Relationship between Scientific Literacy Skills and Students' Argumentation Skills on Climate Change

Rinta Yulianti, Riezky Maya Probosari, Widha Sunarno

Departement of Science Education, Universitas Sebelas Maret
Departement of Science Education, Universitas Sebelas Maret, Departement of Physic Educationtion, Universitas Sebelas Maret

yuliantirinta@student.uns.ac.id,
riezkymprobosari@staff.uns.ac.id, widhasunarno@staff.uns.ac.id

Abstract. This study aims to (1) determine the profile of the scientific literacy skills of seventh-grade students on the theme of climate change, (2) determine the profile of the argumentation skills of seventh-grade students on the theme of climate change, and (3) determine the positive relationship between scientific literacy skills and argumentation skills of seventh-grade students on the theme of climate change. This research is quantitative research using the correlation technique. The sampling technique used in this study was simple random sampling so that 69 students were obtained as samples from all seventh-grade students of one of the junior high schools in Boyolali, Central Java, as the population. The data collection technique used multiple-choice test instruments to measure scientific literacy skills and essay tests to measure argumentation skills. The data analysis technique of this research is descriptive statistical analysis. Based on the data analysis, the results showed that (1) the scientific literacy skills profile of seventh-grade students on the theme of climate change that most stood out was the aspect of evaluating and designing scientific enquiry by 57%, (2) the argumentation skills profile of seventh-grade students on the theme of climate change the most what stands out is the claim aspect of 56%, (3) there is a positive relationship between scientific literacy skills and students' argumentation skills on the theme of climate change with a correlation value of 0.548. It can be interpreted that students' scientific literacy skills can be used to determine the level of students' argumentation skills, which indicates that if the value of scientific literacy skills is high, the value of students' argumentation skills is also high.

Keywords: Science Learning, Scientific Literacy, Argumentation, Correlation

1 Introduction

Scientific literacy is an essential literacy that is very much needed in learning Natural Sciences. Program for International Student Assessment (PISA) 2018 defines scientific literacy as a person's skill to engage in scientific issues [1]. Scientific literacy is considered appropriate and important for the development of science learning in secondary

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schools [2]. Science learning needs to provide direct experience through sensory observation activities such as identification, decision-making, reasoning related to science, and social interaction. The advantage of integrated scientific literacy for science teachers is that the content of scientific material presented by the teacher reveals aspects of reading comprehension by developing questions that are scientific in nature including content, process, and application [3].

The reality of education in Indonesia which is backward when coupled with other countries cannot be denied. Organization for Economic Co-operation and Development (OECD) data highlighted several problems in Indonesian education [4]. In the reading, science, and math categories, Indonesia has a low score and is ranked 74th out of 79 countries. Based on these results, it can be said that current learning has not been able to emphasize basic literacy so that it is embedded in students. Basic literacy, one of which is scientific literacy, is essential for science learning.

Science literacy skills in students will be useful for making statements when arguing. Argumentation skills have potential contributions to science learning including supporting metacognitive and cognitive processes, communication competence and especially critical thinking, scientific literacy, and strengthening students to write and communicate knowledge and then develop reasoning [5]. However, in reality, there are still many students who have difficulties so learning must begin to be directed to involve students in scientific argumentation as part of science [6]. The scientific literacy skill and argumentation skills of students are still relatively low so that further studies are needed so that students make learning more meaningful.

Based on field observations of junior high school students, the lack of scientific literacy and argumentation skills is undeniable, which is marked by the inactivity of students to respond to teachers during the learning process and lack of curiosity about learning so that they do not read and understand the material more deeply. Science learning in junior high schools has a theme or concept regarding climate change. Learning about the theme of climate change is closely related to society at large in life and there are problems related to the causes and impacts in everyday life. The existence of various cases in the theme of climate change can be used as material to train students' argumentation skills in line with the statement that climate change is a scientific social theme that can shape argumentation skills [7].

Previous research that described the scientific literacy profile of students stated that the scientific literacy achievement of students was included in the excellent category [8]. Based on relevant research on the analysis of argumentation skills, it is stated that the quality of students' written argumentation skills is still relatively low, with the quality of argumentation occupying levels one and two [9]. In addition, other research states that the higher the argumentation skill of students, the higher the scientific literacy skill of students. However, in general, the scientific literacy and argumentation skills of students in Indonesia are still lacking [10]. Efforts to improve the quality of science learning must have the support of the latest information on scientific literacy and argumentation skills that have been achieved, especially at the junior high school level.

Previous research on the profile of scientific literacy skills and argumentation skills has indeed been done. However, the research is only limited to each variable. Further

studies accompanied the relationship between scientific literacy skills and argumentation skills, but it is still very limited, especially research that focuses on science subjects at the junior high school level. In addition, the research to be carried out has criteria in terms of location and form of learning implementation that are different from other studies previously. Based on the problems that have been described, this study aims to (1) determine the profile of the scientific literacy skills of seventh-grade students on the theme of climate change, (2) determine the profile of the argumentation skills of seventh-grade students on the theme of climate change, and (3) determine the positive relationship between scientific literacy skills and argumentation skills of seventh-grade students on the theme of climate change. The results of the research have the hope that they can be the basis for developing scientific literacy skills and scientific argumentation skills for students in science learning.

2 Method

The research design uses quantitative research with correlation techniques [11]. The sampling technique used was simple random sampling with a sample of 69 students from seventh-grade students of one of the junior high schools in Boyolali, Central Java, as the population. The research data collection technique used fifteen multiple-choice questions to determine scientific literacy skills and five essay questions to determine written argumentation skills. Scientific literacy skills are measured based on the competency aspects of PISA 2018 [12]. Written argumentation skills were measured based on a model from McNeill & Krajcik [13]. The data analysis technique of this research is descriptive statistical analysis. [11].

3 Finding

3.1 Profile of Scientific Literacy

Students' scientific literacy skills are measured using questions compiled by researchers based on aspects of PISA 2018 competencies, namely, explaining phenomena scientifically, evaluating and designing scientific enquiry, and interpreting data and evidence scientifically. The average value of the scientific literacy test is 52.56. Figure 1 is the average score of science literacy skills in three aspects.

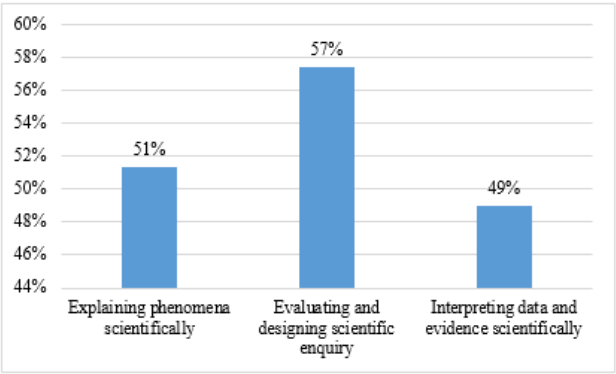


Fig. 1. The Average Score of Scientific Literacy Skills Aspect

Figure 1 shows that the highest scientific literacy skills in the aspects of evaluating and designing scientific enquiry is 57%. While the average in the aspect of explaining phenomena scientifically is 51%, and the aspect of interpreting data and evidence scientifically is 49%. Scientific literacy skills are assessed from three aspects of PISA 2018 competencies. The results show that scientific literacy skills have an average score of 52.56. In more detail, the percentage of the average value in explaining phenomena scientifically is 51%. Problems with aspects of explaining phenomena scientifically are listed in numbers 1, 2, 4, 6, and 11. Figure 2 is an example of student answers on aspects of explaining phenomena scientifically for question number 4.

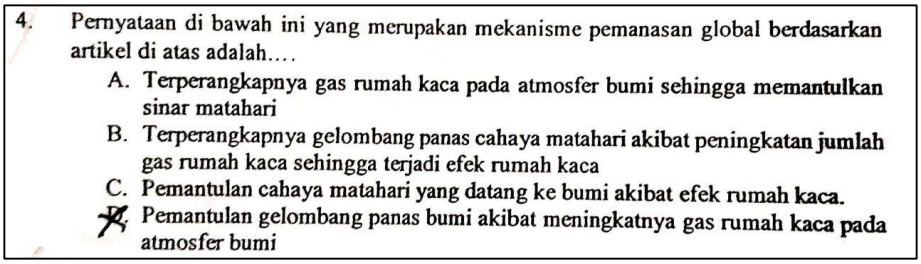
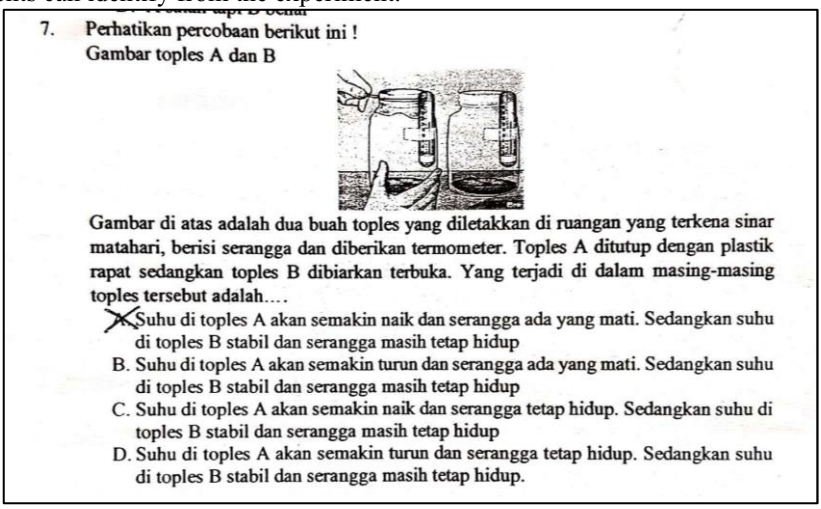

4. Pernyataan di bawah ini yang merupakan mekanisme pemanasan global berdasarkan artikel di atas adalah....
   A. Terperangkapnya gas rumah kaca pada atmosfer bumi sehingga memantulkan sinar matahari
   B. Terperangkapnya gelombang panas cahaya matahari akibat peningkatan jumlah gas rumah kaca sehingga terjadi efek rumah kaca
   C. Pemantulan cahaya matahari yang datang ke bumi akibat efek rumah kaca.
   D. Pemantulan gelombang panas bumi akibat meningkatnya gas rumah kaca pada atmosfer bumi

Fig. 2. Sample Answers Aspect of Explaining Phenomena Scientifically

According to PISA 2018, explaining some scientific phenomena requires understanding how knowledge is obtained with correct data [12]. As many as 58% of students have not answered question 4 correctly. Students have not been able to answer about the mechanism of global warming following the articles presented. These findings follow research that reveals that understanding the concepts that students have learned will affect the ability to explain scientific phenomena [14]. This aspect aims to assess students' understanding of the concept of the material so that it can be used in everyday life [15].

The following finding, the most prominent aspect of scientific literacy is evaluating and designing scientific enquiry, with an average value of 57%. Problems with this

aspect are found in numbers 3, 5, 7, 12, and 13. The following is an example of student answers to question number 7 in Figure 3 which presents an overview of the experiment students can identify from the experiment.


7. Perhatikan percobaan berikut ini !
Gambar toples A dan B

Gambar di atas adalah dua buah toples yang diletakkan di ruangan yang terkena sinar matahari, berisi serangga dan diberikan termometer. Toples A ditutup dengan plastik rapat sedangkan toples B dibiarkan terbuka. Yang terjadi di dalam masing-masing toples tersebut adalah....

A. Suhu di toples A akan semakin naik dan serangga ada yang mati. Sedangkan suhu di toples B stabil dan serangga masih tetap hidup
B. Suhu di toples A akan semakin turun dan serangga ada yang mati. Sedangkan suhu di toples B stabil dan serangga masih tetap hidup
C. Suhu di toples A akan semakin naik dan serangga tetap hidup. Sedangkan suhu di toples B stabil dan serangga masih tetap hidup
D. Suhu di toples A akan semakin turun dan serangga tetap hidup. Sedangkan suhu di toples B stabil dan serangga masih tetap hidup.

Fig. 3. Sample Answers Aspects of Evaluating and Designing Scientific Enquiry

Scientific literacy demands various understandings of the purpose of scientific investigation, namely to produce reliable knowledge about nature. This aspect of evaluating and designing scientific enquiry measures students' accuracy in interpreting the experiment results. As many as 70% of students can answer question number 7 correctly. Problems with this aspect will train students' ability to identify experimental results [15]. The findings of this investigation are different from previous research, which revealed that evaluating and designing scientific enquiry is complex because it relates to aspects of knowledge and attitudes, so students' abilities in this aspect are still lacking [16]. The teacher-centered science learning process that does not emphasize the scientific process can cause a lack of scientific inquiry ability.

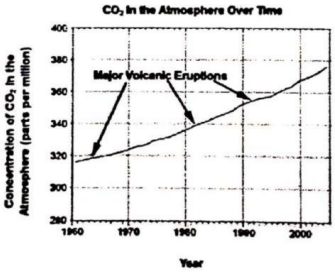
Aspects of interpreting data and evidence scientifically have an average of 49%. Questions with these aspects are found in numbers 8, 9, 10, 14, and 15. Figure 4 contains examples of student answers to question number 14, which present data in graphs and tables so that students can analyze the meaning of the data.

14. Perhatikan grafik dan tbel di bawah ini!

Erupsi vulkanik

Karbon dioksida atmosfer

Gunung berapi memancarkan karbon dioksida (CO_2) selama letusan. Grafik di bawah ini menunjukkan konsentrasi karbon dioksida atmosfer yang telah diukur oleh para ilmuwan sejak 1960.



Tabel di bawah ini menunjukkan kontribusi relatif dari berbagai sumber terhadap karbon dioksida di atmosfer

Sumber	Kontribusi CO_2 di Atmosphere
Emisi Vulkanik	<1%
Emisi oleh manusia	20%
Respirasi tanaman	40%
Respirasi mikroba dan dekomposisi	40%

Berdasarkan informasi yang diberikan, efek apa yang dimiliki letusan gunung berapi terhadap konsentrasi karbon dioksida di atmosfer adalah ....

A. Efek utama, karena ada banyak letusan
B. Efek utama, karena setiap letusan mengeluarkan sejumlah besar material
C. Efek kecil, karena kadar CO_2 di atmosfer menurun selama letusan
D. Efek kecil, karena gunung berapi melepaskan sedikit CO_2 dibandingkan dengan

Fig. 4. Sample Answers Aspect of Interpret Data and Evidence Scientifically

Aspects of interpreting data and evidence scientifically, namely analyzing and evaluating scientific data, claims, and arguments into various representations and making appropriate conclusions. As many as 52% of students have been unable to identify information on the questions to find patterns in the data so they can conclude correctly. Problems in the third aspect of scientific literacy competence provide students' demands for problem identification through scientific data exploration. Most students have difficulty inferring data due to a lack of practice with this question. These findings align with previous research, which revealed that students still have low abilities in interpreting data and scientific evidence [16]. Mastery of concepts in science learning is still lacking, so they cannot interpret data correctly even though the questions are simple [17].

3.2 Profile of Argumentation Skill

Students' argumentation skills were measured using written questions compiled by researchers according to the indicators of McNeill & Krajcik, with four aspects, namely claim, evidence, reasoning, and rebuttal. The average value of the argumentation skills test results is 30.58. The following is the average argumentation skill score shown in Figure 5.

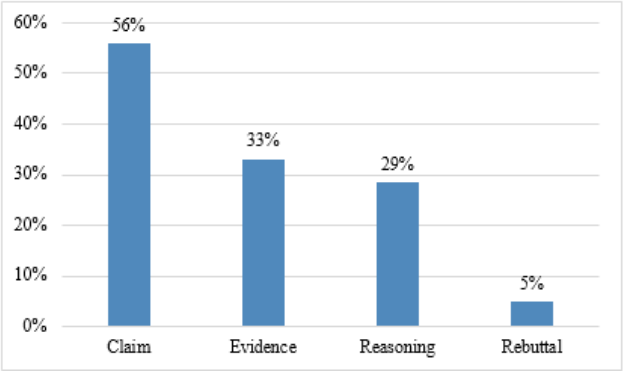


Fig. 5. The Average Score of Argumentation Skills Aspect

Figure 5 shows that the argumentation skills of seventh-grade junior high school students are the highest in the claim aspect, which is 56%. The average aspects of evidence, reasoning, and rebuttal are 33%, 29%, and 5%, respectively. This result shows that the student's superior argumentation skill is the claim aspect. Students can file a claim against a problem but are still unable to complete it with further explanations in the form of evidence, reasoning, or even giving a rebuttal. Table 1 contains examples of student answers to argumentation question number 1.

Table 1. Sample Answers of Argumentation Aspect

Question	Conclude, Is carbon dioxide the leading cause of global warming?
Claim	Yes, carbon dioxide (CO_2) is the leading cause of global warming
Evidence	Global warming is mainly caused by too much carbon dioxide (CO_2) and other gases in the atmosphere.
Reasoning	Because global warming is mainly caused by carbon dioxide
Rebuttal	In addition to carbon dioxide, other gases are the leading cause of global warming

A *claim* is a statement that answers the original question. Already 75% of students can make a claim correctly on the problem presented in number 1. For example, in Table 1, students can make the correct claim, but most of them are constrained if they have to provide evidence and reasoning that supports the claim. Evidence and reasoning provided by students do not use sufficient data to support claims, let alone connect claims and evidence. Most of the students did not give a rebuttal to the arguments given. Only 6% of students gave rebuttals with counterclaims without data or reasons.

The findings described above follow previous research that the highest argumentation aspect is the claim of 92%, and the rebuttal aspect is only 11% [18]. Aspects of evidence and reasoning that are still lacking are also found in previous studies, and students still have difficulty finding evidence and making reasons that connect the evidence with claims [19]. Argumentation skills need to be developed when learning because of the lack of argumentation skills because most students do not understand the basic concepts on the theme of climate change [18].

3.3 Relationship between Scientific Literacy Skill and Argumentation Skill

The data obtained were tested to answer the hypothesis by conducting prerequisite tests first, namely normality and linearity tests. The results of the normality test are contained in Table 2.

Table 2. Normality Test Results

Normality Test	One-Sample KS Test			Result	Decision
	Test Statistic	N	Sig.		
Argumentation* Scientific Literacy	0.088	69	0.200	> 0.05	Normal

The normality test results showed a significance value of 0.200 where the value was > 0.05, indicating that the data from the scientific literacy and argumentation variables were normally distributed.

The following prerequisite test is the linearity test contained in Table 3.

Table 3. Linearity Test Results

Linearity Test	Deviation from Linearity		Result	Decision
	N	Sig.		
Argumentation* Scientific Literacy	69	0.390	> 0.05	Linear

The results of the linearity test show a significance value of 0.390, where the value is > 0.05, indicating a linear relationship between the scientific literacy variable and argumentation.

After the prerequisite test has been fulfilled, the research hypothesis is tested, namely that there is a positive relationship between scientific literacy skills and argumentation skills on climate change. Hypothesis analysis using Pearson product-moment correlation as contained in Table 4.

Table 4. Hypothesis Test Results

Hypothesis Test	N	Sig.	Pearson Correlation	Result
Argumentation* Scientific Literacy	69	0.00	0.548	Pearson Correlation > r tabel Sig. < 0.05

The correlation test results show that the coefficient of scientific literacy and argumentation skills is 0.548. The correlation coefficient shows a positive value which means the research hypothesis is accepted that there is a positive relationship between scientific literacy and arguments on the theme of climate change.

4 Discussion

4.1 Profile of Scientific Literacy Skill

Overall, students have relatively the same scientific literacy skills in these three aspects, especially on the theme of climate change. The highest aspect is evaluating and designing scientific enquiry with 57%. Some students already have conceptual knowledge in solving social-scientific problems with the theme of climate change. Aspects of evaluating and designing scientific enquiry are complex because they relate to aspects and attitudes that train students' skills in finding experimental results [15], [16]. Mastery of scientific literacy skills is influenced by several factors, including the learning strategies used by teachers to build science process skills [14]. Various students' scientific literacy skills are influenced by their parents' background, interests, learning curriculum, and learning environment [10].

4.2 Profile of Argumentation Skill

The results on argumentation skills show that the highest aspect is the *claim*. Students can provide statements or claims to answer a given problem with the theme of climate change. However, they still struggle to find evidence to support the claim and make reasons that link the evidence to the claim. Argumentation skills need to be developed [18]. The lack of argumentation skills is also because most students do not understand the basic concepts of the theme of climate change. Meanwhile, argumentation skills are influenced by mastery of fundamental concepts with the theme of climate change. Factors that have the potential to influence students' arguments include conceptual knowledge, social environment, gender, and ability to reason or think critically [20].

4.3 Relationship between Scientific Literacy Skill and Argumentation Skill

The results of this study indicate a positive relationship between scientific literacy and argumentation with the theme of climate change. It can be interpreted that students' scientific literacy skills can be used to determine the level of students' argumentation skills, which indicates that if the value of scientific literacy skills is high, the value of students' argumentation skills is also high. This study's results align with previous research, which shows a significant and positive relationship between argumentation skills and scientific literacy skills. Students' argumentation skills are useful for predicting students' scientific literacy skills [21]. Argumentation skills have potential contri-

butions to science learning including supporting metacognitive and cognitive processes, communication competence and especially critical thinking, scientific literacy, and strengthening students to write and communicate knowledge and then develop reasoning [5]. Scientific literacy skills will help make statements when debating.

Argumentation is an integral part of science. One aspect of scientific literacy skills is demonstrated through the analysis and evaluation of scientific data, claims, and arguments into some representations and making suitable conclusions [12]. Argumentation is an essential component of scientific literacy because students must understand good arguments and how to use arguments to communicate. If good arguments support scientific literacy, students will speak and write to understand scientific knowledge and improve literacy [22]. Although argumentation has a vital role in scientific literacy, argumentation is also rare in science learning [23]. Arguments as an essential component of scientific literacy should be emphasized to be integrated with classroom teaching with socio-scientific issues to establish a context for studying science [24]. Scientific argumentation involves knowledge through the argumentation of questions, claims, evidence, and reasoning, which will ultimately increase students' scientific literacy [22].

Based on the research that has been done, it can be seen that there is a positive relationship between scientific literacy skills and argumentation skills on the theme of climate change. The results of the research findings have also been proven by previous studies that have been described. This study has limitations in describing the answers to scientific literacy skills in more detail because the question instruments used to measure students' abilities are limited to multiple choice questions. Multiple-choice questions of this type cannot fully represent scientific literacy skills because four answer choices allow students to guess 25% of the answers. In addition, this study has not assessed the quality of students' argumentation.

5 Conclusion

Based on the data analysis, the results showed that (1) the scientific literacy skills profile of seventh-grade students on the theme of climate change that most stood out was the aspect of evaluating and designing scientific enquiry by 57%, (2) the argumentation skills profile of seventh-grade students on the theme of climate change the most what stands out is the claim aspect of 56%, (3) there is a positive relationship between scientific literacy skills and students' argumentation skills on the theme of climate change with a correlation value of 0.548. It can be interpreted that students' scientific literacy skills can be used to determine the level of students' argumentation skills, which indicates that if the value of scientific literacy skills is high, the value of students' argumentation skills is also high. This research can theoretically provide insight into the extent to which students' scientific literacy and argumentation skills are on the theme of climate change. In addition, it can practically be used as an impetus to improve the science learning process further to support the achievement of scientific literacy and argumen-

tation skills. Further research needs to be carried out with research data collection techniques, preferably not only tests but also further observations and interviews so that later the data will be the more representative of the actual situation.

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References

1. OECD, *PISA 2018 Assessment and Analytical Framework*. 2019.
2. U. D. Pertiwi, R. D. Atanti, and R. Ismawati, "Pentingnya Literasi Sains Pada Pembelajaran Ipa Smp Abad 21," *Indones. J. Nat. Sci. Educ.*, vol. 1, no. 1, pp. 24–29, 2018.
3. R. P. Situmorang, "Integrasi Literasi Sains Peserta Didik Dalam Pembelajaran Sains," *Satya Widya*, vol. 32, no. 1, p. 49, 2016.
4. OECD, "What Students Know and Can Do," *PISA 2018 Result*, vol. I, 2019.
5. M. P. Jiménez-Aleixandre and S. Erduran, "Argumentation in Science Education: An Overview," *Argumentation Sci. Educ.*, pp. 3–27, 2007.
6. R. M. Probosari, M. Ramli, Harlita, M. Indrowati, and Sajidan, "Profile of Scientific Argumentation Skills for Biology Education FKIP UNS Students in Plant Anatomy Course," *Bioedukasi J. Pendidik. Biol.*, vol. 8, no. 2, p. 29, 2016.
7. S. Hendri and A. Defianti, "Review: Membentuk Keterampilan Argumentasi Siswa Melalui Isu Sosial Ilmiah dalam Pembelajaran Sains," *Pros. Simp. Inov. dan Pembelajaran Sains*, vol. 2015, no. Snips, pp. 545–548, 2015.
8. A. Mawardini, A. Permanasari, and Y. Sanjaya, "Profil literasi sains siswa SMP pada pembelajaran IPA terpadu tema pencemaran lingkungan," *Pros. Semin. Nas. Fis. SNF 2015*, vol. IV, no. 1996, pp. 49–56, 2015.
9. S. Zairina and S. N. Hidayati, "Analisis Keterampilan Argumentasi Siswa SMP Berbantuan Socio-Scientific Issue Pemanasan Global," *Pensa E-Jurnal:Pendidikan Sains*, vol. 10, no. 1, pp. 37–43, 2022.
10. R. Fadlika, D. Hernawati, and V. Meylani, "Kemampuan Argumentasi Dan Kemampuan Literasi Sains Peserta Didik Kelas Xi Mipa Pada Materi Sel," *LENSA (Lentera Sains) J. Pendidik. IPA*, vol. 12, no. 1, pp. 9–18, 2022.
11. D. Ary, L. C. Jacobs, C. Sorensen, and A. Razavieh, *Introduction to Research in Education*, Eighth Edi. USA, 2010.
12. OECD, "PISA 2018 Science Framework," pp. 97–117, 2019.
13. K. L. McNeill and J. S. Krajcik, *Supporting Grade 5-8 Students in Constructing Explanations in Science: The Claim, Evidence, and Reasoning Framework for Talk and Writing*. 2011.
14. N. Wulandari and H. Sholihin, "Analisis Kemampuan Literasi Sains Pada Aspek Pengetahuan Dan Kompetensi Sains Siswa Smp Pada Materi Kalor," *Edusains*, vol. 8, no. 1, pp. 66–73, 2016.

15. D. Hernawati, M. Amin, and V. Meylani, "Analisis Kognitif Mahasiswa Biologi melalui Literasi Sains terhadap Materi Zoologi Vertebrata," *Pros. Semin. Nas. Biol.*, pp. 9–25, 2015.
16. A. Fauziyah, P. Prasetyaningsih, and L. T. Biru, "Analysis of Scientific Literacy Skills in Solving Question Science on Food Security Themes in Serang City," *J. Penelit. Pendidik. IPA*, vol. 6, no. 2, pp. 56–63, 2021.
17. N. I. Arding and S. Atun, "Analysis of Junior High School students' scientific literacy on simple effort and aircraft for everyday life," *J. Phys. Conf. Ser.*, vol. 1440, no. 1, 2020.
18. H. A. Noer, S. Setiono, and R. Y. Pauzi, "Profil Kemampuan Argumentasi Siswa Smp Pada Materi Sistem Pernapasan," *J. Pelita Pendidik.*, vol. 8, no. 2, pp. 138–144, 2020.
19. A. C. Pritasari, S. Dwiastuti, and R. M. Probosari, "Peningkatan Kemampuan Argumentasi melalui Penerapan Model Problem Based Learning pada Siswa Kelas X MIA 1 SMA Batik 2 Surakarta Tahun Pelajaran 2014/2015," *Pendidik. Biol.*, vol. 8, no. 1, pp. 1–7, 2016.
20. W. Songsil, P. Pongsophon, B. Boonsoong, and A. Clarke, "Developing scientific argumentation strategies using revised argument-driven inquiry (rADI) in science classrooms in Thailand," *Asia-Pacific Sci. Educ.*, vol. 5, no. 1, 2019.
21. R. Delfita, F. Setiawati, D. Marneli, and A. I. Putra, "Relationship between Scientific Argumentation Skills and Students' Scientific Literacy Skills," *J. Pendidik. Biol.*, vol. 11, no. 1, pp. 52–58, 2022.
22. Y. C. Chen, "Using the Science Talk–Writing Heuristic to Build a New Era of Scientific Literacy," *Read. Teach.*, vol. 73, no. 1, pp. 51–64, 2019.
23. E. Manz, *Representing Student Argumentation as Functionally Emergent From Scientific Activity*, vol. 85, no. 4. 2015.
24. O. Sengul, "Linking scientific literacy, scientific argumentation, and democratic citizenship," *Univers. J. Educ. Res.*, vol. 7, no. 4, pp. 1090–1098, 2019.