JPPIPA 11(8) (2025)

Jurnal Penelitian Pendidikan IPA

http://jppipa.unram.ac.id/index.php/jppipa/index

Effect of Argument Driven Inquiry (ADI)-STEM Model on Students' Numeracy Literacy and Scientific Argumentation Skills

Syukurman Laia[1*], Nurdin Siregar[1], Mariati Purnama Simanjuntak[1]

[1] Physics Department, FMIPA, Universitas Negeri Medan, Medan, Indonesia

Received: June 19, 2025
Revised: August 01, 2025
Accepted: August 25, 2025
Published: August 31, 2025

Corresponding Author:
Syukurman Laia
Syukurmanlaia98@gmail.com

DOI: 10.29303/jppipa.v11i8.11787

Abstract: This study aims to determine the significant effect of the argument driven inquiry (ADI)-STEM learning model on numeracy literacy and scientific argumentation skills of students on the subject matter of dynamic fluid class XI semester II at SMAN 10 Medan T.P 2024/2025. This type of research is a quasi experiment and the research design is a two-group pretest-posttest. The population in this research is the entire class XI of SMAN 10 Medan T.P 2024/2025. The sample in this study consisted of two classes selected randomly with simple random sampling technique, class XI IPA-1 as an experimental class using argument driven inqiry (ADI)-STEM learning model with a total of 36 students and class XI IPA-2 as a control class with conventional learning model with a total of 31 students. The instrument in this study was a test in the form of a 10 question essay. Data analysis was used with manova test. The results of the study were obtained with the average value of the numeracy literacy pretest of the experimental class and control class 53.89 and 54.19 respectively while the scientific argumentation of the experimental class and control class 52.22 and 51.68 respectively. The average post-test scores of numeracy literacy of experimental and control classes were 83.22 and 71.48 respectively while scientific argumentation of experimental and control classes were 86.78 and 70.90 respectively. Data analysis using manova test concluded that there is a significant effect of argument driven inquiry learning model on numeracy literacy and scientific argumentation.

Keywords: Argument Driven Inquiry (ADI) Model; Numeracy Literacy; Scientific Argumentation; STEM

Introduction

The paradigma shift in Indonesia's curriculum towards an independent curriculum focuses on developing students' overall potential. The independent curriculum aims to improve the quality of education in Indonesia (Hutagalung and Kurniati, 2024). In order not to fall behind other countries in the world, an independent curriculum has become the choice for educational recovery (Nugraha, 2022). The implementation of the independent curriculum emphasizes differentiated learning, which focuses on how teachers address students' strengths and needs to be more proactive in the learning process (Tami and Friyatmi, 2023).

In line with the implementation of the independent curriculum, 21st century learning must be able to improve the competitive skills needed with a focus on strengthening numeracy literacy and scientific argumentation, which are expected in the learning process (Melta et al, 2024). According to the National Literacy Movement (Kemendikbud 2017), mastering the six basic literacy components is crucial, including language literacy, numeracy, digital literacy, scientific literacy, financial literacy, and cultural and civic literacy. According to Abidin et al. (2018), literacy involves utilizing language and visuals to critically understand and communicate information through various media. Ekowati et al. (2019) state that literacy is related to an individual's ability to understand, process, and give

How to Cite:
Laia, S., Siregar, N., & Simanjuntak, M. P. (2025). Effect of Argument Driven Inquiry (ADI)-STEM Model on Students' Numeracy Literacy and Scientific Argumentation Skills . *Jurnal Penelitian Pendidikan IPA*, *11*(8), 1275–1288. https://doi.org/10.29303/jppipa.v11i8.11787

meaning to information and knowledge obtained. Winata et al. (2021) define numeracy as the ability to use number concepts, arithmetic operations, and numerical data interpretation to solve problems. According to Oktariya et al. (2023), numeracy encompasses the ability to think logically using procedures, facts, and mathematical tools to solve contextual problems, as well as the application of number concepts and arithmetic skills.

Numeracy literacy encompasses the understanding and analysis of statements based on symbols and language that are often encountered in everyday contexts (Chairunnisya et al., 2023). Hadi and Zidah (2021) state that numeracy literacy is the ability of students to use mathematical concepts in reasoning, analysis, and interpretation of data (such as text, symbols, graphs, and numbers) to solve everyday problems. Nurjumiati et al. (2022) state that numeracy literacy is the ability of students to apply number concepts from arithmetic operations in everyday life. Numeracy literacy can connect the mathematics learned with real-world situations (Mutmainah, 2023). The Minimum Competency Assessment (AKM) evaluates students' reasoning ability in solving problems that require basic mathematical knowledge to solve. Numeracy literacy is one example of this (Izzatin et al., 2022).

In addition to numeracy literacy skills, scientific argumentation is very important for students. One of the skills that students must possess is argumentation, defined as a structured component used to solve problems by employing argumentative statements (Widhi et al., 2021). Roja et al. (2020) state that argumentation is one of the skills students must possess to connect what they learn with what they do in their daily lives.

The quality of an argument can be assessed using empirical and theoretical criteria. Empirical criteria can be seen through the consistency of claims with evidence, the sufficiency of evidence, the predictive power of claims, and quality, while theoretical quality is measured by how complete the explanation is, whether it is useful, and whether it is consistent with other ideas (Suganda et al., 2021). Developing scientific arguments is very important because it can teach scientific thinking, communication, and acting like a scientist (Fakhriyah et al., 2021).

Students' numeracy and scientific reasoning skills can be tested using the PISA test, which can be taken by students from various countries. Indonesia's PISA scores have declined, particularly in the areas of numeracy and scientific reasoning, with the 2018 PISA results showing a decline (Viyanti et al, 2023). Supported by research by Sartianis (2022), it was revealed that Indonesians are still very lacking in numeracy literacy and far behind other countries. Similarly, research by Nisak and Suprapto (2022) found that in learning activities, many students still have low scientific argumentation skills, which affects their learning outcomes and overall life, including the possibility of losing good job opportunities. In line with Ayana et al.'s (2022) research, it was revealed that many students are still asked to collect data, but when involved in argumentation, they find it difficult to present their arguments.

Observational data collected by researchers at SMA Negeri 10 Medan indicate that students' numeracy and scientific argumentation skills are still relatively low. Many students are unable to use symbols and numbers in problem-solving contexts and have difficulty evaluating data presented in diagrams, tables, and graphs, indicating a low level of numeracy. Specifically regarding dynamic fluid material, students appear to face challenges in interpreting the relationships between physical variables such as pressure, velocity, and cross-sectional area. Previous studies indicating that most students struggle to read and analyze data from various visual representations reinforce these findings (Faqih et al., 2022; Rahman et al., 2023).

Students' scientific argumentation skills are also still relatively low. It appears that some students find it difficult to make claims about a phenomenon, are unable to analyze data, explain the relationship between data and phenomena, and are unable to provide support with data from that phenomenon. Students are also unable to formulate claims based on data and experience difficulties in constructing valid, evidence-based arguments (Pitorini et al., 2020; Sari et al., 2021). Another phenomenon identified by researchers is that when using essay-based tests on physics material, particularly dynamic fluid material, students still struggle to analyze questions presented in the form of diagrams, tables, and graphs. They also fail to use symbols and numbers to solve problems, making it difficult to make predictions in the decision-making process. Additionally, students are unable to claim a phenomenon and cannot provide opinions based on valid data, making it difficult to provide counterarguments and support for the phenomenon.

Students still lack numeracy and scientific reasoning skills, as evidenced by their declining average scores. In 2021-2024, students scored ≤ 75. The average scores obtained by students are presented in Table 1.

Table 1. Student Learning Outcomes at SMAN 10 Medan

Year	Average Score	Subject
2021/2022	60	Physics
2022/2023	65	Physics
2023/2024	60	Physics

Teacher-centered learning processes still influence students' abilities, as many students feel passive and lack participation in class. The learning received by students does not match their needs. As a result, they face difficulties in analyzing readings in various formats and fail to use various types of symbols and numbers to solve problems and draw conclusions about what they have learned. Students are unable to claim a phenomenon and cannot provide opinions based on valid data, making it difficult to provide counterarguments and support for the phenomenon. At the same time, the learning process has been implemented using a group system, but there are no practical activities that encourage students to claim a phenomenon for analysis and use it as data to support their arguments. In the learning system, modeling can only be applied to students who have the ability to argue (Dulim and Madlazim, 2022).

Researchers conducted interviews with physics teachers at SMA Negeri 10 Medan and found that although some students actively participated in class discussions, most students tended to be passive. Low participation during discussions or group learning indicates a lack of reinforcement of argumentation skills in the learning process (Puteri et al., 2025; Admoko et al., 2022). The implementation of a learning model that still relies on conventional teaching methods makes it difficult for students to obtain the best explanations that clearly connect claims with evidence. Siregar and Pakpahan (2020) state that the teaching provided is too teacher-centered, thereby failing to accommodate students' scientific arguments; in other words, their teaching cannot accommodate students' scientific arguments.

The approaches used by teachers are still not very diverse, especially when it comes to science, technology, engineering, and mathematics (STEM), so students aren't able to combine media use with learning, which means the learning process isn't working as well as it could. STEM is a bunch of related fields, where science needs math to process data, and engineering and technology are applications of science (Hermanto et al, 2025). Through the systematic integration of knowledge, concepts, and skills, the STEM approach is expected to provide meaningful learning for students: 1. Asking questions and identifying problems, 2. Building and using models, 3. Planning and conducting investigations, 4. Analyzing and interpreting data, 5. Utilizing computational, information, and computer technology skills, as well as mathematics, 6. Building scientific truths and developing problem-solving approaches (engineering), 7. Making arguments based on facts, and 8. Developing theories based on evidence (Putra et al., 2023).

Facing the 21st century, students need to master several skills, such as numeracy literacy and scientific argumentation. One approach that is considered effective in addressing these issues is the implementation of an integrated STEM argument-driven inquiry (ADI) learning model. The application of the ADI model can improve students' numeracy literacy and scientific argumentation skills. The ADI model guides students to conduct scientific investigations, formulate hypotheses, perform experiments, interpret data, and construct arguments based on the evidence obtained (Purnomo et al., 2023; Manurung et al., 2020). In line with Syargiy et al. (2023), who state that ADI learning with a laboratory can develop students' argumentation and creativity skills. ADI learning assisted by a laboratory can significantly improve scientific argumentation skills (Fuadah et al., 2023).

The implementation of the ADI learning model is necessary to prepare students for the world of work, and one way to do this is to integrate science, technology, engineering, and mathematics (STEM) into the learning process. Learning using the ADI model with the STEM approach can better develop numeracy and argumentation skills because students are able to generate creative solutions and become self-regulated learners who think critically and are encouraged to express their opinions and arguments regarding a problem. In line with Hikmah et al. (2023), who stated that the ADI model integrated with STEM can train students' argumentation and self-efficacy skills, enabling them to provide solutions to problems in presenting their ideas, opinions, or perspectives. This is supported by research by Nurhidayati et al. (2023), which revealed that argumentation skills are influenced by the ADI STEM learning model. Integrated STEM learning in education can enhance numeracy literacy and equip students with logical, critical, creative thinking skills, as well as the ability to collaborate in presenting arguments (Kelana et al., 2020). Based on the above discussion, it is important for researchers to conduct a study titled “The Influence of the Argument Driven Inquiry (ADI)-STEM Model on Students' Numeracy Literacy and Scientific Argumentation Skills.

Method

The research was conducted at SMA Negeri 10 Medan which is located at Jalan Tilak No. 108 and conducted on students of class XI semester II T.A 2024/2025. The research time was held in January - March 2025. This type of research includes quasi experiment. The population in this study were all students of class XI IPA SMA Negeri 10 Medan in the school year 2024/2025 semester II consisting of six classes. The sample in the study consisted of two classes randomly selected by simple random sampling technique. The type of research is a quasi experiment presented in a two-group pretest-post-test design. The data collection techniques used in this study were observation, interviews, and numeracy literacy and scientific argumentation tests.

Result and Discussion

Pretest Data Analysis of Experimental and Control Classes

Pretest data analysis was conducted with the aim of measuring students' initial abilities before receiving the learning process. Students' numeracy literacy and scientific argumentation skills were measured by giving numeracy literacy and scientific argumentation tests of 10 questions each. The results of pretest data obtained from experimental and control classes are presented in Table 2 and Table 3.

Table 2. Numeracy Literacy Pretest Data

Class	N	minimum value	maximum value	Average	Standard Deviation
Experiment	36	36	76	5.89	9.15
Control	31	36	71	54.19	10.00

Table 3. Scientific Argumentation Ability Pretest Data

Class	N	minimum value	maximum value	Average	Standard Deviation
Experiment	36	32	67	52.22	7.02
Control	31	36	77	51.68	9.96

Normality Test Pretest

The normality test in this study used Shapiro Wilk with the help of the SPSS 25.0 program with the condition that if the sig value. > 0.05, it can be concluded that the data is normally distributed otherwise, if the sig value. <0.05, it is concluded that the data is not normally distributed. The results of testing the pretest data of numeracy literacy and scientific argumentation of students in the experimental class and control class obtained are presented in Table 4.

Table 4. Normality Test of Pretest Data

Ability	Class	*Sig*	Conclusion
Numeracy Literacy	Experiment	0.088	Normal
	Control	0.219	Normal
Scientific Argumentation	Experiment	0.067	Normal
	Control	0.058	Normal

Homogeneity Test of Pretest Data

The homogeneity test of numeracy literacy and scientific argumentation pretest data in experimental and control classes was carried out with the Levene Statistic test with the help of the SPSS 25.0 program with the condition that if the sig value. > 0.05 it is concluded that the data variance is homogeneous, otherwise if the sig value. <0.05 it is concluded that the data variance is not homogeneous. The results of the homogeneity test of the numeracy literacy and scientific argumentation pretest data obtained are presented in Table 5.

Table 5: Homogeneity Test of Pretest Data

Ability	*Sig*	conclusion
Numeracy Literacy	0.490	Homogen
Scientific Argumentation	0.018	Homogen

Pretest Similarity Test

The hypothesis test used is the manova test using the help of the SPSS 25.0 program, which is to measure differences in different observation groups in data analysis. If the sig value. > 0.05 then Ho is accepted and Ha is rejected, if the sig value. <0.05 then Ho is rejected and Ha is accepted. The results of the pretest hypothesis test using the manova test are presented in Table 6.

Table 6. Pretest Manova Test Results

Effect	sig.
Pillai’s Trace	0.960
Wilks’ Lambda	0.960
Hotelling’s Trace	0.960
Roy’s Largest Root	0.960

Based on the results of the pretest manova test in Table 6, the significance value of Pillai's Trace, Wilks' Lambda, Hotelling's Trace, Roy's Largest Root is greater than 0.05 or 0.960> 0.05 so it is concluded that Ho is accepted and Ha is rejected in the event that there is no significant difference between the experimental class and the control class in numeracy literacy and scientific argumentation.

Post-test Data Analysis of Experimental and Control Classes

The two samples have been given different treatments, the experimental class is given learning by applying the argument driven inquiry (ADI)-STEM learning model and in the control class the conventional model is applied. Post-test data was obtained after the learning process was completed by giving numeracy literacy and scientific argumentation tests that were identical to the pretest test instruments in both samples.

The post-test data obtained from the experimental and control classes are presented in Table 7 and Table 8.

Table 7. Numeracy Literacy Posttest Data

Class	N	Minimum value	Maximum value	Average	Standard Deviation
Experiment	36	72	100	83.22	6.40
Control	31	56	84	71.48	9.22

Table 8. Posttest Data of Scientific Argumentation Ability

Class	N	Minimum value	Maximum value	Average	Standard Deviation
Experiment	36	72	100	86.78	7.27
Control	31	56	84	70.90	8.03

Normality Test Posttest

The normality test in this study used Shapiro Wilk with the help of the SPSS 25.0 program with the condition that if the sig value. > 0.05, it can be concluded that the data is normally distributed otherwise, if the sig value. <0.05, it is concluded that the data is not normally distributed. The results of testing the posttest data of numeracy literacy and scientific argumentation of students in the experimental class and control class obtained are presented in Table 9.

Table 9. Normality Test of Posttest Data

Ability	Class	*Sig*	Conclusion
Numeracy Literacy	Experiment	0.169	Normal
	Control	0.022	Normal
Scientific Argumentation	Experiment	0.057	Normal
	Control	0.015	Normal

Homogeneity Test of Posttest Data

The homogeneity test of numeracy literacy and scientific argumentation Posttest data in experimental and control classes was carried out with the Levene Statistic test with the help of the SPSS 25.0 program with the condition that if the sig value. > 0.05 it is concluded that the data variance is homogeneous, otherwise if the sig value. <0.05 it is concluded that the data variance is not homogeneous. The results of the homogeneity test of the numeracy literacy and scientific argumentation posttest data obtained are presented in Table 10.

Table 10: Homogeneity Test of Posttest Data

Ability	*Sig*	conclusion
Numeracy Literacy	0.013	Homogen
Scientific Argumentation	0.411	Homogen

Hypothesis Testing

Post-test hypothesis testing with manova test was used to determine the effect of ADI-STEM on numeracy literacy and scientific argumentation skills of students in both sample groups. Post-test manova test by considering the results of Pillai's Trace, Wilks' Lambda, Hotelling's Trace, Roy's Largest Root by using the SPSS 25.0 program. The basis for decision making in research for the manova test if the sig value. > 0.05 then Ho is accepted and Ha is rejected, if the sig value. <0.05 then Ho is rejected and Ha is accepted. The results of the posttest hypothesis test using the manova test are presented in Table 11.

Table 11. Postest Manova Test Results

Effect	sig.
Pillai's Trace	0.000
Wilks' Lambda	0.000
Hotelling's Trace	0.000
Roy's Largest Root	0.000

Based on the results of the pretest manova test in Table 11, the significance values of Pillai's Trace, Wilks' Lambda, Hotelling's Trace, Roy's Largest Root are greater than the significance level (α) = 0.05 or 0.000 <0.05 so it is concluded that Ho is rejected and Ha is accepted in terms of there are significant differences between experimental and control classes in numeracy literacy and scientific argumentation after the application of the ADI-STEM model.

correlation test

The correlation test was used to test the relationship/correlation between numeracy literacy and scientific argumentation with the application of the ADI-STEM model. Correlation testing uses the SPSS 25.0 program with product moment correlation. The criteria for testing the correlation is done if the sig value. <0.05 then the two variables show a significant relationship otherwise if the sig value. > 0.05 or negative then the two variables are not correlated or not significantly related. The results of Pearson correlation and Significance between numeracy literacy and scientific argumentation of students are presented in Table 12.

Table 12. Relationship between Numeracy Literacy and Scientific Argumentation

		Numeracy Literacy	Scientific Argumentation
Numeracy Literacy	Pearson Correlation	1	0.755
	Sig.(2-tailed)		0.000
	N	36	36
Scientific Argumentation	Pearson Corelation	0,.755	1
	Sig.(2-tailed)	0.000	
	N	36	36

Based on Table 12, the Pearson correlation shows a value of 0.755, it is concluded that the level of relationship between numeracy literacy and scientific argumentation is positive, where the level of relationship between the two variables is reciprocal and the correlation coefficient is in the high category (Arikunto, 2017). Based on the sig value. (2-tailed) < 0.05 or 0.000 < 0.05, it is concluded that numeracy literacy and scientific argumentation of students have a significant relationship after the application of ADI-STEM. The graph of the strength level of the relationship between numeracy literacy and scientific argumentation is presented in Figure 1.

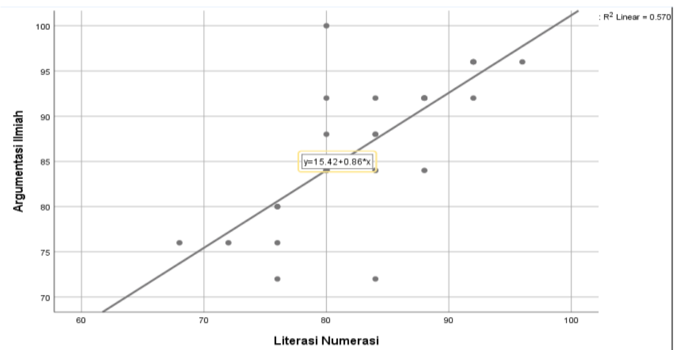

Figure 1. Graph of the Level of Relationship between Numeracy Literacy and Argumentation

Based on Figure 1, it shows that numeracy literacy and scientific argumentation have a positive relationship. This means that the higher the numeracy literacy value, the higher the scientific argumentation value. The value of R2 =0.570 and the value of R is 0.755 indicating that the correlation between numeracy literacy and argumentation is in the high category. The regression equation obtained from Figure 4.1 is Y =15.42 +0.86X meaning that the value (a) or a positive constant of 15.42. The regression coefficient value (b) is 0.86 (positive), which shows a linear effect.

Normalized Gain Test (N-gain).

The improvement of students' numeracy literacy skills and scientific argumentation can be calculated by the Normalized Gain (N-gain) test where if g ≥ 0.7 is categorized as high, 0.3 ≤ g > 0.7 is categorized as medium and if g < 0.3 is categorized as low. The average value of pretest and posttest in experimental class and control class will be analyzed as a whole. The N-gain increase in numeracy literacy based on the overall pretest and posttest is presented in Table 13.

Table 13. Numeracy Literacy N-gain Improvement

Class	Average Pretest	Average Pretest	N-gain	Categori
Experiment	51.78	83.22	0.62	Medium
Control	54.19	73.68	0.35	Medium

Based on Table 13, it is known that the increase in N-gain of numeracy literacy in the control class of 0.35 is categorized as moderate and the experimental class is 0.62 in the moderate category. The mean scores of the pretest and posttest in the control class and experimental class were also analyzed as a whole. The N-gain increase in scientific argumentation based on the overall pretest and posttest is presented in Table 14.

Table 14. Scientific Argumentation N-gain Improvement

Class	Average Pretest	Average Pretest	N-gain	Categori
Experiment	52.22	86.78	0.71	High
Control	51.68	70.52	0.38	Medium

Based on Table 14, it can be seen that the N-gain increase in scientific argumentation in the control class of 0.38 is categorized as low and the experimental class of 0.71 is in the high category. The experimental class N-gain was higher than the control class for numeracy literacy and scientific argumentation.

The Effect of Argument Driven Inquiry (ADI)-STEM Model on Numeracy Literacy and Scientific Argumentation Skills

Numeracy and scientific reasoning literacy are two skills that are needed in education. Students' numeracy and scientific reasoning literacy skills greatly influence problem solving, decision making, and understanding concepts in various aspects of life, including science, technology, and mathematics. Low numeracy and scientific argumentation skills are characterized by students who have difficulty using numbers and symbols related to mathematics to solve problems in everyday life, difficulty analyzing information presented in various formats, and inability to make predictions when making decisions. Meanwhile, scientific argumentation skills are characterized by students who tend to be passive in expressing arguments or opinions in learning activities.

The study was conducted on two groups consisting of an experimental class and a control class. The experimental class applied the argument-driven inquiry (ADI) model combined with the STEM approach, while the control class used conventional learning methods. The application of the STEM-based ADI model in the experimental class was carried out through the following stages:

Problem: Weak Water Pressure on the Upper Floors of Multi-Story Houses

1. *Identify tasks and questions*

Why is water pressure on upper floors often weaker than on the ground floor in multi-story houses or tall buildings? Even though the water source comes from the same tank.

Students understand the concept (science) of substances flowing through pipes with different cross-sectional areas and differences in fluid pressure at heights from a specific reference point, especially in dynamic fluids. Students then analyze this in developing the claim that the larger the cross-sectional area of the pipe through which the fluid flows, the smaller the fluid velocity, and vice versa. Furthermore, if the fluid velocity increases, it will cause a decrease in pressure in the fluid flow. This is supported by (Mulyani, 2019), which shows that through science learning, students are able to recognize a concept or knowledge, especially in literacy skills.

2. *Planning and conducting investigations (conducting experiments).*

Students designed an experiment by applying scientific concepts to engineering through the use of pipes (technology) and installing them at different heights to supply water from the tank. The students observed that when the upper water was turned on at a height of (h_2), the fluid pressure (P_2) decreased and the velocity (v_2) increased, while at a height of (h_1), the pressure (P_1) increased, but the velocity (v_1) decreased. This data was used by students to support their claims in formulating their hypotheses. Research conducted by (Sulistiwati, 2021) shows that learning involving technology makes the process of knowledge transfer easy, comfortable, and effective and can influence students' mathematical literacy skills.

3. *Analyze (interpret data).*

The information (data) obtained is then analyzed to make the statement that students interpret the data using the continuity principle formula ($A_1v_1 = A_2v_2$) and Bernoulli's principle ($P + ½\ \rho v_2 + \rho gh$ = constant) (mathematics) to connect the data with the claims they obtain as warrants and interpret them in the form of reports. Research conducted (Fitria & Azrial, 2021; Muhiddin & Agussalim, 2023) Research applying the ADI learning model and related to STEM components offers students the opportunity to understand the concepts of physics (science) and engineering (technology), engineering, and mathematics through discussions, practicums, and projects. This research shows that this can improve students' scientific argumentation skills.

4. *Using mathematics and computational thinking.*

This stage encourages students to use various numbers and symbols. The use of mathematics aims to solve problems using formulas. In accordance with the data obtained by students previously, this stage encourages students to formulate claims in accordance with the problem (*qualifier*). Results confirmed by (Aulia, 2023; Syahmani, 2021; Sulistianingsih & Yanto, 2024) show that the stages applied in the STEM approach and ADI learning model can improve students' mathematical abilities and have a positive impact on their ability to argue scientifically.

5. *Developing explanations.*

This stage encourages students to explain using the concepts of continuity and Bernoulli's principle in interpreting the results of analysis from previous experiments to make predictions and decisions about their observations. The results of these predictions and decisions. Students use measuring instruments (manometers, stopwatches, and water pipes) to obtain experimental data to construct explanations in presenting their arguments. Students apply the flow rate formula Q = A.v, the principle of continuity ($A_1v_1 = A_2v_2$), and Bernoulli's principle ($P + ½\ \rho v_2 + \rho gh$ = constant) as evidence in their explanatory arguments. The results of the study (Astuti et al., 2023; Simatupang et al., 2024) support the idea that providing students with an understanding of science concepts and the application of that knowledge with their skills in design or engineering and mathematical abilities for analytical calculations can improve their thinking and reasoning abilities, especially in terms of literacy and argumentation skills.

6. *Engage in evidence-based argumentation.*

At this stage, students communicate their ideas in accordance with scientific fluid concepts, then write down their observations and present well-reasoned arguments. Based on the data obtained, students provide rebuttals. Students use the principle of continuity (A1v2

= A2v2) and Bernoulli's principle (P + ½ ρv2 + ρgh = constant) where if the fluid velocity increases, it will affect the pressure (P) decreasing, or the height (h) decreasing as evidence in presenting their arguments. These results are confirmed by (Pramesti et al, 2022) that the application of the ADI model with STEM can influence students' scientific literacy and argumentation skills.

7. Obtain, evaluate, and communicate information.

At this stage, researchers encourage students to evaluate information through investigations that have been carried out and then communicate the results of the experiments to be interpreted with their respective groups. Students formulate reasons that are correct according to the principle of continuity (A1v2 = A2v2) and Bernoulli's principle (P + ½ ρv2 + ρgh = constant). These are reasons to support the warrant in the form of backing. The results of applying the ADI model are supported by research conducted by Nasution (2019), which found that the ADI model can have a significant effect on students' scientific argumentation skills.

The results obtained through the application of the ADI model combined with STEM in the experimental class had a positive impact on numeracy literacy and scientific argumentation skills. This was demonstrated by an increase in students' numeracy literacy and scientific argumentation scores obtained through pre-tests and post-tests given to students during the learning process. Meanwhile, in the control class, which used conventional learning methods, there was no significant effect on students' numeracy literacy and argumentation skills. The application of the ADI-STEM model provides support by facilitating students in developing numeracy and argumentation skills through science, technology, engineering, and mathematics (STEM). These results are reinforced by (Nurhidayati et al., 2023) that the ADI learning model with a STEM approach can improve students' literacy and scientific argumentation.

Based on the syntax of the ADI model, ADI has a significant and positive influence on numeracy literacy. Students in analyzing information obtained a score of 78%, students in using various numbers and symbols and solving problems obtained a score of 85%, and students who could interpret the results of the analysis to make predictions and decisions obtained a score of 83%. These results are supported by (Fadlika et al., 2022) that the ADI model can improve numeracy literacy skills. Furthermore, the ADI model also has a relationship with scientific argumentation, as this model provides students with the opportunity to develop their own methods. Through this argument-based and inquiry-based learning model, students were able to formulate a conclusion (claim) and obtained a score of 85%. Students analyzed data to support the claim (data) and obtained a score of 86%. Students analyzed statements in explaining the relationship between data and claims (warrant) and obtained a score of 93%. students are able to formulate claims in accordance with the problem (qualifier) with a score of 87%, students can explain the relationship between data and warrant (rebuttal) with a score of 78%, and students can make a reasoned argument to support the data obtained (backing) with a score of 78%. These results are confirmed by (Utami et al, 2022) that through the application of the ADI model, students' scientific argumentation skills can improve. This is in line with the stages of the model applied, which encourage students to be active subjects who are directly involved in the scientific process from the beginning to the end of learning.

Based on the syntax, ADI focuses students more on solving contextual problems. The stages of the ADI model greatly contribute to students' numeracy and scientific argumentation literacy skills, but some stages play a more dominant role in each skill. In the second ADI syntax, planning and conducting investigations are more dominant in numeracy literacy and scientific argumentation skills. Students conduct experiments and then collect data for analysis through measurements by linking concepts (science) to understand phenomena in developing claims and justifying evidence based on experiments. These results are supported by research by Eymur & Cetin (2024), which states that ADI supports students' literacy skills and argumentation using claims, evidence, and justification of evidence.

The third ADI syntax analyzes and interprets data. This stage is more inclined towards numeracy literacy, how students analyze or interpret data to make predictions in decision-making using physics formulas to obtain valid data. Ambarwati et al, (2024) found that applying the ADI model has an effect on mathematical literacy and communication.

The fourth syntax of ADI uses mathematics and computational thinking. This stage emphasizes numeracy and scientific argumentation skills. By applying mathematics with various symbols and numbers in solving everyday problems, students are encouraged to formulate claims in accordance with the problem (qualifier). Hidayat & Aripin (2019) revealed that this stage of the ADI model helps students in arguing, especially when they find solutions to problems, and assists students in the process of problem solving through mathematics.

The fifth ADI syntax builds explanations. This stage further enhances scientific argumentation skills in drawing conclusions to make statements based on evidence. Research conducted by Epriliyani & Deta (2025) reveals that through the ADI model with a STEM approach, students' scientific argumentation skills are at a high level.

The sixth syntax of ADI involves evidence-based argumentation. Argumentation skills are emphasized more at this stage in presenting arguments with strong reasoning and valid data. This can provide opportunities for students to engage in scientific practices, such as formulating arguments, analyzing data, and communicating findings based on existing evidence (Erenler et al., 2024).

The fifth ADI syntax builds explanations. This phase further enhances scientific argumentation skills in drawing conclusions to make statements based on evidence. Research by Epriliyani & Deta (2025) shows that the ADI model with a STEM approach leads to high-level scientific argumentation skills in students.

The sixth syntax of ADI concerns evidence-based argumentation. Argumentation skills are emphasized more in this phase, in presenting arguments with strong reasoning and valid data. This can provide students with opportunities to engage in scientific practices, such as formulating arguments, analyzing data, and communicating findings based on existing evidence (Erenler et al., 2024).

Relatie tussen rekenvaardigheid en wetenschappelijke argumentatie

Numeracy and scientific reasoning are two fundamental aspects that cannot be separated. The relationship between numeracy and students' scientific reasoning has a high and significant correlation. The strength of the relationship between these two aspects is influenced by the application of the STEM-based ADI learning model. Numeracy can begin with analyzing presented information, after which students are able to use different types of numbers and symbols. Furthermore, students can interpret the results of the analysis to make predictions and decisions. This activity can enhance students' ability to provide arguments for claims, then analyze data to support claims, and finally, students can explain and formulate reasons to support claims by providing justification. Numeracy and scientific reasoning should be integrated into the learning process through the application of the ADI model in combination with STEM.

The results of the correlation test were conducted to determine the relationship between variables. (Bestiantono, D.S., 2020) suggests that the level of the relationship between scientific literacy and scientific argumentation is significant through the ADI model response. The relationship between arithmetic skills and scientific argumentation was found to be 0.728. This figure shows the strong correlation between arithmetic skills and scientific argumentation. Based on the obtained significance value of 0.000 <0.05, it is concluded that the relationship between arithmetic skills and scientific argumentation is positive, meaning that the relationship is unidirectional: as arithmetic skills increase, scientific argumentation skills also increase, and conversely, as arithmetic skills decrease, scientific argumentation skills also decrease. These results are supported by research (Anjiani & Bestiantono, 2023) that has shown that improving arithmetic skills simultaneously affects scientific argumentation skills. These results are supported by research (Anjiani & Bestiantono, 2023) that showed that improving reading and writing skills simultaneously affects scientific argumentation skills through the application of the ADI model.

Conclusion

The results of the study show that there is a significant effect on the numeracy literacy and scientific argumentation abilities of students in class XI IPA 1 at SMA Negeri 10 Medan about fluid dynamics with the application of the STEM-based ADI model. Based on the results of statistical tests, the application of the STEM-based argument-driven inquiry (ADI) model has a significant effect on students' numeracy, literacy, and scientific argumentation skills. However, in the process of implementing the STEM aspect, the emphasis is placed on the project design. This research only makes the project design, but the production of the project has not been fully implemented. Therefore, some suggestions from researchers include: The need to improve the implementation of STEM projects. Further research can be conducted on other physics materials to see the consistency of the effect of the ADI-STEM model on different aspects of students' skills, as well as adding other variables such as creativity or teamwork..

Acknowledgments

We would like to express our deepest gratitude to our advisor who has guided us throughout the research process and to the respondents who have made significant contributions to the success of this study.

Author Contributions

All authors have made a real contribution in completing this manuscript.

Funding

This research was funded by personal funds.

Conflicts of Interest

The authors declare no conflict of interest.

References

Abidin, Y., Mulyati, T., dan Yunanshah, H. (2018). *Pembelajaran Literasi*. Jakarta:Bumi Aksara.

Admoko, S., Suprapto, N., Suliyanah, Deta, U. A., Achmadi, H. R., Hariyono, E., & Madlazim. (2021). Using Toulmin's Argument Pattern Approach to Identify Infodemics in the Covid-19 Pandemic Era. *Journal of Physics: Conference Series*, *1805*(1).
https://iopscience.iop.org/article/10.1088/1742-6596/1805/1/012011

Ambarwati, R., Supriadi, N., Noviana, D., Putra, R. W. Y., Mujib, M., & Andriani, S. (2024). Study of effect of argument driven inquiry model and mathematical literacy on student mathematical communication. *Al-Jabar : Jurnal Pendidikan Matematika*, *15*(1), 285. https://doi.org/10.24042/ajpm.v15i1.22333

Anggraeni, A., Andiani, A., Aisyah,T. F., Rahmadani, T., Rahman, A., dan Logayah, D. S. (2022). Mengabdi Demi Meningkatkan Kualitas Literasi dan Numerasi: *Guepedia*.

Anjiani, L. L., & Bestiantono, D. S. (2023). Pengaruh Keterampilan Argumentasi terhadap Kemampuan Literasi Fisika Peserta Didik dengan Diterapkannya Model Pembelajaran Argument-Divine. 9–13.

Arikunto, S. (2017). *Dasar-dasar Evaluasi Pendidikan*. Jakarta: PT Bumi Aksara.

Ananda, P.N., dan Salamah, U. (2021). Meta Analisis Pengaruh Integrasi Pendekatan STEM dalam Pembelajaran IPA terhadap Kemampuan literasi numerasi Siswa. *Jurnal Penelitian dan Pembelajaran Fisika,* 7(1): 54 – 64.

Afifa, I. N., Hasnunidah, N., Maulina, D., Education, B., & Lampung, U. (2021). *Biosfer : Jurnal Pendidikan Biologi students' Creative Thinking Skill : Environmental Pollution*. *14*(1), 1–12.

Amiroh, F., & Admoko, S. (2020). Tinjauan terhadap Model-model Pembelajaran Argumentasi Berbasis Tap dalam Meningkatkan Keterampilan Argumentasi dan Pemahaman Konsep Fisika dengan Metode Library. *Inovasi Pendidikan Fisika*, *9*(2), 207–214.

Antonio, R. P., & Prudente, M. S. (2021). Metacognitive Argument-Driven Inquiry in Teaching Antimicrobial Resistance: Effects on Students' Conceptual Understanding and Argumentation Skills. *Journal of Turkish Science Education*, *18*(2), 192–217.

Astuti, W., Sulastri, S., Syukri, M., & Halim, A. (2023). Implementasi Pendekatan Science, Technology, Engineering, and Mathematics untuk Meningkatkan Kemampuan Literasi Sains dan Kreativitas Siswa. *Jurnal Pendidikan Science Indonesia*, *11*(1), 25–39.

Ayana, Y., Fakhruddin, F., & Zulfarina, Z. (2022). Validation of Student Worksheet (LKPD) Based Argument-Driven Inquiry (ADI) Assisted with PhET to Train Argumentation Skills the Pressure Materials. *Unnes Science Education Journal*, *11*(2), 69–76.

Bestiantono, D.S. (2020). Students' Responses toward Scientific Argumentation with ADI Learning Model to Physics Literacy: A Case of Indonesian Senior High School Students. *Studies In Learning and Teaching* (SiLeT). 1(1), 3-11.

Cahyono, A. N., Asikin, M., Zahid, M. Z., Laksmiwati, P. A., & Miftahudin. (2021). The Robo STEM Project: Using Robotics Learning in a STEM Education Model to Help Prospective Mathematics Teachers Promote Students' 21st-Century Skills. *International Journal of Learning, Teaching and Educational Research*, 20(7), 85–99.

Castro, E. A. M. (2023). Analysis of Problem Solving Ability of First Middle School Students in Learning Science. *Integrated Science Education Journal*, *4*(2), 43–53.

Chairunnisya, S., Abdurrahman, Distrik, I. W., Herlina, K., Rosidin, U., & Rabbani, G. F. (2023). Engineering Design Process (EDP) Strategy Integrated PjBL-STEM in Learning Program: Need Analysis to Stimulate Numeracy Literacy Skills on Renewable Energy Topic. *Jurnal Penelitian Pendidikan IPA*, *9*(12), 11197–11206.

Dani, A. U. (2021). Pengaruh Model Pembelajaran Argument Driven Inquiry Terhadap Kemampuan Berpikir Tingkat Tinggi Peserta Didik. *Inspiratif Pendidikan*, *10*(2), 257–264.

Dina, R. N., Zainuddin, Z., & Pada, A. U. T. (2022). Implementation of Argument-Driven Inquiry Learning Model to Enhance Student's Science Process Skills and Self-Efficacy. *JIPF (Jurnal Ilmu Pendidikan Fisika)*, *7*(1), 9.

Dulim, A. Y., & . M. (2022). Penerapan Model Argumentasi Driven Inquiry (ADI) Dengan Bantuan PhET Simulation Untuk Melatih Argumentasi Ilmiah Peserta Didik Kelas XI SMA Pada Topik Gas Ideal. *IPF: Inovasi Pendidikan Fisika*, *11*(1), 20–28.

Ekowati, D. W., dan Sundawayani, B. I. (2019). *Literasi Nmuerasi untuk Sekolah Dasar*. Malang: Universitas Muhammadyah Malang.

Epriliyani, E. W., & Deta, U. A. (2024). The Influence of the Argument-Driven Inquiry Learning Model in Physics Learning with the STEAM Approach on the Scientific Argumentation Ability. *IPF: Inovasi Pendidikan Fisika*, *14*(1), 6–10. https://doi.org/10.26740/ipf.v14n1.p6-10

Erenler, S., Cetin, P. S., & Eymur, G. (2024). Impact of Argument-Driven Inquiry Activities on Pre-service Science Teachers' Views of the Nature of Scientific Inquiry in the Context of Climate Change Education. In *Science and Education* (Issue 0123456789). https://doi.org/10.1007/s11191-024-

00512-4

Eymur, G., & Çetin, P. S. (2024). Investigating the role of an inquiry-based science lab on students' scientific literacy. *Instructional Science*, *52*(5), 743–760. https://doi.org/10.1007/s11251-024-09672-w

Fadlika, R., Hernawati, D., & Meylani, V. (2022). Kemampuan Argumentasi dan Kemampuan Literasi Sains Peserta Didik Kelas Xi Mipa pada Materi Sel. *LENSA (Lentera Science): Jurnal Pendidikan IPA*, *12*(1), 9–18.

Fakhriyah, F., Rusilowati, A., Nugroho, S. E., & Saptono, S. (2021). Mengembangkan Kemampuan Argumentasi Ilmiah Calon Guru Sekolah Dasar sebagai Bentuk Penguatan Keterampilan Abad 21. *Prosiding Seminar Nasional Pascasarjana Pascasarjana Universitas Negeri Semarang*, *4*(1), 190–195.

Faudah, M. I., Mobarok, H., & Suliyanah. (2023). The Effect og Argument Driven Inquiry (ADI) Model on the Scientific Argumentation Ability of High School Students on the Topic Of Light Waves. *International Journal of Research and Community Empowerment,* 1(2): 53-61.

Faqih, M. I., Adriyani, Z., & Listiyani, L. (2023). Advanced Chatbot Development to Improve Student Literacy and Numeracy Skills. *Phenomenon : Jurnal Pendidikan MIPA*, *12*(2), 206–215.

Firdausi, E. A. (2020). *Kemampuan Penalaran Ilmiah dan Pengusaan Konsep Elastisitas dan Hooke dengan Pembelajaran Inkuiri untuk Pendidikan STEM pada Siswa Kelas XI …*. *5*(2), 129–133.

Hadi et al. (2021). Analisa Kemampuan Literasi Numerasi dan Self-Efficacy Siswa Madrasah dalam Pembelajaran Matematika Realistik. *Jurnal Ilmiah Wahana Pendidikan*, *7*(7), 300–310.

Hake, H.R. (1998). "Interactive-engagement Versus Traditional Methods: A six-Thousand-Student Survey of Mechanics Test Data for Introductory Physics Courses." *American Journal of Physics*, 66 (1), pp. 64 – 74

Han, W., Susanto, D., Dewayani, S., Pandora, P., Hanifah, N., Miftahussururi., Nento, M. N., & Akbari, Q. S. (2017). "Materi Pendukung Literasi Numerasi." *Kementrian Pendidikan dan Kebudayaan, Tim GLN Kemendikbud.*, *8*(9), 1–58.

Hal, V. N., Simatupang, H., Dwi, R., Djulia, E., & Simanjuntak, M. P. (2024). Argument Driven Inquiry Berbantuan Virtual Laboratory Untuk Meningkatkan Kemampuan Literasi Digital Dan Literasi Sains Mahasiswa IPA . 7(2), 1313–1320.

Hermanto, D., Ardianto, D., Permanasari, A., Ipa, P., Keguruan, F., & Bogor, U. P. (2025). *Evaluation of STEM Integration in Science Teaching Materials : An Independent Curriculum Perspective*. *6*(1), 10–14. https://doi.org/10.37251/jee.v6i1.1290

Hidayat, W., & Aripin, U. (2019). The improvement of students' mathematical understanding ability influenced from argument-driven inquiry learning. *Journal of Physics: Conference Series*, *1157*(3), 0–6. https://doi.org/10.1088/1742-6596/1157/3/032085

Hikmah, S. I., Tukiran, & Nasrudin, H. (2023). Validity of Student Worksheets Based on Model Argument Driven Inquiry Integrated by STEM to Train Students' Argumentation Ability and Self-Efficacy in Chemical Equilibrium Material. *International Journal of Recent Educational Research,* 4(4): 416-433.

Husna. (2023). Peningkatan Kemampuan Literasi Numerasi dan Literasi Digital. Ponorogo: Uwais Inspirasi Indonesia.

Hutagalung, S. D. G., dan Kurniati, E. (2024). Analisis Perubahan Kurikulum terhadap Hasil Belajar Fisika Siswa SMAN 3 Kota Jambi (Studi Perubahan Kurikulum 2013 ke Kurikulum Merdeka). *Jurnal Penelitian Bidang IPA dan Pendidikan IPA,* 1(2): 1-8.

Insanul Hikmah, S., Tukiran, T., & Nasrudin, H. (2023). Validity of Student Worksheets Based on Model Argument Driven Inquiry Integrated by STEM to Train Students' Argumentation Ability and Self-Efficacy in Chemical Equilibrium Material. *IJORER : International Journal of Recent Educational Research*, *4*(4), 416–433.

Irvan, A., Admoko, S. (2020). Analisis Kemampuan Argumentasi Ilmiah Siswa Berbasis Pola Toulmin ' S Argument Pattern (Tap) Menggunakan Model Argument Driven Inquiry dan Diskusi pada Pembelajaran Fisika SMA. *IPF: Inovasi Pendidikan Fisika*, *09*(03), 318–324.

Ishaq, I. M., Khaeruddin, K., & Usman, U. (2022). Analisis Kemampuan Berargumentasi Dalam Pembelajaran Fisika Peserta Didik Sma Negeri 8 Makassar. *Jurnal Science Dan Pendidikan Fisika*, *17*(3), 211.

Izzatin, M., Kartono, K., Zaenuri, Z., & Dewi, N. R. (2022). Pengembangan Literasi Numerasi Siswa Melalui Soal HOTS. *Prosiding Seminar Nasional Pascasarjana UNNES*, 630–634.

Kamal, F. A., Subali, B., Astuti, B., Rusilowati, A., & Widiyatmoko, A. (2024). Pengembangan LKPD Digital Berbasis STEM Untuk Meningkatkan Literasi Numerasi Dan Sains Peserta Didik. *Jurnal Penelitian Pendidikan IPA*, *10*(5), 2454–2464.

Karawahenni, Y. D. V., Sutopo, S., Hidayat, A., & Mustika, M. (2024). Can Argument-Driven Inquiry-Assisted Virtual Laboratory Improve Pre-service Physics Teachers' Mastery Concept of Simple Harmonic Oscillation? *Jurnal Pendidikan Science*, *12*(1), 23–33.

Kelana, J. B., Wardani, D. S., Firdaus, A. R., Altaftazani, D. H., & Rahayu, G. D. S. (2020). The effect of STEM approach on the mathematics literacy ability of elementary school teacher education students. *Journal of Physics: Conference Series*, *1657*(1).

Kemendikbud, (2017). *Tingkatkan Literasi Baca-Tulis, Kemendikbud Adakan Pertemuan Penulis Bahan Bacaan*. Jakarta: kemendikbud.

Kuki, A. D., Agustini, R., & Azizah, U. (2023). Analysis of Effectiveness Argument-Driven Inquiry to Improve Students' Argumentation Skill and Conceptual Understanding. *IJORER : International Journal of Recent Educational Research*, *4*(3), 329–342.

Kurniasih, I. (2023). Evaluasi Kurikulum Merdeka. Surabaya: Kata Pena.

Manurung, I. F. U., Mailani, E., & Simanuhuruk, A. (2020). Penerapan Model Pembelajaran Argument Driven Inquiry Berbantuan Virtual Laboratory Untuk Meningkatkan Kemampuan Literasi Sains Mahasiswa Pgsd. *Js (Jurnal Sekolah)*, *4*(4), 26.

Melta, D., Azhar, M., Yohandri, Y., Arsih, F., & Razak, A. (2024). Argument-driven inquiry learning model to improve students' argumentation skills in science learning: systematic literature review. Edu Sains: Jurnal Pendidikan Sains & Matematika, 12(1), 46–54. https://doi.org/10.23971/eds.v12i1.5843

Muhiddin, S. M. A., & Agussalim, A. (2023). Penerapan Model Argument-Driven Inquiry untuk Meningkatkan Kemampuan Berargumentasi Ilmiah Mahasiswa pada Topik Kalor. *Karst : JURNAL PENDIDIKAN FISIKA DAN TERAPANNYA*, *6*(2), 94–106. https://doi.org/10.46918/karst.v6i2.2108

Mulyani, H., & ... (2024). Profil Kemampuan Literasi Sains Calon Guru Sd: Analisis Pada Aspek Kompetensi. *Pendas: Jurnal Ilmiah …*, *09*. http://journal.unpas.ac.id/index.php/pendas/article/view/17892%0Ahttps://journal.unpas.ac.id/index.php/pendas/article/download/17892/7475

Mutmainah, Y. H., Suhendar, U., & Sumaji, S. (2023). Perbandingan Pengaruh Pendekatan RME dan Saintifik Terhadap Kemampuan Literasi Numerasi. *JNPM (Jurnal Nasional Pendidikan Matematika)*, *7*(1), 35.

Nasution,E.S.(2019).Peningkatan Keterampilan Berargumentasi Ilmiah pada Siswa Melalui Model Pembelajaran Argument Driven Inquiry (ADI). *Jurnal Eksakta Pendidikan* (Jep), 3(2),100-108.

Nisak, F. N. F., & Suprapto, N. (2022). Analisis Kemampuan Argumentasi Ilmiah Siswa Dengan Penggunaan Media Photovoice Pada Materi Pembiasan Cahaya. *IPF: Inovasi Pendidikan Fisika*, *11*(1), 35–45.

Nugraha, T. S. (2022). Kurikulum Merdeka untuk pemulihan krisis pembelajaran. *Inovasi Kurikulum*, *19*(2), 251–262.

Nurhidayati, E., Masykuri, M., Isma, D., & Fakhrudin, A. (2023). Pengaruh Model Pembelajaran Argument Driven Inquiry (ADI) Dengan Pendekatan STEM Terhadap Keterampilan Argumentasi Pada Materi Cahaya dan Alat Optik. *Jurnal Pendidikan IPA*, *12*(3), 171–182.

Nurjumiati, N., Syahriani Yulianci, & Asriyadin, A. (2022). Pengaruh Model Inquiry Berbasis Literasi Numerasi Terhadap kemampuan Pemodelan Matematis dan Bahasa Simbolik Fisika. *Jurnal Pendidikan Mipa*, *12*(3), 945–948.

Oktariya, P., Herlina, K., & Abdurrahman, A. (2023). Development of Problem-Based e-LKPDs Assisted by CANVA to Stimulate Numeracy Skill and Visual Literacy. *Jurnal Penelitian Pendidikan IPA*, *9*(12), 12303–12308.

Pitorini, D. E., Suciati, S., & Ariyanto, J. (2020). Kemampuan argumentasi siswa: Perbandingan model pembelajaran inkuiri terbimbing dan inkuiri terbimbing dipadu dialog Socrates. *Jurnal Inovasi Pendidikan IPA*, *6*(1), 26–38.

Pramesti, D., Probosari, R. M., & Indriyanti, N. Y. (2022). Effectiveness of Project Based Learning Low Carbon STEM and Discovery Learning to Improve Creative Thinking Skills. *Journal of Innovation in Educational and Cultural Research*, *3*(3), 444–456.

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.

Puteri, S. A., Sari, M. P., & Diliarosta, S. (2025). " *Pengaruh Model Pembelajaran Argument-Driven Inquiry (Adi) Terhadap Kemampuan Argumentasi*. 307–314.

Putra, N., Asrizal., Usmeldi. (2023). Meta-Analisis Pengaruh Stem pada Pembelajaran Fisika terhadap Pemahaman Konsep dan Keterampilan Berpikir Kreatif Siswa. *Jurnal Pendidikan IPA*. 12 (3): 228-239.

Putri, L. A., Permanasari, A., Winarno, N., & Ahmad, N. J. (2021). Enhancing Students' Scientific Literacy Using Virtual Lab Activity with Inquiry-Based Learning. *Journal of Science Learning*, *4*(2), 173–184.

Rahmah, I. F., Irianto, A., & Rachmadtullah, R. (2023). Problem Based Learning Models to Numeracy Literacy Skills : A Study in Elementary School. *Journal of Education and Teacher Training Innovation*, *1*(1), 1–10.

Rahmadeni, Septiana, A., & Syaripah. (2023). Numeracy Literacy Module Based on Local Culture: Effort to Improve Numeracy Literacy Skill. *Jurnal Pendidikan dan Pembelajaran Matematika*, 7(1): 10-25.

Roja, F. F. M., Yuliati, L., dan Suyudi, A. (2020). Kemampuan Argumentasi dan Penguasaan Konsep Dinamika Rotasi dan Pembelajaran Inkuiry untuk Pendidikan STEM pada Siswa Kelas XI

SMAN 2 Malang. *Jurnal Riset Pendidikan Fisika,* 5(2): 129-133.

Rustaman, N. Y. (2016). Pembelajaran Sains Masa Depan Dengan STEM Education. *Prosiding Seminar Nasional Biologi Edukasi*.Padang:Program Studi Pendidikan Biologi, STKIP PGRI SumateraBarat.

Riyanti, V., Hamdiyati, Y., & Purwianingsih, W. (2023). The Effect of Argument-Driven Inquiry (ADI) on Argumentation Skills and Students' Concept Mastering of Human Excretory System Materials. *Journal of Science Learning*, *6*(2), 125–135.

Sabekti, A. W., Khoirunnisa, F., Liliasari., dan Mudzakir, A. (2020). Integrasi Argumentasi Ilmiah dalam Pembelajaran Kimia. Yogyakarta: CV Budi Utama.

Sampson, V., Enderle, P., Gleim, L., Jonathon, P. P.,Hester, M., Southerland, S., & Wilson, K. (2014). *Argument-Driven Inquiry in Biologi. Amerika*: National Science Teachers Association,

Sari, R. A., Musthafa, B., dan Yusuf, F. N. (2021). Pembelajaran Argument Driven Inquiry pada Materi Suhu dan Kalor untuk Meningkatkan Kemampuan Argumentasi Ilmiah Siswa. *Jurnal Penelitian Pendidikan,* 21(2): 88-97.

Sartianis, G., Yuliati, L., & Parno, P. (2022). Kemampuan Literasi Numerasi Siswa SMA Kelas XI MIPA dalam Mata Pelajaran Fisika. *Quantum: Jurnal Inovasi Pendidikan Science*, *13*(2), 168.

Satriya, M. A., & Atun, S. (2024). The Effect of Argument Driven Inquiry Learning Models on Scientific Argumentation Skills and Higher Order Students on The Topics of Acid Base. *Jurnal Penelitian Pendidikan IPA*, *10*(5), 2663–2673. https://doi.org/10.29303/jppipa.v10i5.6834

Setiawan, A., & Jumadi, J. (2023). Analysis of the Implementation of Argument Driven Inquiry (ADI) in Students' Argumentation Skills. *Jurnal Penelitian Pendidikan IPA*, *9*(6), 127–133.

Simarmata, J., Simanihuruk, L., Ramadhani, R., Safitri, M., Wahyuni, D., dan Iskandar, A. (2020). *Pembelajaran STEM dengan HOTS dan Penerapannya*. Medan: Yayasan Kita Menulis.

Siregar, N., & Pakpahan, R. A. (2020). Kemampuan Argumentasi IPA Siswa melalui Pembelajaran Argumentasi Driven Inquiry (Adi). *LENSA (Lentera Science): Jurnal Pendidikan IPA*, *10*(2), 94–103.

Suganda, T., Parno, P., & Sunaryono, S. (2021). Identifikasi Argumentasi Ilmiah Siswa Topik Gelombang Bunyi dan Cahaya. *Jurnal Pendidikan: Teori, Penelitian, dan Pengembangan*, *6*(9), 1413-1417.

Susanti, N. A., Sarwi, & Aji, M. P. (2023). Rasch Model Analysis: Devolepment of Literacy Numeracy Assesment Instrument of Electromagnetic Inducion. *Physics Communication*, 7(2): 43-53.

Sulistianingsih, M., & Yanto, F. (2024). Studi Literatur : Pengaruh Penerapan Model Pembelajaran Argument Driven Inquiry (ADI) terhadap Keterampilan Argumentasi Siswa pada Mata Pelajaran IPA SMP. *Jurnal Pendidikan Tambusai*, *8*(2), 18944–18954.

Syahmani, E. H. (2021). Pengaruh Pembelajaran dengan Pendekatan STEM Berbasis Lahan Basah pada Literasi Sains Siswa. *Prosiding Seminar Nasional Lingkungan Lahan Basah*, *6*(2).

Syarqiy, D., Yuliati, L., & Taufiq, A. (2023). Exploration of Argumentation and Scientfic Reasoning Ability in Phenomenon-Based Argument-Driven Inquiry Learning in Newton's Law Material. *Jurnal Penelitian Pendidikan IPA*, 9(9): 7264-7272.

Tami dan Friyatmi. (2023). Analisis Implementasi Pembelajaran Diferensiasi dalam Kurikulum Merdeka di SMAN 1 V Koto Kampung Dalam. *Jurnal Pendidikan Science,*3(6): 1277-1285

Toulmin S E 2003 The uses of argument: Updated Edition (New York: Cambridge University Press)

Utami, P. Q., Sumari, S., & Dasna, I. W. (2022). Penerapan Model Pembelajaran Argument Driven Inquiry terhadap Kemampuan Argumentasi Ilmiah. *Jurnal Pendidikan: Teori, Penelitian, dan Pengembangan*, *7*(4), 122.

Utami, S. M., Haryanto., & Subagyo, A. (2024). The Development of Electronic Students' Worksheets (E-LKPD) Based on Argument Driven Inquiry Learning Model to Improve Scientific Argumentation Skills. *Integrated Science Education Journal,* 5(2): 65-73.

Viyanti., Ramayani, D. L., & Rosidin, U. (2023). Devolepment of Assesment Instruments in Project-Based Learning to Measure Students Scientific and Numeracy Literacy Ability on Harmonic Vibration Materials. *Jurnal Penelitian Pendidikan IPA,* 9(7): 5039-5048

Walidain, S. N., Ardianti, S., Wendari, W., dan Satriawan, I. (2023). Analisis Model Pembelajaran Project Based Learning dalam Pembelajaran Fisika pada Kurikulum Merdeka. *Jurnal Riset Kajian Teknologi & Lingkungan,* 6(2): 137-145.

Wahyningtyas, D. P., Susanti, R. A., dan Elvira, M. (2023). Pembelajaran Berdiferensiasi untuk Implementasi Kurikulum Merdeka. Malang: PT. Literasi Nusantara Abadi Grup.

Wibowo, F. C., Sanjaya, L. A., Darman, D. R., Fitri. U. R., Oktavianty, E., Ermawati, E. A., Nasbey, H., Mahartika, I., Widiyatmoko, A., Haeruman, L. D., & Kusuma, A. F. D. K. (2023). *Pembelajaran Nano Learning dengan STEM.* Medan: Yayasan Kita Menulis.

Widhi, M. T. W., Hakim, A. R., dan Wulansari, N. I. (2021). Analisis Ketrampilan Argumentasi Ilmiah Siswa pada Model Pembelajaran dengan Toulmin's Argumentation Pattern (TAP) dalam Memahami

Konsep Fisika dengan Metode *Library Research. Journal of Education,* 5(1): 79- 91.

Winata, A., Widiyanti, I. S. R., & Sri Cacik. (2021). Analisis Kemampuan Numerasi dalam Pengembangan Soal Asesmen Kemampuan Minimal pada Siswa Kelas XI SMA untuk Menyelesaikan Permasalahan Science. *Jurnal Educatio FKIP UNMA*, *7*(2), 498–508.