

Exploration of The Influence of Environmental Concern and Reading Interest on 7th Grade Students' Argumentation Skills Regarding Socioscientific Issues

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Abstract

Keywords:

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Argumentation skills are essential competencies for students engaging with socio-scientific issues (SSI), yet many junior high school students in Indonesia struggle to construct logical, evidence-based arguments. This study investigates the influence of environmental concern and reading interest on the argumentation skills of Grade 7 students at a State Junior High School in Jenangan Sub-district, employing a mixed-methods sequential explanatory design. Quantitative data were collected from 173 students through questionnaires and argumentation tests and analyzed using multiple linear regression, while qualitative data were obtained through in-depth interviews with six purposively selected students. Results indicate that environmental concern and reading interest jointly and significantly influence students' argumentation skills ($F = 6.254, p = 0.002$), with a combined explanatory power of 5.8% (Adjusted $R^2 = 0.058$), meaning that 94.2% of the variance in argumentation skills is attributable to other factors. Reading interest contributed slightly more strongly (Adjusted $R^2 = 0.060$) than environmental concern (Adjusted $R^2 = 0.038$). The limited overall contribution was explained by four qualitatively identified factors: difficulty connecting personal experiences to arguments, non-scientific reading habits, insufficient argumentation practice, and limited teacher guidance during SSI discussions. Discussion experience, parental interaction, social media use, and peers influenced argumentation; teachers should strengthen structured argumentation practices.

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Introduction

Scientific argumentation is one of the fundamental competency students must develop in 21st-century science education. Argumentation enables students to construct claims based on valid data, provide logical reasoning, and critically evaluate differing viewpoints (Haudek & Zhai, 2024). In the Indonesian education context, the development of argumentation skills has become increasingly relevant, as the national curriculum (*Kurikulum Merdeka*) emphasizes student-centered, inquiry-based, and contextually meaningful learning (Wikara et al., 2022).

Despite this emphasis, studies in Indonesia consistently report that students' argumentation skills remain underdeveloped, particularly at the junior high school level where students are just beginning to engage with abstract reasoning and evidence-based thinking (Andriani et al., 2025; S. Wahyuni et al., 2026). This gap is especially critical because early adolescence represents a formative period for developing reasoning habits that persist into higher education and everyday life.

Argumentation skills can be cultivated through contextually grounded approaches, one of which is the socio-scientific issues (SSI) approach. The SSI approach engages students with real-world controversies that intersect science and society, encouraging them to connect scientific concepts to personal experiences and ethical considerations (Högström et al., 2025; Sanchez et al., 2024). Within this framework, two internal student factors are theoretically linked to argumentation capacity: environmental concern and reading interest. Environmental concern reflects an individual's affective and behavioral orientation toward preserving the natural environment, encompassing actions such as reducing waste, conserving energy, and engaging in sustainability practices (Handayani et al., 2024). Theoretically, students with strong environmental concern are more likely to engage critically with environmental arguments because their prior attitudes provide a cognitive and emotional anchor for evaluating claims (Zeng et al., 2023). Reading interest, on the other hand, shapes argumentation through knowledge accumulation and critical literacy. Students who actively read, particularly scientific texts, develop a broader conceptual base, richer vocabulary, and a greater capacity to evaluate and construct evidence-based arguments (Cao et al., 2024; Morris, 2025). Together, these two factors are proposed as internal contributors to the quality of students' argumentation, particularly when engaging with SSI that require both scientific knowledge and personal value judgment.

Each variable in this study is operationalized through established theoretical indicators. Argumentation skills are assessed using the Toulmin Argumentation Pattern (TAP), comprising six elements: claim, data, warrant, backing, qualifier, and rebuttal (Hakim et al., 2023). Environmental concern is measured through behavioral indicators including plastic reduction, waste sorting, carbon emission awareness, energy conservation, tree planting, and material reuse (Handayani et al., 2024). Reading interest is measured through enjoyment of reading, awareness of its benefits, reading frequency, and breadth of reading materials (Wahyuni et al., 2020). These indicators were selected for their alignment with the developmental characteristics of junior high school students and their suitability for the SSI context employed in this study.

Preliminary observation conducted at a State Junior High School in Jenangan Sub-district revealed a concerning pattern: students in Grade 7 demonstrated severely limited argumentation skills, with an average score of only 20% across the six TAP indicators (Hakim et al., 2023). No student reached the adequate performance threshold. Concurrently, low environmental concern was evident from infrequent classroom cleaning participation, and low reading interest was reflected in students' reluctance to engage with reading materials and their tendency to copy peers' answers. These preliminary findings point to a meaningful relationship between students' affective dispositions, particularly environmental concern and reading interest, and their argumentation performance.

Existing research, however, has not directly examined the simultaneous influence of these two affective variables on junior high school students' argumentation skills, particularly within an SSI framework in the Indonesian context. Prior studies have explored argumentation in relation to instructional methods (Marthaliakirana et al., 2022), conceptual understanding (Karlina & Alberida, 2021), and environmental education attitudes (Purba et al., 2023), but have not treated environmental concern and reading interest as co-predictors of argumentation within a single empirical study. Furthermore, most existing research on argumentation in Indonesia has been conducted at the senior high school or university level (Asriyani et al., 2023; Probosari et al., 2022), leaving junior high school students, who are at a critical formative stage relatively underexplored. This study addresses that gap by empirically investigating the influence of environmental concern and reading interest on Grade 7 students' argumentation skills in relation to SSI, while also exploring qualitatively the underlying factors that moderate this relationship.

This study therefore aims to: (1) examine the simultaneous influence of environmental concern and reading interest on the argumentation skills of Grade 7 students in relation to SSI; (2) identify the factors that contribute to the limited influence of these variables on argumentation; and (3) explore other factors that play a role in shaping students' argumentation skills. The novelty of this study lies in its integration of two underexplored affective predictors, environmental concern and reading interest within a mixed-methods sequential explanatory design applied to junior high school students engaging with SSI in the Indonesian educational context. This combination has not been previously investigated, offering a more holistic understanding of the affective dimensions of student argumentation that can inform both theory and classroom practice.

Method

This study uses a mixed methods approach with a sequential explanatory research design, where the research is carried out in two stages, starting with quantitative research followed by qualitative research to explore the findings in more depth (Creswell & Clark, 2017). The research was conducted at a State Junior High School in Jenangan Sub-district with Grade 7 students as the research subjects, from February to April 2025. The sampling technique for quantitative data was random sampling, allowing each Grade 7 student an equal chance of being selected as a respondent. The number of quantitative participants in this study was 173 students, which was considered sufficient to represent the existing population.

For qualitative data, purposive sampling was used, selecting six students, two each representing low, medium, and high levels of argumentation skills based on the argumentation test results. This sample size was considered sufficient for the qualitative strand of this study for several reasons. First, in sequential explanatory mixed methods designs, the qualitative phase serves an explanatory function rather than an independent inquiry, meaning its purpose is to elaborate and interpret the quantitative findings rather than to achieve broad representativeness (Creswell & Clark, 2017). Second, the stratified selection across three performance levels ensures maximum variation in perspectives while maintaining analytical manageability (Renjith et al., 2021). Third, qualitative research prioritizes depth of information over breadth of sample; with structured in-depth interviews, six participants across distinct

performance categories are sufficient to generate meaningful explanatory data (Tisdell et al., 2025). Data adequacy was further ensured through the interview process, where recurring themes across participants indicated informational sufficiency.

Quantitative data were collected using questionnaires and tests. The questionnaire used a four-point Likert scale, ranging from 1 (strongly disagree) to 4 (strongly agree). The test consisted of descriptive questions designed to measure students' argumentation skills based on the Toulmin Argumentation Pattern (TAP), comprising six elements: claim, data, warrant, backing, qualifier, and rebuttal (Hakim et al., 2023). Instrument validity was tested using Pearson product-moment correlation with an r-table value of 0.404 ($n = 24, \alpha = 0.05$). Of the 28 items in the environmental concern questionnaire, 27 items were declared valid (r-values ranging from 0.408 to 0.818), with one item dropped due to an r-value below the threshold. Of the 16 items in the reading interest questionnaire, 14 items were valid (r-values ranging from 0.503 to 0.761), with two items excluded for the same reason. All six items of the argumentation skills test were valid, with r-values ranging from 0.463 to 0.845. Only valid items were retained for data collection and analysis. Reliability was assessed using Cronbach's alpha, yielding coefficients of 0.922 for environmental concern, 0.898 for reading interest, and 0.791 for argumentation skills, all exceeding the minimum threshold of 0.60 and classified as highly reliable (Cronbach, 1951).

Data analysis was conducted in two phase. Quantitative data were analyzed using multiple linear regression (SPSS version 27), preceded by classical assumption tests including normality (Kolmogorov-Smirnov), multicollinearity (VIF), and heteroscedasticity (Glejser). The regression analysis included the F-test, t-test, and coefficient of determination (R^2) to examine simultaneous and partial influences of the independent variables on argumentation skills (Indartini & Mutmainah, 2024). Qualitative data were analyzed through inductive coding using Atlas.ti 9, following three stages: open coding, axial coding, and selective coding, to identify themes that explain and contextualize the quantitative findings (Sudarmanto et al., 2026).

Results and Discussion

The Influence of Environmental Concern and Reading Interest on Argumentation Skills

Based on the results of a study examining the influence of environmental concern and reading interest on the argumentation skills of Grade 7 students at State Junior High School 1 Jenangan, who were given questionnaires and test items related to socio-scientific issues, it was found that both environmental concern and reading interest had a significant influence on students' argumentation skills. This finding is supported by the data presented in Table 1.

Table 1. Simultaneous F-Test Results

ANOVA ^a					
Model	Sum of Squares	df	Mean Square	F	Sig.
1 Regression	209,389	2	104,694	6.254	.002 ^b
Residual	2846.080	170	16,742		
Total	3055.468	172			

a. Dependent Variable: ARGUMENTATION SKILLS
 b. Predictors: (Constant), READING INTEREST, ENVIRONMENTAL CONCERN

Based on the simultaneous F-test results presented in Table 1, the p-value of 0.002 is below the significance threshold of $\alpha = 0.05$, indicating that environmental concern and reading interest jointly and significantly influence students' argumentation skills. These quantitative findings are consistent with the view of Handayani et al. (2024), who state that environmental maintenance is a crucial aspect of nature preservation. One form of environmental maintenance is conservation, which is defined by Munib et al. (2022) as an effort to protect and maintain the environment regularly in order to prevent damage or extinction. Individuals who care about conservation are also more likely to evaluate and construct arguments effectively (Jayasinghe & Darner, 2020; Manugeran et al., 2023).

Table 2. Partiat T-Test Results

Model	Coefficients ^a		Standardized Coefficients	t	Sig.
	Unstandardized Coefficients	Std. Error			
1 (Constant)	B		Beta		
	2.395	2.843		.843	.401
ENVIRONMENTAL CONCERN	.153	.075	.176	1.783	.043
READING INTEREST	.179	.084	.207	2.144	.033

a. Dependent Variable: ARGUMENTATION SKILLS

The partial t-test results in Table 2 reveal that both variables individually contribute significantly to argumentation skills. Environmental concern showed a significant partial influence ($\beta = 0.176$, $t = 1.783$, $p = 0.043 < 0.05$), indicating that students with stronger environmental concern tend to demonstrate better argumentation performance. This finding aligns with Jayasinghe & Darner (2020), who found that conservation concern positively influences students' ability to evaluate biodiversity-related arguments, suggesting that affective orientation toward environmental issues provides a cognitive and emotional anchor for constructing and evaluating claims. Reading interest demonstrated a relatively stronger partial influence ($\beta = 0.207$, $t = 2.144$, $p = 0.033 < 0.05$), indicating that students with higher reading interest tend to exhibit stronger argumentation skills. This is consistent with Purbaningrum et al. (2024), who established a positive relationship between reading interest and critical thinking, and with Demircioglu et al. (2023), who emphasized that engagement with scientific texts builds the conceptual foundation necessary for evidence-based argumentation. Comparing the two predictors, reading interest ($\beta = 0.207$) exerts a slightly more dominant influence on argumentation skills than environmental concern ($\beta = 0.176$), suggesting that access to and engagement with information through reading plays a more direct role in shaping students' argumentation capacity.

Table 3. Results of the Determination Coefficient Test (R^2)

No	Variable	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	Environmental Concern	.208	.043	.038	4.134
2	Reading Interest	.255	.065	.060	4.087
3	Environmental Concern and Reading Interest	.262	.069	.058	4.09166

Table 3 presents the coefficient of determination for each predictor individually and in combination. Individually, environmental concern explains 3.8% of the variance in argumentation skills (Adjusted $R^2 = 0.038$), while reading interest explains 6.0% (Adjusted $R^2 = 0.060$), indicating that reading interest has a slightly stronger individual contribution than environmental concern. When combined, both variables jointly explain 5.8% of the variance in students' argumentation skills (Adjusted $R^2 = 0.058$), with the remaining 94.2% attributable to other variables beyond the scope of this study. While this figure may appear modest, it is theoretically interpretable and consistent with findings in the argumentation literature. Argumentation is a complex, multidimensional cognitive skill that cannot be reduced to affective predictors alone; it is shaped by a constellation of factors including instructional quality, prior knowledge, discussion experience, and social environment (Erduran et al., 2015; Kuhn & Crowell, 2011). The low R^2 therefore does not diminish the significance of the finding, as both variables were statistically significant (environmental concern: $p = 0.043$; reading interest: $p = 0.033$; simultaneous: $p = 0.002$), but rather reflects the inherent complexity of argumentation as a dependent variable. This is consistent with Karlina & Alberida (2021), who similarly found that no single factor fully accounts for students' argumentation performance, and with Casado-Ledesma et al. (2021), who emphasized that argumentation development is a gradual process shaped by multiple interacting variables. The modest explanatory power of environmental concern and reading interest thus underscores the need for a qualitative investigation to identify the broader factors that moderate this relationship, which is addressed in the subsequent section.

These findings are broadly consistent with, yet also extend, prior research on the predictors of argumentation skills. Karlina & Alberida (2021) identified conceptual understanding and active participation as key contributors to argumentation in biology learning, suggesting that cognitive factors play a dominant role. The present study complements this by demonstrating that affective factors, specifically environmental concern and reading interest, also contribute meaningfully, albeit modestly, to argumentation performance. Similarly, Jayasinghe & Darner (2020) found that conservation concern influences students' evaluations of biodiversity arguments, which aligns with the significant influence of environmental concern observed in this study. However, the present study extends their work by situating this relationship within a junior high school SSI context in Indonesia, where students'

environmental attitudes are still developing. Regarding reading interest, Purbaningrum et al. (2024) established a positive relationship between reading interest and critical thinking in elementary school students, and the present finding suggests this relationship extends to argumentation skills at the junior high school level. Taken together, these comparisons suggest that while affective factors are not the primary drivers of argumentation, they constitute a meaningful and underexplored dimension of argumentation development that warrants further investigation.

Factors Causing the Low Influence of Environmental Concern and Reading Interest on Students' Argumentation Skills

Qualitative data were analyzed to explore the factors contributing to the limited influence of environmental concern and reading interest on students' argumentation skills. Based on the network coding results presented in Figure 1, four interconnected factors were identified as follows

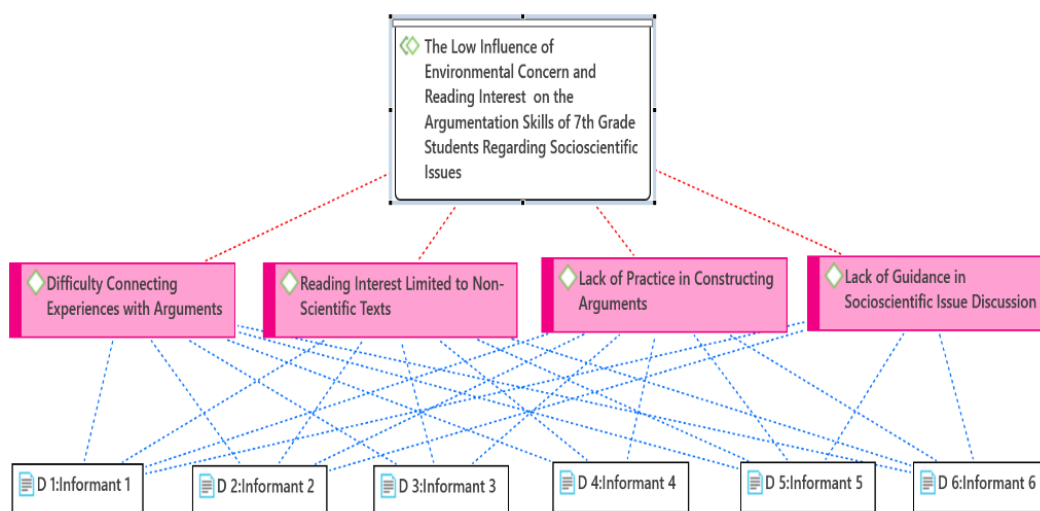


Figure 1 Network Coding Results: The Low Influence of Environmental Concern and Reading Interest on Grade 7 Students' Argumentation Skills Regarding Socioscientific Issues

Based on Figure 1, the low influence of environmental concern and reading interest on argumentation skills is attributed to several factors, including:

1. Difficulty Connecting Experience to Arguments

The network coding analysis revealed that the primary factor contributing to the limited influence of environmental concern on argumentation skills is students' difficulty in translating their environmental behaviors into structured argumentative reasoning. While most students demonstrated awareness of environmental issues and engaged in related behaviors such as reducing plastic use, participating in school greening programs, and proper waste disposal, they were largely unable to leverage these experiences as a foundation for constructing evidence-based arguments. Students with medium argumentation ability stated that environmental concern was less helpful because they found it difficult to connect environmental concern with their arguments. Similarly,

students with low argumentation ability noted that their daily environmental activities did not feel relevant to the argumentation topics discussed in class. This pattern was consistent across all performance levels, suggesting a fundamental gap between affective environmental orientation and the cognitive demands of scientific argumentation. Scientific argumentation relies not only on personal experience or attitudes but on deep conceptual understanding and the use of relevant scientific evidence (Marin et al., 2024). The SSI context, which requires students to integrate personal values with scientific reasoning, appears to exacerbate this gap when students lack the scaffolding to bridge the two domains (Bächtold et al., 2023; Högström et al., 2024).

2. Reading Interest Limited to Non-Scientific Reading

Across all six interview participants, reading interest was consistently oriented toward non-scientific materials. Students with high argumentation ability reported enjoying Wattpad, comics, and illustrated stories, while students with medium and low ability preferred fiction novels, social media quotes, and online entertainment content. None of the participants reported regular engagement with scientific texts related to environmental or social issues. This finding explains why reading interest, despite being a statistically significant predictor, contributes only modestly to argumentation skills. Students with high argumentation ability acknowledged that reading helps when studying for tests, but this instrumental reading did not appear to translate into deeper argumentative capacity. While students trained using scientific argumentation models showed improvement in identifying key elements of scientific articles, they continued to struggle with understanding rhetorical structures and qualifiers (Archila et al., 2025; Münchow et al., 2023). Reading scientific texts specifically provides accuracy, data validity, and theoretical grounding essential for constructing sound arguments (Probosari et al., 2022). The predominantly non-scientific reading habits of participants thus limit the knowledge base available for evidence-based argumentation, regardless of overall reading interest level.

3. Lack of practice constructing arguments

Interview data consistently revealed a lack of regular practice in constructing arguments across all performance levels, though the manifestation differed by ability group. Students with low argumentation ability explicitly cited fear of making mistakes and passive behavior in classroom discussions as major barriers, with one student stating they preferred to wait for the lesson to end rather than participate. Students with medium ability acknowledged rarely participating in discussions unless the topic was personally interesting, such as motorcycles or games rather than environmental issues. Even students with high argumentation ability noted that their practice opportunities came primarily from extracurricular activities such as student council (OSIS) rather than from science lessons. This suggests that formal science instruction provides insufficient structured opportunities for argumentation practice. Argumentation skills improve significantly when students are given more frequent and structured opportunities to express and defend their arguments through targeted instructional strategies (Altun & Ozsevgec, 2025; Asriyani et al., 2023).

4. Lack of Guidance in Discussion of Socioscientific Issues

A consistent pattern across all six participants was the perception that teachers rarely guided students toward structured argumentative thinking during SSI discussions.

Students with high argumentation ability noted that teachers typically explained environmental issues in terms of causes and effects without supporting students in developing evidence-based arguments. Students with medium ability similarly observed that classroom discussions emphasized environmentally responsible behavior rather than deep exchange of reasoned perspectives. This teacher-centered, descriptive approach to SSI discussion limits students' exposure to the argumentative discourse necessary for developing the claim-data-warrant structure central to the Toulmin model. Targeted teacher guidance is essential for fostering higher-quality argumentation, enabling students to move beyond surface-level descriptions toward more sophisticated reasoning (Nussbaum et al., 2024; Zhang et al., 2022). Students who received argument-based instruction showed significant improvement in their argumentation abilities, underscoring the critical role of instructional scaffolding in argumentation development (Iwuanyanwu, 2023; Palma-Jiménez et al., 2025).

Other Factors Influencing Students' Argumentation Skills

In addition to the factors discussed above, the qualitative analysis also revealed other variables that appear to exert a more substantial influence on students' argumentation skills. Based on the network coding results presented in Figure 2, four additional factors were identified as follows.

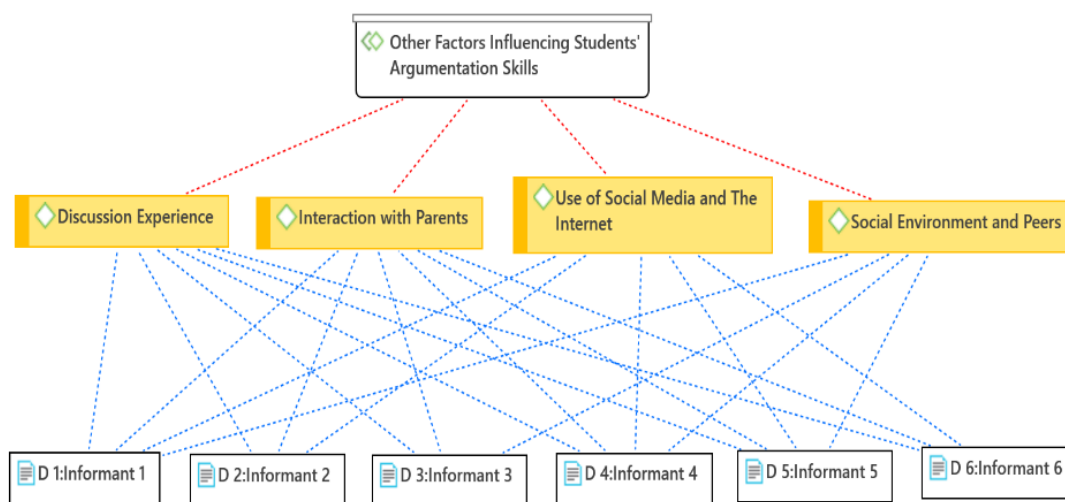


Figure 2 Network Coding Results: Other Factors Influencing Grade 7 Students' Argumentation Skills Regarding Socioscientific Issues

Based on Figure 2, in addition to environmental concern and reading interest, several other factors appear to have a more significant influence on students' argumentation skills when discussing SSI. The factors that influence argumentation skills include:

1. Discussion Experience

Interview data consistently identified discussion experience as the most influential factor in shaping students' argumentation skills across all performance levels. All six participants agreed that discussion was more helpful than either environmental concern or

reading interest in supporting argumentation development. Students with high argumentation ability articulated this most clearly, noting that discussion enables the exchange of ideas, stimulates creativity, and helps generate stronger arguments through collaborative thinking. One participant with high ability further noted that involvement in student council (OSIS) provided regular structured opportunities to express and defend opinions, which directly strengthened their argumentation capacity. In contrast, students with medium and low ability acknowledged the benefit of discussion but reported barriers to active participation, including lack of interest in the topic, shyness, and low self-confidence. Students with low ability stated that they preferred to observe rather than participate, waiting for more capable peers to lead the discussion. This divergence across performance levels suggests that discussion experience benefits students differentially depending on their confidence and engagement level. Students actively involved in evidence-based discussions developed stronger argumentation skills, more frequently using claims supported by data and sound justifications (Bächtold et al., 2023). Students engaged in argumentative dialogue also developed their reasoning abilities more effectively over time (Iordanou & Rapanta, 2021; Rapanta & Felton, 2022). These findings collectively suggest that creating a psychologically safe discussion environment is as important as the discussion activity itself, particularly for students with low argumentation ability who self-select out of participation.

2. Interaction With Parents

Parental interaction emerged as a differentiating factor between students with varying levels of argumentation ability. Students with high argumentation ability reported frequent discussions with parents about various topics, including current events and daily experiences, with parents actively prompting them to explain the reasoning behind their opinions. This habitual practice of justifying one's views at home appeared to transfer to greater argumentative capacity in academic settings. Students with medium ability reported moderate parental interaction, primarily in the form of storytelling and sharing information rather than structured dialogue. Students with low argumentation ability, by contrast, reported minimal meaningful discussion at home, with one participant noting that serious discussions rarely occurred in their household. This gradient pattern across performance levels supports the theoretical proposition that family communication serves as an important early context for developing argumentative reasoning. Through daily interactions, parents model evidence-based reasoning and provide children with broader informational resources that support intellectual development (Bubikova-Moan & Sandvik, 2023). Parental stimulation through thought-provoking questions in everyday conversations also plays a crucial role in developing children's critical and argumentative thinking (Franco-Mariscal et al., 2024; Setyaningsih & Rahardi, 2024). The present findings extend this theoretical proposition to the junior high school level in the Indonesian context, suggesting that home discourse patterns constitute a meaningful background factor in students' argumentative development

3. Social Media and Internet

All six participants reported relying on social media and the internet as primary sources of information when preparing to construct arguments, regardless of their

argumentation ability level. Students across all performance levels described searching Google or browsing social media before forming opinions in discussions or written tasks. Students with medium ability explicitly stated that they would open Google on their phone before expressing any opinion, while students with high ability described social media and internet access as providing more detailed and varied information to support their arguments. However, a critical distinction emerged between high and low ability students in how they processed this information. Students with high argumentation ability appeared to use online information selectively to supplement their existing knowledge base, while students with low ability tended to rely on internet searches as a substitute for independent reasoning, often feeling unable to argue without first consulting online sources. While social media provides an interactive space for practicing claim formulation and responding to opposing views, the resulting argumentation is often fragmented and unstructured (Crudele & Raffaghelli, 2023; Dykes et al., 2024). Without adequate digital literacy skills, students risk constructing arguments based on biased or inaccurate online information (Sunarti, 2024; Tsai, 2023). These findings highlight the need for explicit guidance in evaluating online sources as part of science argumentation instruction, particularly given the near-universal reliance on internet searches observed among participants.

4. Social Environment and Peers

The social environment and peer dynamics emerged as a significant contextual factor shaping students' willingness and ability to engage in argumentation. A consistent pattern across medium and low ability students was the tendency to remain passive in discussions because they perceived their peers as more knowledgeable or more articulate. Students with low argumentation ability stated that only the more capable students participated actively, leading them to disengage entirely from the discussion process. This self-exclusion from argumentative discourse further limits their practice opportunities, creating a compounding disadvantage over time. Students with medium ability similarly reported that their participation was contingent on topic relevance and the social dynamics of the group, suggesting that peer influence mediates the relationship between individual motivation and actual argumentative engagement. In contrast, students with high argumentation ability reported that their social environments, including OSIS membership and regular family discussions, provided consistent encouragement to express and defend opinions. Peer interaction can increase cooperation and idea exchange but can also create social pressure that discourages participation among less confident students (Ngo, 2024). A psychologically safe environment for expressing arguments also positively impacts the development of students' argumentation skills (Dawson, 2024; Doğan et al., 2022). These findings suggest that addressing peer dynamics and fostering inclusive discussion norms are essential components of any instructional strategy aimed at improving argumentation skills at the junior high school level

Conclusion

This study demonstrates that environmental concern and reading interest jointly and significantly influence Grade 7 students' argumentation skills in relation to socio-scientific issues, with a combined explanatory power of 5.8% (Adjusted $R^2 = 0.058$). Between the two

predictors, reading interest exerted a slightly stronger individual influence (Adjusted $R^2 = 0.060$) than environmental concern (Adjusted $R^2 = 0.038$). To the authors' knowledge, this is the first empirical study to treat these two affective variables as co-predictors of argumentation within a mixed-methods design at the junior high school level in Indonesia, offering a more holistic understanding of the affective dimensions of argumentation development. The limited contribution of these variables is explained by four factors: difficulty connecting environmental experiences to arguments, non-scientific reading habits, insufficient argumentation practice, and limited teacher guidance during SSI discussions. Discussion experience, parental interaction, social media use, and peer dynamics were identified as additional influential factors. These findings suggest that science teachers should incorporate structured argumentation practice using the Toulmin model, gradually shift students toward scientific reading materials, and create inclusive discussion environments that encourage participation across ability levels. Future research should examine other potentially dominant variables such as metacognitive awareness and instructional quality, and explore intervention designs that directly target the limiting factors identified in this study.

Credit Authorship Contribution Statement

Jamus Alma'ruf: Conceptualisation, Software, Visualisation, Formal analysis, and Writing the original draft. **Ulinuha Nur Faizah:** Conceptualisation, Methodology, Formal analysis, Resources, Writing, & Supervision. **Omnia Salah Ahmed:** Project administration, review & editing.

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