings indicate that students are able to construct initial ideas and basic justifications but still experience difficulties in evaluative reasoning. Furthermore, ethno-thermochemistry contexts appear to support contextual understanding and activate students' prior knowledge, but they have not been optimal in promoting higher-order argumentation skills. This study emphasizes the importance of explicit argumentation scaffolding in ethno-thermochemistry-based chemistry learning to support students' scientific reasoning.

How to Cite: Martam, N. W. K., Laliyo, L. A. R., Thayban, T., Lukum, A., & Tangio, J. S. (2026). Students' Scientific Argumentation in Ethno-Thermochemistry: A Toulmin-Based Analysis Across Argumentation Levels. *Jambura J. Educ. Chem.*, *8*(2), 189-196. https://doi.org/10.37905/jjec.v8i2.38541

1. INTRODUCTION

Chemistry is widely recognized as a discipline that involves abstract concepts requiring students to integrate multiple levels of representation, namely macroscopic, microscopic, and symbolic forms. This complexity often creates substantial learning difficulties, particularly when students are unable to establish meaningful connections among these representations. As a result, misconceptions frequently arise, especially in topics that involve invisible processes and energy transformations (Andriani et al., 2025; Hendratmoko et al., 2023a; Sulistina et al., 2024). One such topic is thermochemistry, which is considered challenging due to its emphasis on energy changes, heat transfer, and enthalpy, all of which cannot be directly observed.

Thermochemistry encompasses several fundamental concepts, including system and surroundings, exothermic and endothermic reactions, and enthalpy changes (Ramli Munasprianto et al., 2022). These concepts require students to understand not only observable phenomena but also underlying energy processes at the molecular level. Previous studies have shown that students frequently experience misconceptions in thermochemistry, particularly in

https://doi.org/10.37905/jjec.v8i2.38541

distinguishing between exothermic and endothermic processes and in identifying the boundaries of systems and surroundings (Sihaloho et al., 2021). These difficulties highlight the need for instructional approaches that can bridge the gap between abstract scientific concepts and students' real-life experiences.

One promising approach to addressing this issue is the integration of ethnoscience into chemistry learning. Ethnoscience refers to the way local communities interpret, classify, and understand natural phenomena based on cultural practices, traditions, and accumulated knowledge passed down through generations (Khoriyah Nur Fatimah et al., 2025; Munandar et al., 2024; Prayogi et al., 2023). In the context of science education, ethnoscience provides a meaningful framework for connecting scientific concepts with culturally relevant experiences, thereby making learning more contextual and accessible (Dewi et al., 2019).

In thermochemistry, many everyday cultural practices inherently involve energy transformations and heat transfer processes. For example, traditional cooking methods such as boiling, steaming, grilling, and smoking food represent real-world applications of thermochemical principles. In the Gorontalo context, local foods such as binte biluhuta (boiling process), ilabulo and bilenthango (grilling process), ikan fufu (smoking process), and tili aya and kolombengi (steaming and baking processes) illustrate various forms of heat transfer and energy exchange. These culturally embedded practices provide authentic contexts that can help students understand how thermochemical processes occur in everyday life.

However, understanding contextual phenomena alone is not sufficient to ensure deep conceptual learning. Students must also be able to explain these phenomena scientifically by constructing logical and evidence-based arguments. Scientific argumentation plays a crucial role in this process, as it enables students to articulate claims, support them with evidence, and justify their reasoning based on scientific principles (Harianto et al., 2025; Moju et al., 2025). Through argumentation, students develop critical thinking skills and learn to evaluate the validity of ideas, which are essential competencies in science education.

Scientific argumentation can be systematically analyzed using the Toulmin Argument Pattern (TAP), which consists of six key components: claim, grounds (data), warrant (reasoning), backing (support), qualifier, and rebuttal (Toulmin, 1958). This framework provides a comprehensive structure for assessing the quality of students' arguments, ranging from basic assertions to complex evaluative reasoning. In educational contexts, the TAP framework has been widely used to examine students' ability to construct and justify scientific explanations (Putri & Rohaeti, 2025). The use of the Toulmin Argument Pattern (TAP) in this study is relevant because the context of ethno-thermochemistry requires students not only to understand local cultural phenomena but also to explain these phenomena using scientific concepts of thermochemistry. Therefore, TAP was selected because it is capable of analyzing the relationships among each TAP component, enabling students to construct their arguments systematically when interpreting ethno-thermochemistry phenomena.

Despite its importance, numerous studies have reported that students' scientific argumentation skills remain relatively low. Students tend to focus on making claims without adequately supporting them with evidence or logical reasoning. For instance, previous research found that while a majority of students could formulate claims, only a small proportion were able to provide supporting data, and even fewer demonstrated the ability to include qualifiers or rebuttals in their arguments (Turós et al., 2025). Similarly, other studies have shown that although students may achieve moderate performance in claim, grounds, and warrant components, their ability to provide backing and engage in evaluative reasoning remains significantly underdeveloped (Agusni Pratiwi et al., 2023).

These findings suggest that students are generally capable of constructing basic arguments but struggle to develop higher-order argumentation skills. This limitation indicates that current instructional practices may not sufficiently support the development of critical and evaluative thinking. While contextual approaches such as ethnoscience can enhance students' engagement and conceptual understanding, their impact on advanced argumentation skills remains unclear.

Furthermore, existing research on ethnoscience in science education has primarily focused on improving conceptual understanding and scientific (Wiratma & Yuliamiastuti, 2023), with limited attention given to its role in developing scientific argumentation. In particular, studies that specifically examine argumentation skills within the context of ethno-thermochemistry are still scarce. This represents a significant research gap, as integrating cultural contexts with argumentation frameworks has the potential to enhance both conceptual understanding and higher-order thinking skills.

In addition, previous studies indicate that familiarity with contextual phenomena does not automatically lead to improved critical thinking or argumentation abilities (Sihaloho et al., 2021). Students may be able to describe observable processes but often lack the ability to explain underlying mechanisms or evaluate alternative explanations. This highlights the need to investigate how ethnoscience-based contexts influence different levels of argumentation, particularly in terms of higher-order components such as qualifier and rebuttal.

Therefore, this study aims to analyze students' scientific argumentation profiles in the context of ethno-thermochemistry learning. By examining students' performance across the six components of the Toulmin Argument Pattern, this research seeks to identify patterns in argumentation skills and determine the extent to which ethnoscience contexts support different levels of reasoning.

The findings of this study are expected to contribute to the field of chemistry education in several ways. First, they provide empirical evidence on the effectiveness of ethnoscience in supporting scientific argumentation. Second, they highlight specific areas where students require further instructional support, particularly in higher-order reasoning. Finally, the results offer insights for designing more effective learning strategies that integrate contextual approaches with explicit argumentation training, thereby promoting deeper and more meaningful learning in thermochemistry.

2. METHOD

a. Research Design and Participants

This study employed a descriptive quantitative (non-experimental) design. The research was conducted during the even semester of the 2025/2026 academic year in February 2026 and aimed to profile students' scientific argumentation skills in the context of ethno-thermochemistry learning. This design was chosen because the study systematically describes students' argumentation skills based on measurable components.

The research was conducted at SMA Negeri 1 Telaga Biru, Gorontalo, Indonesia. The participants consisted of 101 high school students from grades XI and XII enrolled in the science track (MIPA). The sample was selected using a purposive sampling technique, considering that the students had already studied thermochemistry and were familiar with cultural practices relevant to the ethnoscience contexts used in this study.

Demographically, the participants shared relatively similar socio-cultural backgrounds closely related to local Gorontalo traditions. This homogeneity provided a suitable context for examining the relationship between ethnoscience-based phenomena and students' scientific argumentation skills.

b. Research Instrument

The instrument used in this study was a multiple-choice test developed to assess students' scientific argumentation based on the Toulmin Argument Pattern (TAP) framework. The test consisted of 36 items distributed across six ethnoscience-based phenomena relevant to students' daily experiences, namely binte biluhuta, ilabulo, ikan fufu, tili aya, kolombengi, and bilenthango. These contexts were selected to represent various thermochemical processes such as heat transfer, energy transformation, and phase changes within culturally familiar settings.

Each item was designed to measure six components of scientific argumentation: claim, grounds, warrant, backing, qualifier, and rebuttal. The tiered format allowed students not only to select answers but also to demonstrate their reasoning processes, making it suitable for capturing the structure and depth of their arguments. Students' responses were scored using a dichotomous scoring system (0 and 1), where correct answers received a score of 1 and incorrect answers received a score of 0. The instrument example can be seen in Figure 1.

This phenomenon is used to answer questions 1.1 – 1.6

Binte Biluhuta is a traditional Gorontalo dish made from sweet corn, fish, grated coconut, and spices such as onions, kaffir lime leaves, and lemongrass. The preparation process involves boiling the corn and other ingredients until fully cooked. When freshly prepared, the broth tastes savory and thick, accompanied by a strong aroma. However, after some time, as the dish begins to cool, the broth appears thinner, the savory taste diminishes, and the fat solidifies on the surface. These changes in taste and texture may seem to result merely from normal cooling; however, some argue that they are caused by the transfer of thermal energy between the food and the surrounding air.

(a)

1.1 In your opinion, the cause of the change in temperature and texture of *Binte Biluhuta* is… (***Claim***)
a. Changes in taste and texture are solely the result of water evaporation without the involvement of thermal energy
b. The food releases thermal energy to the environment, causing its temperature and molecular energy to decrease
c. No energy process occurs because the food has already finished cooking
d. The change in texture occurs due to the absorption of energy from the air into the food
e. The cooling process indicates that the food absorbs energy to balance the environmental temperature

(b)

1.2 Evidence supporting the answer to question 1.1 that thermal energy transfer occurs from *Binte Biluhuta* to the environment is… (***Grounds***)
a. Changes in the physical properties of the fat layer in the broth occur as energy decreases
b. The aroma of the spices remains strong even though the temperature gradually decreases
c. The broth becomes thicker due to particle sedimentation at the bottom of the bowl
d. The color and shape of the food remain the same before and after cooling
e. Other answer

(c)

1.3 The statement that explains the reasoning linking questions 1.1 and 1.2—that heat affects the quality of *Binte Biluhuta*—is… (***Warrant***)
a. The energy in the food increases as the surrounding environmental temperature decreases
b. Cooling is not related to energy because no chemical changes occur in the food
c. A decrease in temperature indicates that the kinetic energy of molecules decreases as heat is released to the environment
d. The previous heating reaction causes the temperature to remain constant after cooling
e. Other answer

(d)

1.4 The statement that links thermal energy and changes in food temperature, thereby supporting the answer in question 1.3, is… (***Backing***)
a. The concept of enthalpy states that energy is transferred from the system to the surroundings but is not lost
b. The law of conservation of energy states that the total energy of a system always changes during a reaction
c. The kinetic theory of gases states that all molecules always move at a constant speed
d. Boyle's law explains the relationship between pressure and volume of gases in a closed system
e. Other answer

(e)

1.5 The statement that most appropriately describes the limitation that heat transfer is the primary cause of changes in the texture of *Binte Biluhuta*, but does not universally apply under all conditions, is… (***Qualifer***)
a. Texture changes are entirely determined by cooling, without influence from broth composition
b. Ingredient composition fully determines texture, and heat has no significant role
c. Texture changes occur randomly and cannot be explained through thermal energy mechanisms
d. Texture changes are influenced by heat, but ingredient composition affects the final outcome
e. Other answer

(f)

1.6 Although thermal energy is a major factor in changes in the texture and taste of *Binte Biluhuta*, there are views suggesting that other factors also play a role, such as evaporation, spice mixing, and salt content. The most appropriate scientific statement to describe other conditions influencing changes in texture and taste is… (***Rebuttal***)
a. All changes in texture and taste are solely determined by heat from the fire; ingredients and composition have no effect
b. Cooling still involves the transfer of thermal energy, which affects the texture and taste of the food
c. The texture of the corn and broth changes solely due to the surrounding air temperature, not thermal energy from the cooking process
d. Cooling has no effect whatsoever on the texture of the corn and the taste of the broth; therefore, thermal energy is irrelevant
e. Other answer

(g)

Figure 1. The Instrument example. (a) Phenomenon Ethno-thermochemistry, (b) Claim, (c) Grounds, (d) Warrant, (e) Backing, (f) Qualifer, (g) Rebuttal.

To ensure the quality of the instrument, both content and construct validity were established. Content validity was evaluated through expert judgment involving three chemistry education specialists. The experts assessed each item based on its alignment with Toulmin's argumentation components, clarity of construction, relevance to thermochemistry concepts, and appropriateness of the ethnoscience context. The evaluation indicated that all items were suitable for use, with minor revisions made to improve clarity and contextual accuracy.

Construct validity and item quality were analyzed using the Rasch model. The results showed that most items met acceptable fit criteria, with Outfit Mean Square (MNSQ) values within the ideal range. Additionally, all items demonstrated positive Point Measure Correlation (PTMEA CORR) values, indicating that each item was consistent with the underlying construct of scientific argumentation.

The reliability of the instrument was determined using Cronbach's Alpha, which yielded a coefficient of 0.94, categorized as very high reliability. This result indicates that the instrument has excellent internal consistency and is highly reliable for measuring students' scientific argumentation skills.

c. Data Collection

Data were collected in a single session after students had completed the thermochemistry learning unit. Prior to the test, students were informed about the purpose of the study and given instructions on how to complete the instrument.

The test was administered over 100 minutes, based on prior pilot testing which confirmed that this duration was sufficient for students to read, understand, and respond to all items effectively. During the administration, classroom conditions were maintained to minimize distractions and ensure optimal concentration.

All student responses were collected anonymously to ensure confidentiality and to comply with ethical research standards.

d. Data Analysis

The collected data were analyzed using descriptive statistics, specifically percentages, to determine students' levels of achievement across each component of the Toulmin Argument Pattern.

The percentage of achievement was calculated using the following formula:

$$P = \frac{f}{N} \times 100\% \tag{1}$$

where:
P = percentage of achievement
f = number of students with correct responses
N = total number of students

https://doi.org/10.37905/jjec.v8i2.38541

The results were presented in tabular form and described narratively to illustrate students' overall argumentation profiles across different ethnoscience phenomena.

In addition, a comparative analysis across argumentation components was conducted to identify patterns of progression or decline from lower-order to higher-order reasoning. This analysis aimed to provide a comprehensive understanding of the distribution of students' scientific argumentation skills.

3. RESULT AND DISCUSSION

3.1. Result

The results of this study describe students' scientific argumentation profiles across six ethnothermochemistry phenomena: binte biluhuta (F1), ilabulo (F2), ikan fufu (F3), tili aya (F4), kolombengi (F5), and bilenthango (F6). Students' performance was analyzed based on the six components of the Toulmin Argument Pattern (TAP), namely claim (C), grounds (G), warrant (W), backing (B), qualifier (Q), and rebuttal (R).

Students demonstrated the highest performance in the claim component (65%–77%), followed by moderate performance in grounds and warrant, and a significant decline in higher-order components, particularly backing, qualifier, and rebuttal (25%–40%).

Table 1 presents the percentage of students' achievement across each argumentation component for all six phenomena.

Table 1. Students' scientific argumentation ability across ethnothermochemistry phenomena

Phenomenon	Toulmin Argument Pattern (%)					
	C	G	W	B	Q	R
F1	68	53	44	32	27	25
F2	74	58	54	46	44	36
F3	77	64	57	52	44	40
F4	65	57	54	46	36	35
F5	74	68	61	47	40	35
F6	77	59	50	44	40	39

There were differences in achievement across the TAP components, with claim being the highest-achieved component and rebuttal the lowest. To provide a clearer comparison of the achievement of each argumentation component across the six ethno-thermochemistry phenomena, the data are illustrated in a bar chart in Figure 1.

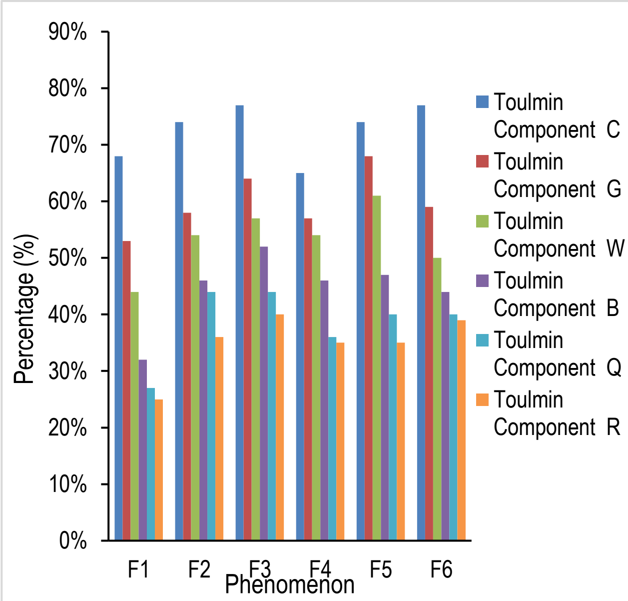

Figure 1. Comparison of toulmin argumentation component achievement in ethno-thermochemistry phenomena

Figure 1 shows a decline in students' scientific argumentation achievement from lower-level components to higher-level components across all ethno-thermochemistry phenomena. The claim component emerged as the most dominant aspect, whereas rebuttal showed the lowest achievement. This pattern indicates that students found it easier to express initial ideas than to develop evaluative and critical arguments. The decline in achievement from warrant to rebuttal also suggests that the more complex the required argumentation structure, the greater the students' difficulty in constructing comprehensive and in-depth scientific reasoning.

Across the six ethnoscience phenomena investigated, variations in achievement also provided important insights. The smoked fish phenomenon (F3) demonstrated the highest overall performance, particularly in claim (77%), grounds (64%), and rebuttal (40%). This indicates that contexts more closely related to students' daily experiences tend to facilitate their ability to connect phenomena with relevant scientific concepts. Nevertheless, even the highest-performing higher-level argumentation component in F3 remained relatively low. This finding emphasizes that contextual learning alone is insufficient to develop advanced argumentation skills.

Another interesting pattern was observed in the kolombengi phenomenon (F5), where students achieved relatively high scores in grounds (68%) and warrant (61%), yet still showed a decline in qualifier (40%) and

https://doi.org/10.37905/jjec.v8i2.38541

rebuttal (35%). This suggests that students were able to understand and explain the phenomenon, but still experienced difficulties in evaluating and critically challenging arguments. The pattern indicates that students were relatively capable of explaining phenomena based on the available information; however, they still struggled to evaluate arguments and consider alternative explanations critically. Overall, the findings indicate that students' scientific argumentation skills were still dominated by basic argumentation components rather than higher-level argumentation components.

3.2. Discussion

The findings of this study reveal a consistent pattern in students' scientific argumentation, where high achievement was observed in lower-level components (claim, grounds, and warrant), but a significant decline occurred in higher-level components (backing, qualifier, and rebuttal). This pattern reflects a fundamental issue in science education related to the development of argumentation skills.

From a structural perspective, the dominance of claim compared to the other components can actually be theoretically predicted. According to (Yang, 2022) claim, data, and warrant constitute the backbone of argumentation, whereas components such as qualifier and rebuttal represent higher-order reasoning that does not always emerge in students' arguments. This explains why students in the present study demonstrated better performance in lower-level components than in evaluative components.

The dominance of the claim component indicates that students were generally able to generate initial responses when confronted with contextual phenomena. This is consistent with the view that argumentation begins with the formulation of claims as the primary element of reasoning. Within Toulmin's framework, a claim represents the conclusion or position that students seek to justify (Beniermann et al., 2021). Furthermore, research in science education has shown that students tend to produce claims more easily because they rely on prior knowledge and intuitive reasoning rather than structured justification (Erduran et al., 2015).

However, the transition from claim to grounds and warrant only demonstrated moderate achievement, indicating that students had begun to connect evidence and reasoning, but not consistently. Argumentation theory emphasizes that grounds (evidence) and warrant (reasoning) are the core structures linking data to claims; however, both components require explicit instructional support to develop optimally (Beniermann et al., 2021). This explains why students in the present study were able to provide basic justification, yet had not reached an optimal level.

A more crucial finding was the decline in achievement in the backing, qualifier, and rebuttal components, which indicates students' limited engagement in higher-level evaluative argumentation. These components require metacognitive abilities such as evaluating claims, considering limiting conditions, and examining alternative explanations. The low achievement in these components suggests that the instruction received by students had not explicitly trained such evaluative skills (Yalçınkaya Önder & Pekmez, 2020). Previous studies have also emphasized that these components are cognitively more demanding and rarely emerge in students' arguments without structured training. For example, research in science education consistently shows that students experience difficulties incorporating rebuttals and qualifiers because these components require evaluative thinking and the consideration of multiple possible explanations (Hendratmoko et al., 2023).

This pattern indicates that students' argumentation skills remain at a descriptive and transitional stage and have not yet reached evaluative reasoning. In line with international research trends, argumentation in science education is often limited to connecting claims and evidence, while the ability to evaluate arguments remains underdeveloped (Erduran et al., 2015). This strengthens the idea that higher-level argumentation does not develop naturally, but rather must be taught explicitly.

From the perspective of scientific practice, argumentation is not merely about expressing opinions, but involves the process of justifying and evaluating knowledge claims based on evidence. Argumentation plays a central role in constructing scientific explanations and knowledge (Sparks et al., 2022). Therefore, the low achievement in backing and rebuttal indicates that students have not been fully engaged in authentic scientific reasoning practices.

Variations across ethnochemistry contexts also provided important insights. The smoked fish phenomenon (F3) demonstrated the highest achievement, indicating that contexts with clearer connections to thermochemistry concepts may facilitate better argument construction. This finding supports previous studies showing that familiar and relevant contexts improve students' ability to generate claims and connect them with evidence. Thus, ethno-thermochemistry functions as an effective starting point for developing argumentation by activating prior knowledge and making abstract concepts easier to understand.

Nevertheless, the findings also indicate that even within the most effective context, higher-level argumentation components remained low. This is consistent with previous studies showing that contextual familiarity alone does not guarantee the development of critical thinking or evaluative reasoning skills. Students may be able to understand and describe phenomena, yet still be unable to critique or refine arguments.

This limitation highlights an important issue in science education, namely the lack of student engagement in argument evaluation practices, such as identifying counterarguments or testing the strength of explanations. Within Toulmin's framework, rebuttal plays a crucial role because it represents the ability to challenge claims and consider alternative perspectives (Beniermann et al., 2021). The absence of this component indicates that students have not yet reached mature scientific reasoning.

Another important implication of this study is that ethnochemistry functions as a contextual bridge rather than a complete instructional solution. Although ethnochemistry is effective in supporting conceptual understanding and initial reasoning, this approach does not automatically develop higher-level argumentation skills. These findings extend previous literature by demonstrating that the impact of contextual learning is level-dependent, meaning that it is effective for basic reasoning but insufficient for more advanced cognitive processes.

4. CONCLUSION

This study reveals a consistent gap in students' scientific argumentation, with strong performance in lower-order components but limitations in higher-order elements such as backing, qualifier, and rebuttal. These findings indicate that students' reasoning remains at the level of knowledge construction rather than knowledge evaluation. While ethno-thermochemistry contexts support initial understanding, they do not sufficiently promote evaluative and metacognitive reasoning. This highlights the level-dependent nature of contextual learning and the need for explicit argumentation scaffolding. The study is limited to a descriptive design and specific context. Future research should explore intervention-based approaches. Policy implications suggest integrating argumentation into curriculum, assessment, and teacher training to strengthen higher-order reasoning skills.

5. ACKNOWLEDGEMENTS

The author expresses sincere gratitude to the students and teachers of SMA Negeri 1 Telaga Biru for their assistance and participation in the data collection process. The author also extends appreciation to the academic supervisors for their significant contributions to the refinement of this research and its publication.

6. REFERENCES

Agusni Pratiwi, Alberida Heffi, Fadilah Muhyiatul, & Fajrina Suci. (2023). Analisis Kemampuan Argumentasi Peserta Didik Pada Pembelajaran Biologi Melalui Model Problem Solving Berbasis Isu Sosiosaintifik. *Jurnal Ilmiah Mandala Education (JIME)*, *9*(3), 2656–5862. https://doi.org/10.58258/jime.v9i1.5748/http

Andriani, N., Supardi, S., & Patriot, E. A. (2025). Evaluating Argumentation Skills: Science Literacy and Scientific Approach in Junior High School. *Jurnal Inovasi Pendidikan IPA*, *11*(1), 284–295. https://doi.org/10.21831/jipi.v11i1.76900

Beniermann, A., Mecklenburg, L., & Upmeier Zu Belzen, A. (2021). Reasoning on controversial science issues in science education and science communication. *Education Sciences*, *11*(9). https://doi.org/10.3390/educsci11090522

Dewi, C. A., Khery, Y., & Erna, M. (2019). An ethnoscience study in chemistry learning to develop scientific literacy. *Jurnal Pendidikan IPA Indonesia*, *8*(2), 279–287. https://doi.org/10.15294/jpii.v8i2.19261

Erduran, S., Ozdem, Y., & Park, J. Y. (2015). Research trends on argumentation in science education: a journal content analysis from 1998–2014. *International Journal of STEM Education*, *2*(1). https://doi.org/10.1186/s40594-015-0020-1

Harianto, B., Pursitasari, I., & Heliawati, L. (2025). Analysis of Students Chemical Literacy through Ethnochemistry Learning in Material Colligative Properties of Solution. *IJIS Edu : Indonesian Journal of Integrated Science Education*, *7*(1), 2025–2065. https://doi.org/10.29300/ijisedu.v7i1.5000

Hendratmoko, A. F., Madlazim, M., Widodo, W., Suyono, S., & Supardi, Z. A. I. (2023a). Inquiry and Debate in Science Learning: Potential Strategy for Improving Students' Scientific Argumentation Skills. *International Journal of Education in Mathematics, Science and Technology*, *12*(1), 114–138. https://doi.org/10.46328/ijemst.3152

Hendratmoko, A. F., Madlazim, M., Widodo, W., Suyono, S., & Supardi, Z. A. I. (2023b). Inquiry and Debate in Science Learning: Potential Strategy for Improving Students' Scientific Argumentation Skills. *International Journal of Education in Mathematics, Science and Technology*, *12*(1). https://doi.org/10.46328/ijemst.3152

Khoriyah Nur Fatimah, Sumarti Susilogati Sri, & Harjono. (2025). Chemistry in Education Development of Ethno-STEM Test Instrument to Equip Chemical Literacy on Thermochemistry Material. *Chemined*, *14*(1). https://doi.org/10.15294/chemined.v14i1

Moju, M., Taylor, L., & Iweuno, B. (2025). Tackling the challenge of chemical representations through sensemaking practices in chemistry education. *Discover Education*, *4*(1). https://doi.org/10.1007/s44217-025-00703-3

Munandar, H., Thayban, T., & Kurniawati, E. (2024). Pendekatan Etnokimia dalam Pendidikan Kimia: Literature Review Terhadap Berbagai Metode dan Penerapannya. *Pentagon : Jurnal Matematika Dan Ilmu Pengetahuan Alam*, *2*(2), 81–89. https://doi.org/https://doi.org/10.62383/pentagon.v2i2.200

Prayogi, S., Ahzan, S., Indriaturrahmi, Rokhmat, J., & Verawati, N. N. S. P. (2023). Dynamic blend of ethnoscience and inquiry in a digital learning platform (e-learning) for empowering future science educators' critical thinking. *Journal of Education and E-Learning Research*, *10*(4), 819–828. https://doi.org/10.20448/jeelr.v10i4.5233

Putri, T. S., & Rohaeti, E. (2025). Scientific Argumentation in Chemistry Education: A Literature Review of Practices. *Challenges, And Solutions. Tarbiyah: Jurnal Ilmiah Kependidikan*, *14*(1), 127–142. https://doi.org/10.18592/tarbiyah.v14i1.14666

Ramli Munasprianto, Saridewi Nanda, Budhi Mustika Tiktik, & Suhendar Aang. (2022). *KIMIA SMA/MA Kelas XI*. Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi. https://buku.kemdikbud.go.id

Sihaloho, M., Hadis, S. S., Kadir Kilo, A., & Akram La Kilo. (2021). Diagnosa Miskonsepsi Siswa SMA Negeri 1 Telaga Gorontalo pada Materi Termokimia. *Jambura Journal of Educational Chemistry*, *3*(1). https://doi.org/https://doi.org/10.34312/jjec.v3i1.7133

Sparks, R. A., Jimenez, P. C., Kirby, C. K., & Dauer, J. M. (2022). Using Critical Integrative Argumentation to Assess Socioscientific Argumentation across Decision-Making Contexts. *Education Sciences*, *12*(10). https://doi.org/10.3390/educsci12100644

Sulistina, O., Rahayu, S., Dasna, I. W., & Yahmin. (2024). Enhancing the scientific argumentation skills of prospective chemistry teacher using integrated chemical literacy strategy. *International Journal of Evaluation and Research in Education*, *13*(6), 4346–4353. https://doi.org/10.11591/ijere.v13i6.26935

Turós, M., Kenyeres, A. Z., Balla, G., Gazdag, E., Szabó, E., & Szűts, Z. (2025). A Toulmin Model Analysis of Student Argumentation on Artificial Intelligence. *Education Sciences*, *15*(9). https://doi.org/10.3390/educsci15091226

Wiratma, I. G. L., & Yuliamiastuti, I. A. A. (2023). Ethnochemistry potential of vines contained in lontar usada taru pramana on students' scientific explanation skills through task-based learning. *Jurnal Pendidikan IPA Indonesia*, *12*(2), 208–220. https://doi.org/10.15294/jpii.v12i2.42826

Yalçınkaya Önder, E., & Pekmez, E. (2020). Argumentation Practices in Science Education. *International Journal of Innovative Approaches in Education*, *3*(4). https://doi.org/10.29329/ijiape.2019.226.1

Yang, R. (2022). An empirical study of claims and qualifiers in ESL students' argumentative writing based on Toulmin model. *Asian-Pacific Journal of Second and Foreign Language Education*, *7*(1). https://doi.org/10.1186/s40862-022-00133-w