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Evaluating Argumentation Skills: Science Literacy and Scientific Approach in Junior High School

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Abstract: *This research aims to enhance students' argumentation skills at the junior high school level by implementing science learning based on scientific literacy. This research uses a quasi-experimental design with a quantitative descriptive method. The instruments used were (1) an essay test with an instrument in the form of scientific argumentation description questions with as many as six items and (2) an interview with the teacher about the science learning process in the classroom. To measure students' argumentation skills refer to the Toulmin Argumentation Pattern (TAP) argumentation skills indicators. This research used a sample of one of the junior high schools in Muara Enim District. The result shows student's argumentation skills are still in level 1 with 58,1% as a weak category, level 2 with 30,95 % as a weak category, and level 3 with 10,95%. The teacher through interview sessions explains that the students' argumentation skills are lacking because they are affected by low confidence and nervousness. When learners are asked, learners give short answers which cannot provide the right sentence to explain something Learners are accustomed to using local language in expressing opinions and have not been able to express argumentation orally in the form of organized sentences. Based on these findings, further research needs to be done on the application of appropriate learning models that can train students' argumentation skills.*

Keywords: *argumentation, scientific approach, science learning, science literacy*

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INTRODUCTION

The 21st-century era makes the development of the world increasingly fast and complex. These changes aim at improving the quality of life of modern society. The 21st century is also characterized by the massive transformation from agricultural to industrial and knowledge societies (Kim et al., 2019). The tight challenges faced by society require a paradigm shift. The education system can provide 21st-century skills that learners need to face every aspect of global life (Cai & Gut, 2020). From various studies on the concept and characteristics of 21st-century education, it inevitably becomes a demand as well as a big challenge for teachers in their teaching management. The provision of quality science education will have an impact on the development of a country. Science education depends on the learning used in each country (York et al., 2019). Through science education, students can engage with the effects of science on daily life and students' role in society. By applying science concepts in science education, Indonesian students are expected to be able to solve problems in real life in the 21st-century era. Scientific literacy is one of the learning implementations in the 21st century. Given the importance of science literacy, it is essential to educate learners to have science literacy, which is a primary goal in any science education reform. Scientific literacy plays a crucial role in shaping individuals who are not only knowledgeable about science but also capable of applying scientific principles in their daily lives,

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contributing to informed decision-making processes, and actively engaging in discussions related to science and technology (Windyariani & Amalia, 2019).

Based on preview observation, grade VII students in South Sumatra must improve in solving science literacy questions for physical content. An average of 46.4 on a scale of 100 was obtained. This weakness is caused by the limited ability to express thoughts in writing, the need to be more accustomed to connecting available information, weak basic science concepts and scientific reasoning skills, and the inability to build appropriate arguments about how they relate to everyday life (Anita et al., 2021). Osborne et al. (2016) show that students can explain some physical phenomena well, but they cannot argue well when asked more in-depth questions. The learning system refers to 21st-century learning, namely the ability to think critically, solve problems, collaborate, and communicate (Atiş Akyol, 2023; Kim et al., 2019). These abilities can be achieved through well-prepared learning. The main component of the learning process is involvement in various important aspects, including formulating questions, describing mechanisms, and building arguments. One of these components is that students must have good argumentation skills. Lestari et al., (2024) argue that students' argumentation skills are essential for analysis. Argumentation can help students express an opinion based on facts, reasons, and evidence and evaluate and justify information from various sources in drawing conclusions (Cho & Jonassen, 2002; Arsyim et al., 2022). Argumentation skills not only focus on the components of argumentation being investigated but also adapt to significant topics and learning materials.

Argumentation skills can train students to use their thinking skills. Pratiwi et al., (2019) explain that argumentation skills have an essential role in improving students' critical thinking patterns so that they can add a deep understanding of an idea. Science teaching emphasizes that students should have argumentation skills (Prabaningrum & Waluya, 2020). In addition, argumentation skills are essential to develop in science teaching to improve students' thinking and understanding of the material studied. The argumentation-based teaching process can encourage students to provide appropriate facts, data, and theories to support claims about a problem (Sakai et al., 2020).

The scientific approach to improving argumentation skills among students has gained significant attention in educational research. This approach emphasizes the importance of structured learning environments that foster critical thinking and reasoning abilities through various pedagogical strategies. A notable method is the Argument-Driven Inquiry (ADI) model, which has been shown to enhance students' scientific argumentation skills effectively. Research indicates that the ADI model improves argumentation skills and promotes critical thinking, particularly among junior high school students studying topics such as light (Nazila et al., 2019). This model encourages students to engage in scientific discourse, thereby facilitating a deeper understanding of scientific concepts.

The implementation of socioscientific issues (SSI) debates has been found to significantly enhance undergraduate students' argumentation skills. By engaging in debates on relevant topics such as global warming and genetically modified organisms, students are provided with opportunities to develop their argumentation skills in a context that mirrors real-world scientific discussions (Martini et al., 2021). This aligns with findings that suggest structured argumentation activities can lead to improved reasoning and conceptual understanding in science education (Venville & Dawson, 2010).

Learners' argumentation skills are important for analysis. Argumentation can help learners express an opinion based on facts, reasons, and evidence and can evaluate and justify information from various sources in the conclusion (Pols et al., 2023). Argumentation skills focus on the components of argumentation that are investigated and adapt them to significant topics and learning materials. Research related to argumentation skills that have been carried out include the research on argumentation skills of high school students on Hooke's law material (Sakai et al., 2020), argumentation skills by showing evidence of arguments, counter-arguments, and rebuttals (Bansal, 2021), the application of Team Group Tournaments and argumentation skills (Palines & Ortega-Dela Cruz, 2021), the argumentation skills of junior high school students in Indonesia (Amala et al., 2023), and argumentation profiles on biological wealth material (Nufus et al., 2021).

The integration of argumentation skills with scientific approaches in science teaching is crucial for enhancing students' scientific literacy (Topalsan, 2020). Teaching argumentation skills as part of scientific inquiry is essential for enhancing students' scientific literacy abilities (Purnomo et al., 2023; Topalsan, 2020). Argumentation in science classrooms is desirable as it fosters critical thinking, communication skills, and scientific reasoning, ultimately contributing to scientific literacy (Cavagnetto, 2010; Hand et al., 2021; Wilson et al., 2024). Based on the urgency above, the researchers are interested

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in analyzing the argumentation skills of high school students through the application of a scientific approach to science literacy. This research was conducted to obtain data in the form of students' argumentation level on magnetism material.

RESEARCH METHOD

This research was conducted using quantitative research and the quasi-experimental method. It is a single treatment design (one-shot case study) on a group of subjects with treatment (X) and then an observation (O) (Ishtiaq, 2019). It produces quantitative data on the achievement of students' argumentation skills in science subjects, especially physics and magnetic material, through the science learning approach based on the scientific approach. It was conducted during the odd semester of the 2023/2024 school year at one of the state junior high schools in Muara Enim Regency, South Sumatra Province, Indonesia. The target population was all students in grade IX, and the sample consisted of 27 students who had above-average abilities established using the purposive sampling technique.

Research Instrument

The instrument used in the data collection is a scientific argumentation description test containing six questions. The description questions given are constructed based on indicators of argumentation skills using Toulmin's Argument Pattern (TAP) model which consists of six components (Andriani et al., 2023; Anita et al., 2021). The test questions given have gone through the validation stage by two material experts, who are lecturers of physics education. The result of reliability is 0.87, which is in a high category. Besides using a test, the data collection also was conducted through interviews with open-ended questions to the seventh-grade teachers about the learning process carried out during learning activities. To measure the argumentation ability of students refers to the indicators of argumentation ability of Toulmin Argumentation Pattern (TAP). The argumentation skill score rubric consists of five levels and is presented in Table 1 below.

Table 1. Argumentation Skill Level

Level	Component	Category
1	*Claim*	Only provide good claims
2	*Claim and Data*	Provide good claims and data
3	*Claim, Data,* and *Warrant*	Provide claims, data, and guarantors that are good
4	*Claim, Data, Warrant, and Backing*	Provide claims, data, guarantors, and good support
5	*Claim, Data, Warrant, Backing, Qualifier, and Rebuttal*	Provide good claims, data, guarantors, supporters, and quality and/or exclusions

Data Analysis

The collected data was processed using various analytical methods. The data were presented as a description or explanation of the results and students' argumentation skills. Then, the data were grouped or categorized in the argumentation ability rubric according to the level of argumentation ability adaption by Amiruddin et al. (2023) as shown in Table 2 below.

Table 2. Categories of Argumentation Determination Mastery Level

Mean Score (%)	Mastery Level
80.00 – 100.00	Excellent
60.00 – 79.99	Good
40.00 – 59.99	Moderate
20.00 – 39.99	Weak
0.00 – 19.99	Very Weak

The criteria for students' argumentation skills were analyzed and adjusted to the level that described the quality of students' argumentation in working on questions in the form of percentages. The percentage

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of students' argumentation ability at each level of students' argumentation ability follows the results of the description questions that have been carried out as follows:

$$\text{Percentage}(\%) = \frac{\text{Data amount of argumentation level}}{\text{All of data amount}} x100\% \quad (1)$$

FINDINGS AND DISCUSSION

Analysis of Argumentation Skills on Magnetism Material

The level of students' argumentation skills was grouped based on the categories according to Table 2. The grouping categories were calculated one by one from each student's answer as shown in Table 3 below.

Table 3. Level of Argumentation Skills by TAP Model

Sub-Matter	Test Number	Category				
		Level 1	Level 2	Level 3	Level 4	Level 5
Properties of magnetism	1	7	15	5	0	0
Magnetic lines of force	2	10	12	7	0	0
Earth magnetism magnet	3	11	10	4	2	0
applications	4	20	5	2	0	0
Making magnets materials	5	4	12	5	6	0
become magnetic	6	10	7	4	6	0

Table 3 shows the variations in the category of argumentation levels of students after getting science learning through a science literacy approach carried out for four face-to-face meetings in class. For Question 1, with the sub-matter of the magnetic properties of magnetic lines of force, 25% of students could answer with level-1 argumentation. In comparison, 55% of students could answer it with level-2 argumentation, and only 18% of students could answer it with level-3 argumentation. For Question 4, only 7% of students could provide arguments with good data claims and guarantors at level 3, while 74% could only offer good claims. The highest argument achievement at level 3 is shown through the results of the argument claim on the question of making magnets through materials that have magnetic properties. As many as 22.22% of students could provide arguments through good data and guarantors. In general, this result certainly shows that in each problem no students can give good claims, data, guarantors, supporters, quality, and exceptions through the given sub-material. Formula 1 calculates the percentage of students' argumentation skills for each component. Figure 1 provides an overview of the calculation results.

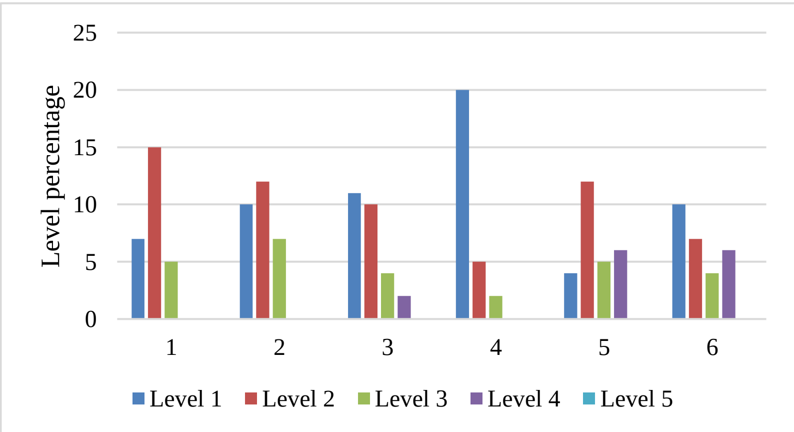

Figure 1. Level of Student's Argumentation Ability according to the Components of Toulmin's Argument Pattern (TAP) Model

The level of student ability represented in Figure 1 shows that the students who provide only good claims to answer questions about the magnetism of earth magnet applications have an achievement of 74%. This shows that the students have difficulty providing supporting data, guarantors, and good quality for the quality of arguments at higher levels. Achievement of level 4 did not appear in Questions 1, 2, and 4. However, for Questions 3, 5, and 6, students could reach level 3 to provide claims to Question 1. This achievement is supported through the application of science learning through a science literacy approach. The stages of science literacy learning through the contact stage, namely the teacher raises issues and problems that exist in society or explores various events that occur around and relates them to the magnetic material being studied. This stage provides students with opportunities to search through references that support each other and the latest (Fasha & Sopandi, 2024). The various qualities of argumentation written by students show the classification of criteria based on the level of argumentation shown in Table 4 below.

Table 4. Measurement Results of Argumentation Ability Components Using the Mastery Level Argumentation Determination Table

Argumentation Skills Level	Percentage	Mean Score (%)	Mastery Level
Level 1	38.3 %	40.00 – 59.99	Weak
Level 2	37.7 %	20.00 – 39.99	Weak
Level 3	16.7 %	0.00 – 19.99	Very Weak
Level 4	8,6 %	0.00 – 19.99	Very Weak
Level 5	0%	0.00 – 19.99	Very Weak

The quality of argumentation through student answers is classified from level 1 to level 4. In this class, the mastery level is still in the weak category, indicating that students still have weak claims and, based on data or data conclusions at level 2 which are relevant to Ika Noviyanti et al. (2019), there are limitations in supporting claims in the use of data. Students provide only limited arguments and warrants based on theories, principles, and laws without refutation. The interpretation of students' answers to problem-solving is shown in the description below.

Question 1 (The nature of magnetism)
Do you agree that if a magnet is cut into smaller pieces, it will still have magnetic properties?

Examples of student answers at each level:
Level 1: Yes, I agree with the statement.
Level 2: Yes, I agree with the statement that the magnetic properties are not lost. cut into small pieces.
Level 3: Yes, I agree with the statement that if a magnet is cut into small parts, it will still have magnetic properties, because the elementary magnets are neatly arranged so that even though they are cut, they still show magnetic poles.

This statement could easily be answered by the students because, during the learning process, they conducted experiments by cutting bar magnets into small pieces so that they saw firsthand how their magnetic properties did not change even though they were cut. Cutting does not separate the two magnetic poles. The students could answer with appropriate arguments, directly explaining why this was so and reasons relevant to the nature of magnetism. They found it difficult to express arguments using their language.

Question 2 (Magnetic lines of force and magnetic pole interaction)
Look at the picture of the magnet above, what is the direction of the magnetic lines of force at each pole? Relate it to the interaction of similar and dissimilar magnetic poles!

Examples of student answers at each level:

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Level 1 *: The magnetic lines of force at each pole show different directions. Similar poles will repel and dissimilar poles will attract.*

Level 2 *: The magnetic lines of force are curved lines that emerge from the north pole of the magnet and curve towards the south pole of the magnet. Poles that are similar will repel and poles that are not similar will attract.*

Level 3 *: The magnetic lines of force at each pole show different directions and do not intersect each other. The magnetic lines of force are denser at the ends of the magnet, indicating that the greatest magnetic force is located at the ends of the magnet.*

The students could answer according to what they saw because they experimented using magnets and iron powder. The pattern of magnetic lines of force was already formed, making it easier to claim the answer (Andriani et al., 2018, 2023). Difficulties arose when presenting arguments and explanations. The students could not connect with the concept of charge at the ends of the magnet. So that there was a repulsive force on similar poles and an attractive force on poles of different types.

> Question 3: A compass has the function of determining or knowing the direction and degree of a map area. The compass always shows the north and south directions. If we look at the position of the needle on the compass, it is slightly tilted at a certain angle. Why is the position of the compass needle slightly tilted and not exactly at the north pole and south pole? Give an explanation.

Examples of student answers at each level:

Level 1 *: There is a deviation due to the presence of earth magnetism.*

Level 2 *: There is deviation at the compass tip due to the influence of the earth's magnetism.*

Level 3 *: There is a deviation in the compass tip due to the influence of the earth's magnetism. The location of the earth's magnetic poles is not exactly at the poles of the earth because the earth rotates towards the sun.*

Level 4 *: Because the direction of the compass needle always coincides with the direction of the Earth's magnetic lines of force, the direction formed by the compass needle in various places on the Earth's surface is always different. The difference can occur in both horizontal and vertical directions.*

The students conducted experiments directly using a compass needle and saw the tip of the compass needle showing a certain direction. The compass needle always points north and south.

> Question 4: Maglev trains are better known as flying (magnetically levitated) trains. It is called a flying train because the tracks are not attached. It flies approximately 10 mm above the tracks. Super fast maglev trains traveling up to 650 km/h, will not fall and derail. Analyze the concept of magnetism contained in the maglev train.

Student answers at level 1: The working principle of the maglev train is to utilize repulsive force.

Students answered this question based on what they read in the book. The maglev train was new to them, as all they had seen so far was a regular train going through the station near their school. They could not imagine a train that could levitate. They could not give the correct argument because the right was far from the conditions in their environment. This shows the need for contextualized learning for students. If there are things outside the environment of students' lives, teachers need to provide media that can bring real examples into the classroom.

> Question 5: Through an experimental design, you have to make a magnet with two materials: permanent magnet and ferrous metal. What is the procedure to make the magnet? Explain with the theory of magnetism that you have learned!

Examples of student answers at each level:

Level 1 *: Making ferrous metal into a magnet by rubbing it with a permanent magnet with the direction of rubbing in the same direction*

Level 3 *: Iron that was not a magnet can be made into a magnet by rubbing the iron with one end of a fixed magnet. The direction of rubbing is made in the direction of the*

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elementary magnet contained in the iron so that its location becomes organized and points in one direction. If the iron elementary magnet has been organized and pointed in one direction, it can be said that the iron metal has become a magnet.

For answers at level 1, all students could answer well because they conducted an experiment to make a magnet. From the experiment, they know that rubbing in the same direction will determine the success of making a magnet by induction. Their answers in this section started to be long and they argued with the concept of elementary magnets. However, the argumentation did not come from the students' sentences, but they sought information by reading the textbooks provided by the school.

Question 6:
Below are some different types of materials. Test them using a magnet. Classify these materials and explain why some are easily affected by magnets and some are difficult or very little affected.

Examples of student answers at each level:

Level 1 : *Ferromagnetic materials (easily affected by magnetism).*
Diamagnetic material/substances that include diamagnetic materials.

Level 4 : *Based on the properties of materials against the influence of magnets, the materials are classified into four parts, namely ferromagnetic and non-magnetic. Ferromagnetic objects/materials are different materials that are very easily influenced by magnets and can also be easily magnetized.*

In this section, students could directly identify objects that were strongly, weakly, and not attracted by magnets. They did this directly to test these materials. The classification that they made was based on what they got when testing. This shows that the argumentation that students bring up does not come directly from themselves but they look for information from books.

Teacher Interview Results Related to the Role of Scientific Argumentation in Science Learning

Interview activities with teachers in this study were carried out by asking several short questions related to integrated science learning activities at a junior high school in Gelumbang. The teacher has applied learning with a chided inquiry model during his teaching process. The use of laboratories, the availability of practicum tools on magnetism, and the availability of package books for students make it easier for the teachers to explain the material. One of the things that facilitates the learning process is that students who are used as research subjects are accustomed to the teaching model applied by science teachers when they are in grade VIII. Research by Kusuma et al. (2021) reports that learning activities occur using various resources such as the Ministry of Education and Culture handbook and the Internet.

The teacher explained that the learners' argumentation skills needed to be improved because they were influenced by low confidence and nervousness. When asked, students gave short answers where they needed help to provide the correct sentence to explain something. The students were accustomed to using local languages to express opinions and could not express arguments orally in organized sentences (Admoko et al., 2023). In addition, if there are learners who use Indonesian neatly, it will be funny for other students, which adds to the lack of confidence to argue.

Impact of science teaching based on science literacy to optimize argumentation skills

Science teaching using a science literacy approach carried out by teachers during the teaching process has provided direct experience to students (Kneupper, 1978). Based on the results of students' answers to each question, students could quickly provide answers to the questions asked. However, the students' answers were still at level 1 and level 2. They gave only claims without the right reasons. They could claim well what was asked in the question because the teacher used an inquiry learning model when carrying out teaching activities. The students could see and practice directly what was asked of them in the problem. Student learning outcomes depended highly on the teaching process teachers created in the classroom to provide a strong foundation for concept mastery. Science teaching should encourage learners to think critically and develop arguments using evidence, justification, and practical explanations (Cross et al., 2008). More evaluation and improvement are needed to further improve students' mastery of concepts at a higher level. Good concept mastery will make it easier for students to build scientific argumentation skills.

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Hadiprayitno et al. (2022) state that applying science teaching through the stages of science literacy learning is adapted through STL learning. The curiosity stage supports students in finding answers to questions posed by the teacher. In this stage, the teacher provided students with student worksheets so they could discuss them directly. In the LKPD, there were several questions about how trains work in the environment around where they lived. The teacher asked, "Does the magnet on the rail have a function for train work?". The students conducted practicum with the guidelines contained in the student worksheets with the aim that they could understand the concept and function of magnetic work and make magnets through magnetic materials. Studies have shown a positive and significant linear effect between argumentation skills and students' scientific literacy, indicating that developing argumentation skills can lead to improved scientific literacy among students (Handayani & Khairuna, 2022). Implementing approaches like the Science Writing Heuristic can enhance students' argumentation skills, which are considered critical elements in science instruction for improving scientific literacy (Munawaroh et al., 2020). This is in line with Fakhriyah et al. (2022) who write that scientific argumentative skills from the perspective of science literacy highlight the importance of argumentation in developing scientific knowledge and skills.

The next stage is the elaboration phase. At this stage, the exploration, formation, and stabilization of concepts until the questions at the curiosity stage could be answered. Students did practicum so that their abilities could be explored more deeply regarding knowledge, skills, and attitudes. Elaboration phases in science and literacy approaches are crucial for enhancing students' understanding and proficiency. Studies emphasize the importance of integrating science, technology, and literacy into educational frameworks to develop essential competencies for the 21st century (Cengelci & Egmir, 2022). Students must be able to answer questions with solid evidence, reasons, supporting answers, quality, and appropriate refutation based on their sentences. Judging from the results of students' answers, most of the students gave answers based on the information in the question without providing the correct explanation. According to Yulianti & Handayani (2021), students can only understand the question well and provide opinions based on known information (Claim) but have yet to be able to provide correct answers based on evidence from the theory. Students' scientific argumentation skill was categorized as low, namely only 26.31% and 25.19% of samples with scientific argumentation skills in justification and support (Arsyim et al., 2022; Fasha & Sopandi, 2024). Students had difficulty giving answers in the form of scientific sentences. Those who could answer at levels 3 and 4 could answer well only when they had received direction from the teacher and were asked to find the reason using the student handbook. After students read and found the reason, they could write it appropriately. Students' answers are still textbook in nature.

Question-and-answer activities and discussions with friends can train students' self-confidence and argumentation skills. Argumentation skills are important for students to learn a problem gradually. Students can reason more easily in understanding concepts and are brave in providing their ideas in learning due to supporting evidence. The arguments presented by students are considered logical but need to be supported by evidence of the right reasons or supporters, making the argument weak. The students who have not written their arguments well still lack mastery of the learning material even though they have learned it. This corresponds with Heng et al., (2014) and Sulisworo & Safitri, (2022) that the ability of junior high school students on environmental pollution material is more able to write claims correctly. However, only some can provide claims with the correct data. The students who have not written their arguments well still lack mastery of the learning material even though they have learned it.

Scientific work is limited not only to studying and testing the phenomena that arise but also to building arguments to communicate the findings. Scientific communication that can convince the scientific community of the truth of the findings shows how social processes play an essential role in building knowledge (Andriani et al., 2020). The idea of developing argumentation skills for students is an effort to train students to construct knowledge so that their mastery of concepts becomes stronger. Scientific work in the form of building arguments is often forgotten to be developed in science learning in the classroom. Tools/means are needed to build argumentation so that the argumentation process can take place optimally. This is based on previous research by Adriana Sari et al. (2021), where students still have difficulty understanding the concepts in the material, so it is not easy to define or provide statements in their language with the correct data. Efforts can be made by providing guidance or using engaging learning media to convey science material.

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Integrated science learning is expected to improve students' critical thinking in finding concepts or solving problems. Argumentation skills shape students' critical thinking patterns in solving problems. They are essential for students to explain the relationship of facts, procedures, concepts, and methods of solving that are interconnected with each other. To improve students' scientific argumentation skills, they need to consider their level of experience and knowledge (Von Aufschnaiter et al., 2008; Ryu & Sandoval, 2012; Zhu et al., 2020). Learning strategies to improve scientific argumentation skills still need to be developed. Many strategies can be used to improve scientific argumentation skills. Based on the literature study, some strategies are used, such as developing instructional content based on scientific argumentation (Berland & McNeill, 2010; Osborne et al., 2016; Guo et al., 2022) and forming small groups in lab activities. Improving students' scientific argumentation skills can be done through scientific activities (Manz, 2015; Chen et al., 2019). Utilizing technological developments to improve scientific argumentation skills is an essential action that utilizes technology in this Industrial Revolution 4.0 era.

CONCLUSION

Based on the findings above, it can be concluded that the argumentation skills of students seen from the components of Toulmin's Argument Pattern (TAP) model are in the weak category: level 1 with a percentage of 58.1%, level 2 with a percentage of 30.95%, level 3 with a percentage of 10.95%. Of the six questions about magnetism, level 5 amounted to 0%. Other results show students' low argumentation skills, lack of confidence, and nervousness, and that they are not used to expressing opinions in the form of scientific sentences accompanied by supporting evidence. This research certainly has limitations, and therefore it is necessary to conduct further research on the application of appropriate learning models and train to develop students' argumentation skills.

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REFERENCES

Admoko, S., Arizah, K. L., Suprapto, N., Deta, U. A., Suliyanah, S., Hariyono, E., Madlazim, M., Uulaa, R. F. R., Rasuliy, M. W., & Nugroho, Y. S. (2023). Research on Bibliometric Analysis of Toulmin’s Argument Pattern (TAP) in Learning Physics in the Last Ten Years. *International Journal of Current Educational Research*, *2*(1), 66–79. https://doi.org/10.53621/ijocer.v2i1.184

Adriana Sari, N. P. E., Santyasa, I. W., & Gunadi, I. G. A. (2021). The Effect of Conceptual Change Models on Students’ Conceptual Understanding in Learning Physics. *Jurnal Pendidikan Fisika Indonesia*, *17*(2), 94–105. https://doi.org/10.15294/jpfi.v17i2.27585

Amala, I. A., Sutarto, S., Putra, P. D. A., & Indrawati, I. (2023). Analysis of Scientific Literacy Ability Junior High School Students in Science Learning on Environmental Pollution. *Jurnal Penelitian Pendidikan IPA*, *9*(3), 1001–1005. https://doi.org/10.29303/jppipa.v9i3.1816

Amiruddin, M. Z. B., Sari, E. P. D. N., Paramita, U. V., Suliyanah, S., & Admoko, S. (2023). The Contribution Of Toulmin’s Argumentation Patterns In Physics Learning In Indonesia: Literature Review. *Jurnal Pendidikan Matematika Dan IPA*, *14*(1), 93. https://doi.org/10.26418/jpmipa.v14i1.55338

Andriani, N., Saparini, S., & Akhsan, H. (2018). Kemampuan Literasi Sains Fisika Siswa SMP Kelas VII Di Sumatera Selatan Menggunakan Kerangka PISA (Program for International Student Assesment). *Berkala Ilmiah Pendidikan Fisika*, *6*(3), 278. https://doi.org/10.20527/bipf.v6i3.5288

Andriani, N., Saparini, Sudirman, Ismet, Jumalia, & Cahyati, N. (2020). The Potential of Coastal Areas Community Life as a Source of Contextual Learning of Temperature and Heat Materials. *Advances in Social Science, Education and Humanities Research*, *513*, 757–760.

Andriani, N., Triananda, L., Supardi, S., Saparini, S., & Patriot, E. A. (2023). Kemampuan Beragurmentasi Siswa Menggunakan Model Toulmin Pada Materi Hukum Newton di SMP

Negeri 57 Palembang. *Jurnal Ilmu Fisika Dan Pembelajarannya (JIFP)*, *7*(2), 33–39. https://doi.org/10.19109/jifp.v7i2.18355

Anita, Afandi, Tenriawaru, A. B., & Putra, D. A. (2021). Profile of Argumentation Skills using Toulmin's Argumentation Pattern (TAP) in Senior High School Students in Biology Learning: Preliminary Research. *Journal of Physics: Conference Series*, *1842*(1), 012065. https://doi.org/10.1088/1742-6596/1842/1/012065

Arsyim, I., Rubini, B., & Pursitasari, I. D. (2022). Socio Scientific Issues-Based Argumentation Assessment for Middle School Students. *Jurnal Penelitian Pendidikan IPA*, *8*(2), 1034–1041. https://doi.org/10.29303/jppipa.v8i2.844

Atiş Akyol, N. (2023). Examination on 21st -Century Skills of Preschool Teachers. *e-International Journal of Educational Research*. https://doi.org/10.19160/e-ijer.1168267

Bansal, G. (2021). Indian pre-service teachers' conceptualisations and enactment of inquiry-based science education. *Education 3-13*, *49*(3), 275–287. https://doi.org/10.1080/03004279.2020.1854957

Berland, L. K., & McNeill, K. L. (2010). A learning progression for scientific argumentation: Understanding student work and designing supportive instructional contexts. *Science Education*, *94*(5), 765–793. https://doi.org/10.1002/sce.20402

Cai, J., & Gut, D. (2020). Literacy and Digital Problem -solving Skills in the 21st Century: What PIAAC Says about Educators in the United States, Canada, Finland and Japan. *Teaching Education*, *31*(2), 177–208. https://doi.org/10.1080/10476210.2018.1516747

Cavagnetto, A. R. (2010). Argument to Foster Scientific Literacy: A Review of Argument Interventions in K–12 Science Contexts. *Review of Educational Research*, *80*(3), 336–371. https://doi.org/10.3102/0034654310376953

Cengelci, S., & Egmir, E. (2022). The Effect of 21st Century Learner Skills and Metacognitive Awareness on Early Teacher Identity. *Shanlax International Journal of Education*, *10*(S1-Aug), 270–283. https://doi.org/10.34293/education.v10iS1-Aug.4873

Chen, Y., Benus, M. J., & Hernandez, J. (2019). Managing uncertainty in scientific argumentation. *Science Education*, *103*(5), 1235–1276. https://doi.org/10.1002/sce.21527

Cho, K.-L., & Jonassen, D. H. (2002). The effects of argumentation scaffolds on argumentation and problem solving. *Educational Technology Research and Development*, *50*(3), 5–22. https://doi.org/10.1007/BF02505022

Fakhriyah, F., Rusilowati, A., Nugroho, S. E., Saptono, S., Ridlo, S., Mindyarto, B., & Susilaningsih, E. (2022). The scientific argumentative skill analysis reviewed from the science literacy aspect of pre-service teacher. *International Journal of Evaluation and Research in Education (IJERE)*, *11*(4), 2129. https://doi.org/10.11591/ijere.v11i4.22847

Fasha, L. H., & Sopandi, W. (2024). Analysis of Teaching Material: To What Extent are Students' Argumentation Learning. In M. A. Wulandari, D. S. Wardani, A. Hendriyanto, C. Sutinah, G. D. S. Rahayu, S. Murni, D. Fardian, S. Sahara, L. H. Muhaimin, & I. Pauji (Eds.), *Proceedings of the International Conference on Teaching, Learning and Technology (ICTLT 2023)* (Vol. 825, pp. 285–292). Atlantis Press SARL. https://doi.org/10.2991/978-2-38476-206-4_32

Guo, K., Wang, J., & Chu, S. K. W. (2022). Using chatbots to scaffold EFL students' argumentative writing. *Assessing Writing*, *54*, 100666. https://doi.org/10.1016/j.asw.2022.100666

Hadiprayitno, G., Lestari, N., Kusmiyati, K., Sukri, A., & Irawan, J. (2022). Analysis on Students Problem-Solving Skill and Scientific Literacy Based on Higher Order Thinking Skills (HOTS) Viewed from Gender. *Jurnal Penelitian Pendidikan IPA*, *8*(5), 2508–2512. https://doi.org/10.29303/jppipa.v8i5.2287

Hand, B., Chen, Y.-C., & Suh, J. K. (2021). Does a Knowledge Generation Approach to Learning Benefit Students? A Systematic Review of Research on the Science Writing Heuristic Approach. *Educational Psychology Review*, *33*(2), 535–577. https://doi.org/10.1007/s10648-020-09550-0

Handayani, M., & Khairuna, K. (2022). The Effect of Argumentation Skills and Problem Based Learning on Science Literacy of High School Students. *Jurnal Pendidikan MIPA*, *23*(3), 1286–1295. https://doi.org/10.23960/jpmipa/v23i3.pp1286-1295

ISSN 2406-9205 (print), ISSN 2477-4820 (online)

Heng, L. L., Surif, J., & Seng, C. H. (2014). Individual Versus Group Argumentation: Student's Performance in a Malaysian Context. *International Education Studies*, *7*(7), p109. https://doi.org/10.5539/ies.v7n7p109

Ika Noviyanti, N., Rosyadah Mukti, W., Dahlia Yuliskurniawati, I., Mahanal, S., & Zubaidah, S. (2019). Students' Scientific Argumentation Skills Based on Differences in Academic Ability. *Journal of Physics: Conference Series*, *1241*(1), 012034. https://doi.org/10.1088/1742-6596/1241/1/012034

Ishtiaq, M. (2019). Book Review Creswell, J. W. (2014). Research Design: Qualitative, Quantitative and Mixed Methods Approaches (4th ed.). Thousand Oaks, CA: Sage. *English Language Teaching*, *12*(5), 40. https://doi.org/10.5539/elt.v12n5p40

Kim, S., Raza, M., & Seidman, E. (2019). Improving 21st-century teaching skills: The key to effective 21st-century learners. *Research in Comparative and International Education*, *14*(1), 99–117. https://doi.org/10.1177/1745499919829214

Kneupper, C. W. (1978). Teaching Argument: An Introduction to the Toulmin Model. *College Composition & Communication*, *29*(3), 237–241. https://doi.org/10.58680/ccc197816301

Kusuma, N. F., Ikhsan, J., Hujatulatif, A., & Huda, K. (2021). Internet of Things for Smart Future Science Laboratory in Middle School: A Literature Review. *Proceedings of The 6th Asia-Pacific Education And Science Conference, AECon 2020, 19-20 December 2020, Purwokerto, Indonesia*. Proceedings of The 6th Asia-Pacific Education And Science Conference, AECon 2020, 19-20 December 2020, Purwokerto, Indonesia, Purwokerto, Indonesia. https://doi.org/10.4108/eai.19-12-2020.2309150

Lestari, D. P., Paidi, P., & Suwarjo, S. (2024). Effect of the inquiry-based nature of science argumentation instructional model in scientific literacy skills. *Journal of Education and Learning (EduLearn)*, *18*(3), 734–744. https://doi.org/10.11591/edulearn.v18i3.21024

Manz, E. (2015). Representing Student Argumentation as Functionally Emergent From Scientific Activity. *Review of Educational Research*, *85*(4), 553–590. https://doi.org/10.3102/0034654314558490

Martini, M., Widodo, W., Qosyim, A., Mahdiannur, M. A., & Jatmiko, B. (2021). Improving Undergraduate Science Education Students' Argumentation Skills through Debates on Socioscientific Issues. *Jurnal Pendidikan IPA Indonesia*, *10*(3), 428–438. https://doi.org/10.15294/jpii.v10i3.30050

Munawaroh, H. S. H., Yuliani, G., & Aisyah, S. (2020). Implementation of Science Writing Heuristic Approach to Develop Chemistry Students' Argumentation Skill. *Proceedings of the 4th Asian Education Symposium (AES 2019)*. 4th Asian Education Symposium (AES 2019), Manado, Indonesia. https://doi.org/10.2991/assehr.k.200513.033

Nazila, L., Rosidin, U., Distrik, I. W., Herlina, K., & Hasnunidah, N. (2019). The Effect of Applying Argument Driven Inquiry Models to the Critical Thinking Skills of Students Based on Gender Differences. *Scientiae Educatia*, *8*(1), 35. https://doi.org/10.24235/sc.educatia.v8i1.4145

Nufus, S. S., Hadiprayitno, G., & Jufri, A. W. (2021). The Relationship Between Learning Styles with Learning Outcome and Scientific Literacy of Islamic Junior High School (MTs) Students in Mataram. *Jurnal Ilmiah Mandala Education*, *7*(3). https://doi.org/10.36312/jime.v7i3.2286

Osborne, J. F., Henderson, J. B., MacPherson, A., Szu, E., Wild, A., & Yao, S. (2016). The development and validation of a learning progression for argumentation in science. *Journal of Research in Science Teaching*, *53*(6), 821–846. https://doi.org/10.1002/tea.21316

Palines, K. M. E., & Ortega-Dela Cruz, R. A. (2021). Facilitating factors of scientific literacy skills development among junior high school students. *LUMAT: International Journal on Math, Science and Technology Education*, *9*(1). https://doi.org/10.31129/LUMAT.9.1.1520

Pols, C. F. J., Dekkers, P. J. J. M., & De Vries, M. J. (2023). Integrating argumentation in physics inquiry: A design and evaluation study. *Physical Review Physics Education Research*, *19*(2), 020170. https://doi.org/10.1103/PhysRevPhysEducRes.19.020170

Prabaningrum, D., & Waluya, S. B. (2020). The Improvement of Mathematical Communication Skill Through Project Based Learning with STEM Strategy. *Proceedings of the International Conference on Science and Education and Technology (ISET 2019)*. International Conference on Science and Education and Technology (ISET 2019), Kota Semarang, Indonesia. https://doi.org/10.2991/assehr.k.200620.132

ISSN 2406-9205 (print), ISSN 2477-4820 (online)

Pratiwi, S. N., Cari, C., Aminah, N. S., & Affandy, H. (2019). Problem-Based Learning with Argumentation Skills to Improve Students' Concept Understanding. *Journal of Physics: Conference Series*, *1155*, 012065. https://doi.org/10.1088/1742-6596/1155/1/012065

Purnomo, S., Rahayu, Y. S., & Agustini, R. (2023). Effectiveness of ADI-STEM to Improve Student's Science Literacy Skill. *IJORER : International Journal of Recent Educational Research*, *4*(5), 632–647. https://doi.org/10.46245/ijorer.v4i5.382

Ryu, S., & Sandoval, W. A. (2012). Improvements to elementary children's epistemic understanding from sustained argumentation. *Science Education*, *96*(3), 488–526. https://doi.org/10.1002/sce.21006

Sakai, K., Higashinaka, R., Yoshikawa, Y., Ishiguro, H., & Tomita, J. (2020). Hierarchical Argumentation Structure for Persuasive Argumentative Dialogue Generation. *IEICE Transactions on Information and Systems*, *E103.D*(2), 424–434. https://doi.org/10.1587/transinf.2019EDP7147

Sulisworo, D., & Safitri, I. (2022). Online Student-worksheet Based on Toulmin Argumentation Pattern in Physics Learning. *Journal of Physics: Conference Series*, *2394*(1), 012033. https://doi.org/10.1088/1742-6596/2394/1/012033

Topalsan, A. K. (2020). Development Of Scientific Inquiry Skills Of Science Teaching Through Argument-Focused Virtual Laboratory Applications. *Journal of Baltic Science Education*, *19*(4), 628–646. https://doi.org/10.33225/jbse/20.19.628

Venville, G. J., & Dawson, V. M. (2010). The impact of a classroom intervention on grade 10 students' argumentation skills, informal reasoning, and conceptual understanding of science. *Journal of Research in Science Teaching*, *47*(8), 952–977. https://doi.org/10.1002/tea.20358

Von Aufschnaiter, C., Erduran, S., Osborne, J., & Simon, S. (2008). Arguing to learn and learning to argue: Case studies of how students' argumentation relates to their scientific knowledge. *Journal of Research in Science Teaching*, *45*(1), 101–131. https://doi.org/10.1002/tea.20213

Wilson, C. D., Haudek, K. C., Osborne, J. F., Buck Bracey, Z. E., Cheuk, T., Donovan, B. M., Stuhlsatz, M. A. M., Santiago, M. M., & Zhai, X. (2024). Using automated analysis to assess middle school students' competence with scientific argumentation. *Journal of Research in Science Teaching*, *61*(1), 38–69. https://doi.org/10.1002/tea.21864

Windyariani, S., & Amalia, R. A. (2019). Science Literacy in Prospective Elementary School Teachers Through Science Technologu Literacy Learning. *Proceedings of the 4th Progressive and Fun Education International Conference (PFEIC 2019)*. Proceedings of the 4th Progressive and Fun Education International Conference (PFEIC 2019), Makassar, Indonesia. https://doi.org/10.2991/pfeic-19.2019.22

York, S., Lavi, R., Dori, Y. J., & Orgill, M. (2019). Applications of Systems Thinking in STEM Education. *Journal of Chemical Education*, *96*(12), 2742–2751. https://doi.org/10.1021/acs.jchemed.9b00261

Yulianti, D., & Handayani, E. (2021). Enhancement of communication skills through physics learning with science, technology, engineering, and mathematics (stem) approach. *Journal of Physics: Conference Series*, *1918*(5), 052083. https://doi.org/10.1088/1742-6596/1918/5/052083

Zhu, M., Liu, O. L., & Lee, H.-S. (2020). The effect of automated feedback on revision behavior and learning gains in formative assessment of scientific argument writing. *Computers & Education*, *143*, 103668. https://doi.org/10.1016/j.compedu.2019.103668

ISSN 2406-9205 (print), ISSN 2477-4820 (online)