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Development of Student Worksheets Based on Argument-Driven Inquiry to Improve The Scientific Argumentation Ability

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Abstract: Scientific argumentation plays a crucial role in science learning, yet many students face difficulties in constructing and justifying arguments based on evidence. Conventional teaching approaches often do not provide adequate opportunities for structured argumentation. Student Worksheets Based on Argument-Driven Inquiry (ADI) integrate argumentation into experimental activities, yet their use in topics such as vibrations, waves, and light remains underexplored. This study focuses on developing student worksheets based on ADI to enhance the scientific argumentation ability of eighth-grade students at MTsN 1 Jember. The research follows the ADDIE model, consisting of analysis, design, development, implementation, and evaluation. The worksheets underwent validation by three experts and were tested using observation sheets, student questionnaires, and pretest-posttest assessment. Findings indicate that the worksheets are highly valid, practical, and effective, with an N-gain score of 0.7, classified as high. These results suggest that integrating ADI-based worksheets into science instruction can foster students' scientific argumentation ability.

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INTRODUCTION

Natural Science is the study of laws, concepts, and facts about natural phenomena through various research methods. Learning Science helps students understand themselves and their environment, as well as comprehend science in everyday life (Putri, 2017). According to the 21st Century Skills Partnership OECD based in the US, the skills needed in the 21st century are the 4Cs: Communication, Collaboration, Critical Thinking, and Creativity and Innovation (Farida et al., 2018). Therefore, students are indirectly required to master some of these skills, including communication skills (Safira et al., 2018; Lismawati et al., 2021). Through the process of scientific argumentation, students can learn to express their opinions, thus, in science learning, they no longer just memorize facts without understanding concepts, but rather involve insight or comprehension. Scientific argumentation abilities are crucial in learning science, these skills help students develop clear perspectives, logical reasoning, and a rational understanding of phenomena (Ridlo et al., 2023).

Scientific argumentation is an effort to validate claims based on reasoning. The ability to argue is the students' capability to articulate the knowledge they have acquired during the learning process, accompanied by evidence, leading to conclusions (Noviyani et al., 2017; Putri & Admoko, 2022). Argumentation is essential for students to learn how to provide evidence, test and evaluate theories, and communicate like scientists (Duschl & Osborne, 2002; Safira et al., 2018). According to Toulmin (2003), good argumentation consists of claim, evidence, and justification. However, in practice, incorporating argumentation activities into learning is still rare. Consequently, when students are asked to collect data and understand a phenomenon, they often struggle to present results and provide reasons for the data

they have found (Karlina & Heffi, 2021). Previous research by Zairina & Hidayati (2022) showed that the argumentation abilities of 7th-grade students at SMP Negeri 62 Surabaya were generally low. Students tend to make statements in the form of claims but are unable to provide evidence and justification to support those claims. Scientific argumentation ability should be part of the science learning process as they are a strategy for solving problems, questions, disputes, and debates using arguments supported by data and facts (Noviyani et al., 2017). Researchers broadly agree that understanding science requires comprehending how to note "what matters" in generating arguments and emphasizing the need for research to build arguments with a proper structure (Walker et al., 2019).

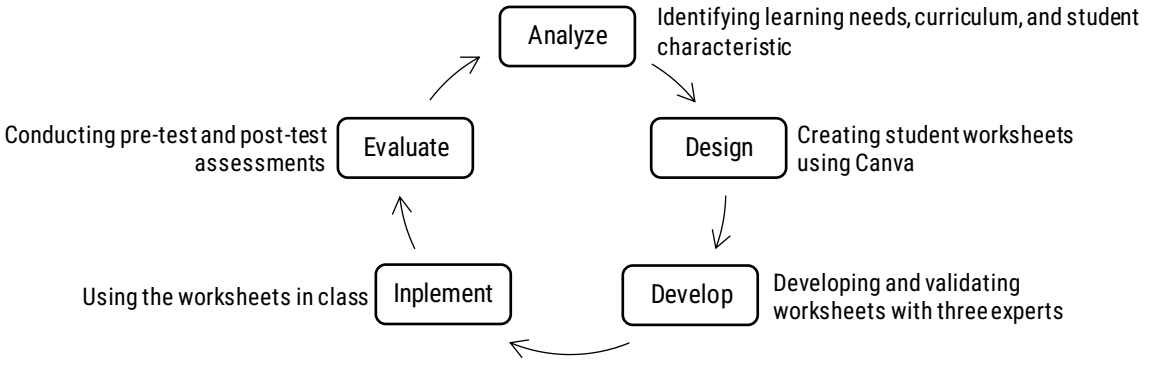
Integrating argumentation into science learning is considered more effective when supported by an appropriate learning model. One such model that can help develop students' scientific argumentation ability is the Argument-Driven Inquiry (ADI) learning model (Novitasari & Admoko, 2022). The ADI model provides opportunities for students to communicate in a structured and interactive manner, conduct their investigations, and collect and analyze data. Essentially, this model is a laboratory-based inquiry model developed with argumentation activities to enable students to work in experimental groups, thereby understanding science concepts practically (Zahara et al., 2018). According to Sampson and Gleim (2011), the Argument-Driven Inquiry model was designed to transform conventional education methods, allowing students to learn about scientific research during their studies.

Based on initial observations and interviews with science teachers at MTs Negeri 1 Jember, because science material is abstract, students often have difficulty understanding the material, making them hesitant to express their opinions or arguments. The low level of students' scientific argumentation can be attributed to their lack of involvement in argumentation activities in class. Additionally, teachers are not accustomed to teaching their students how to argue. They typically only test students' abilities by correcting their answers, having them provide brief explanations, and summarizing a topic (Risnita et al., 2020). Therefore, teachers need educational media that can help them build argumentation activities in the classroom. Educational media such as student worksheets can encourage interactive communication between teachers and students (Putri & Admoko, 2022). Using student worksheets in learning will provide students with opportunities to be more actively involved in exploring the questions they face. Student worksheets are also considered an integral part of the learning design to facilitate the teaching and learning process (Nuha et al., 2023). Previous research on science teachers from several schools showed that 87% of teachers already use student worksheets during their teaching process. However, the student worksheets used have not been able to facilitate students in developing their scientific argumentation ability (Lismawati et al., 2021). A student worksheet based on the Argument-Driven Inquiry is a worksheet designed by applying the steps of this model and is expected to train students to argue scientifically by helping them provide scientific explanations, answer questions with scientific data, and communicate their results. Therefore, the purpose of this research is to develop student worksheets and describe the validity, practicality, and effectiveness of student worksheets based on Argument-Driven Inquiry

METHOD

Research & Development (R&D) was employed in this study to develop Student Worksheets Based on Argument-Driven Inquiry (ADI) to enhance students' scientific argumentation skills. This method facilitated the creation, refinement, and evaluation of instructional materials to ensure their effectiveness. The ADDIE model, which consisted of Analyze, Design, Develop, Implement, and Evaluate stages, guided the development process (Branch, 2009). This study was conducted at MTs Negeri 1 Jember during the 2023/2024 school year, involving 31 Grade VIII G students. Various instruments, including validation sheets, observation checklists, student questionnaires, and pre-test/post-test assessments, were used to evaluate the impact of the worksheets.

The The stages employed in the development of student worksheets based on argument-driven inquiry to enhance scientific argumentation ability are presented in the following diagram:



In this study, the researcher measured students' scientific argumentation based on Toulmin's argumentation indicators, which consist of Claim, Evidence, and Justification. These indicators are presented in Table 1.

Table 1. Indicator of Scientific Argumentation

Indicator	Criteria
Claim	Students can express statements related to scientific phenomena they encounter in the form of opinions or decisions based on their own knowledge and logical reasoning.
Evidence	Students are able to present scientific data, either from learned theories or scientific data obtained from experiments or various information sources.
Justification	Students can provide reasoning or justification that supports the initial claim and evidence

Data collection methods in this research involve observation, interviews, tests, response questionnaires, and documentation. Data analysis methods cover the validity, practicality, and effectiveness of the student worksheets based on Argument-Driven Inquiry. Three expert validators assess the student worksheets, and their evaluations are calculated using Akbar's (2013) validity formula, compared against the categories in Table 2.

$$V - ah = \frac{TSe}{TSh} \times 100\%$$

Information:
V-ah = Expert Validation
TSe = Total empirical score achieved
TSh = Total ideal value overall

Table 2. Criteria For Material And Media Validity

No	Validity Criteria	Validity Level
1.	$85{,}01 < P \leq 100{,}00$	Highly valid
2.	$70{,}01 < P \leq 85{,}00$	Valid
3.	$50{,}01 < P \leq 70{,}00$	Not valid
4.	$25{,}00 < P \leq 50{,}0$	Not highly valid

The practicality data of the student worksheets are obtained from observation sheets filled out by three observers in each classroom session. Practicality analysis is calculated based on the practicality formula according to Akbar (2013), which is compared with the practicality score categories in Table 3.

$$P = \frac{\sum x}{n} \times 100\%$$

Information:
P = Percentage of implementation
Σ*x* = Many items have been implemented
n = Many questions

Table 3. Criteria Of Practicality Of The Developed Product

No	Practicality Criteria	Practicality Level
1.	85,01 < P ≤ 100,00	Very Practical
2.	70,01 < P ≤ 85,00	Practical
3.	50,01 < P ≤ 70,00	Less Practical
4.	25,00 < P ≤ 50,0	Impractical

Effectiveness data are obtained by providing student response questionnaires and tests on scientific argumentation abilities. The analysis of the student response questionnaire data is calculated based on the formula and effectiveness criteria according to Apsari & Ismono (2014) in Table 4 below:

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

Information:
P = Percentage
f = Number of students who voted
N = The maximum number of student scores

Table 4. Student Response Criteria

Percentage	Criteria
80% < P ≤ 100%	Very good
60% < P ≤ 80%	Good
40% < P ≤ 60%	Pretty good
P ≤ 40%	Not good

The improvement of students' scientific argumentation abilities is analyzed using the calculation of normalized average gain scores (N-gain) according to Hake (1998), with categories that can be seen in Table 5 below:

$$N\text{-}gain = \frac{S_{post} - S_{pre}}{S_{maks} - S_{pre}}$$

Information:
N-gain = gain normality test value
S_{post} = post-test score
S_{pre} = pre-test score
S_{maks} = maximum score

Table 5. Criteria for the effectiveness of the product being developed

No	N-gain Score	N-gain Criteria
1.	g ≥ 0,7	High
2.	0,30 ≤ g < 0,7	Medium
3.	g < 0,30	Low

RESULT AND DISCUSSION

Result of this research is student worksheets integrated with the Argument-Driven Inquiry learning model. The developed product is implemented in 8th-grade science classes. The development of student worksheets based on Argument-Driven Inquiry was carried out in 4 learning sessions at MTs Negeri 1 Jember. With the ADDIE development model design, the research results can be outlined as follow :

Analyze Stage

The initial stage of the research involves needs analysis, student analysis, and curriculum analysis. Needs analysis and student analysis were conducted through observations at MTs Negeri 1 Jember. According to the observation results of classroom learning, the school rarely implements learning with student worksheets. Classroom learning is teacher-centered with lecture-style teaching, and the learning

process relies solely on textbooks that present the material in its entirety without accompanying activities that encourage interaction and active involvement among students. Furthermore, when teachers ask questions, students tend to be passive, and the arguments presented are still too reliant on textbooks, indicating that the argumentation abilities are still low. Previous research by Rahayu et al., (2020) found that students' argumentation abilities are still low because the learning process does not provide encouragement and opportunities for them to express arguments, both in writing and orally, to others. The curriculum used by MTs Negeri 1 Jember is the Kurikulum Merdeka. esearchers chose the topics of Vibrations, Waves, And Light for Grade 8 to develop student worksheets aimed at enhancing argumentation abilities. These student worksheets will include various research activities organized based on the Argument-Driven Inquiry learning model to help students develop argumentation abilities.

Design Stage

This stage is a step to design the development product based on previous analysis. The researcher prepares student worksheets adjusted to the Argument-Driven Inquiry model and scientific argumentation indicators using the Canva application. The design of the student worksheets includes a cover, title of the material, student identity, introductory material, learning activities, research reports, and review pages packaged as attractively as possible, which can be seen in Figure 2.

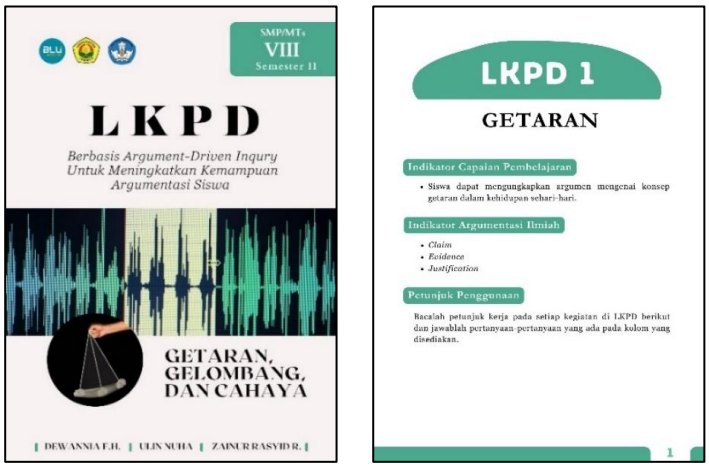


Figure 1. Student Worksheet Cover Design

Experiment activities are chosen to match the topics of vibrations, waves, and light, enabling students to conduct them independently. These activities facilitate direct observation, data collection, result analysis, and conclusion drawing based on evidence. See Figure 3 and Figure 4 for the design of experiment activities and efforts to enhance students' scientific argumentation abilities.

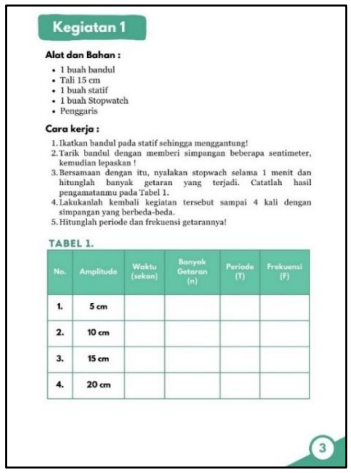


Figure 2. Examples Of Experimental Activities On Student Worksheets

Figure 3. Student Worksheet Design To Improve Scientific Argumentation

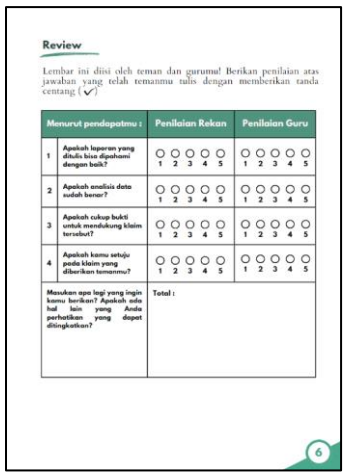
Develop Stage

The validation results from the three validators are then analyzed to obtain the average score and adjusted according to the validity categories previously established. The validation results of the Argument-Driven Inquiry-based student worksheets can be seen in Table 5.

Table 5. Validity Test Results Of Student Worksheets

No	Assessment aspect	Validator			Percentage	Category
		1	2	3		
1.	Contents	88%	83%	96%	89%	Very Valid
2.	Presentation	83%	83%	92%	86%	Very Valid
3.	Language	82%	86%	93%	87%	Very Valid
4.	Graphics	95%	80%	95%	90%	Very Valid
	Average	86%	82%	94%	87%	Very Valid

According to Table 5, the student worksheets based on Argument-Driven Inquiry had a validity percentage of 87%, which is considered very valid. However, some words in the student worksheets based on argument-driven inquiry are in a foreign language and difficult for students to understand. Additionally, the argument assessment sheet uses a 1-5 rating scale but lacks explanations, so the validator suggested adding descriptions for each score interval.



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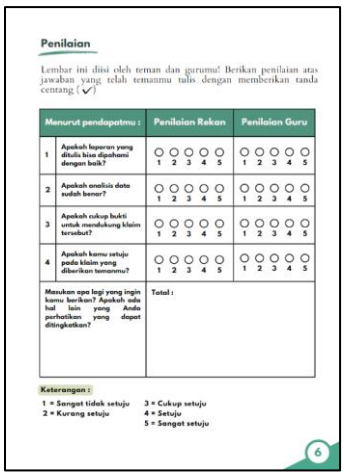

(After revision)

Generally, student worksheets can be considered suitable for use during learning if they meet the feasibility categories assessed from three main aspects: material, language, and media (Ndia et al., 2021). This statement is reinforced by the opinion of Nesri and Kristanto (2020), who stated that a product is considered valid only if the development product contains all the specified elements. In line with the research by Putri and Admoko (2022), who developed student worksheets to improve students' critical thinking skills, with a validity of 88.6% and categorized as highly valid. The student worksheets based on Argument-Driven Inquiry include learning activities called "Ayo Berargumen," which train students to provide opinions in the form of claims, data, and justifications related to science concepts. Sheets for writing laboratory reports and sheets for responding to classmates' opinions are provided at the end of the learning session, in accordance with the steps in the Argument-Driven Inquiry learning model.

Implement Stage

The developed product, which has been validated, is then implemented in classroom learning activities. The implementation phase takes place over 4 learning sessions with 31 student participants. Data on the effectiveness of the product is obtained from observations made by three observers during the learning sessions. Analysis of the practicality test of the student worksheets based on Argument-Driven Inquiry can be seen in Table 6.

Table 6. Practicality Test Results Student Worksheets

No	Observed aspects	Learning sessions (%)				Average (%)
		1	2	3	4	
1	Students open the student worksheets based on Argument-Driven Inquiry and understand the instructions contained in the student worksheets based on Argument-Driven Inquiry	100	100	100	100	100
2	Students sit with the groups that have been formed	83	91.7	100	100	94
3	Students conduct the experiments in the student worksheets based on Argument-Driven Inquiry to collect data.	92	91.7	91.7	100	94
4	Students discuss and create arguments consisting of claims, evidence, and justification.	83.3	91.7	91.7	91.7	90
5	Students present the arguments they have made to other groups.	83	91.7	92	100	92
6	Students collaboratively compile an investigation report to summarize the results of the experiments they have conducted.	91.7	91.7	91.7	91.7	92
7	Students exchange student worksheets based on Argument-Driven Inquiry to provide feedback on the experiments that were previously conducted.	83	92	91.7	91.7	90
Overall average						93%
Category						Very practical

Overall, based on Table 6, the implementation of learning using these student worksheets obtained a score of 93%, which falls into the category of very practical. According to Ndia et al. (2020), a student worksheet is considered suitable for use if the analysis of its practicality yields an average score of 87%. This opinion is also in line with the research conducted by Rahayu et al., (2020), where validity tests with a range of 81% to 100% are considered very good. The high percentage values in each meeting indicate that the implementation of learning using student worksheets based on Argument-Driven Inquiry can be considered very well executed in each meeting. The results of the observation sheets analysis may indicate that the learning process is in line with the teacher's lesson plan (Lismawati et al., 2021). The improvement in the implementation of learning in each meeting can occur due to the repetition of activities, which helps students start learning to communicate effectively.

Evaluate Stage

Scientific Argumentation Ability

The average pretest score obtained by students before using the Argument-Driven Inquiry-based student worksheets is 20.3, while after using the student worksheets based on Argument-Driven Inquiry, the average score obtained is 80.7 based on Figure 4 in belows. From this analysis, there is already an apparent improvement in students' learning outcomes before and after using the student worksheets based on Argument-Driven Inquiry.

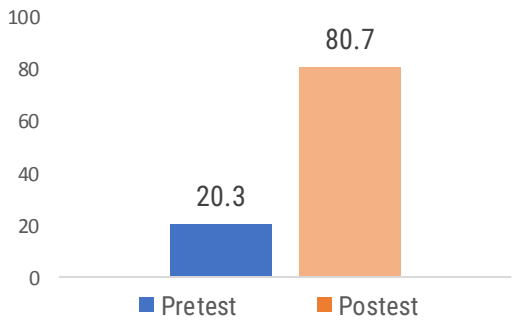

Figure 4. Average Pretest And Posttest Score

According to Novitasari and Admoko (2022), if the student worksheets developed can provide a significant difference between pretest and posttest results, then the student worksheets are categorized as effective for use in learning. Furthermore, the researchers conducted an overall N-gain test and obtained results as shown in Table 7.

Table 7. Effectiveness Of Scientific Argumentation Ability

Component	VIII G Class		N-gain	Category
	Pre test	Post test		
The number of students	31	31		
Lowest Value	11	53	0,70	High
The highest score	47	96		

The N-gain test score to determine the effectiveness of student worksheets based on Argument-Driven Inquiry is 0.70, indicating that the effectiveness of student worksheets based on Argument-Driven Inquiry falls into the high category. This achievement indicates a high improvement in students' scientific argumentation ability after using the student worksheets based on Argument-Driven Inquiry in science learning. Rahayu et al., (2020) mentioned a significant improvement in the use of student worksheets following the Claim, Data, Warrant (CDW) pattern during classroom learning.

In addition to looking at the overall average N-gain score, this researcher also conducted an effectiveness test for each indicator of students' scientific argumentation ability, which include claim, evidence, and justification. The researcher provided 5 evaluative questions, each containing all three indicators. The N-gain test results for each indicator are shown in Table 8.

Tabel 8. Results Of Achievement Of Scientific Argumentation Ability Indicators

Indicator	Pretest Averange	Postest Pretest	N-gain	Criteria
Claim	57	89,7	0,8	High
Evidence	3	76,6	0,8	High
Justification	0,9	75,9	0,8	High

The indicators claim, evidence, and justification each obtained the same average N-gain score of 0.8, indicating a high category. From this, it is evident that students are able to understand the questions and present their arguments in the form of well-structured claims, provide evidence to support their claims, and present justifications that connect the claims with the evidence. The analysis results of these three indicators indicate that student worksheets based on Argument-Driven Inquiry are effective in improving students' scientific argumentation ability for each claim, evidence, and justification indicator.

Student Response

The effectiveness of student worksheets based on Argument-Driven Inquiry was also evaluated based on student response results. Student response questionnaires were distributed to 31 students at MTs 1 Jember after completing the learning process using student worksheets based on Argument-Driven Inquiry. The analysis results indicate that student worksheets based on Argument-Driven Inquiry can be presented in Table 9.

Tabel 9. Results Of Recapitulation Of Student Response Questionnaires

No.	Aspect	Percentage	Category
1.	Interest	94,4%	Very good
2.	Contents	91,5%	Very good
3.	Language	93,5%	Very good
	Average	93,1%	Very good

Based on Table 9. the average total of the three aspects analyzed reached 93.1%. This figure indicates that students have a high level of interest, perceive the content in the student worksheets as

appropriate, and find the language used easy to understand. The obtained scores also indicate that student worksheets based on the Argument-Driven Inquiry have several benefits: students can improve their understanding of the material, enhance critical thinking skills, and become more motivated to learn because the learning process becomes more engaging and less boring (Putri and Admoko, 2020). Lismawati et al., (2021) stated that student worksheets using the Argument-Driven Inquiry model received positive responses, and there was an interest in using student worksheets based on Argument-Driven Inquiry because students were directly involved in classroom learning.

CONCLUSION

Student worksheets based on Argument-Driven Inquiry are highly valid, practical, and effective for science learning, as they enhance students' scientific argumentation skills. Pretest and posttest analysis showed significant improvement, and students responded positively. Based on the data analysis, these worksheets are suitable as teaching materials. However, this study is limited to the topics of vibrations, waves, and light. Future research is recommended to explore their use in other scientific topics or education levels to further assess their effectiveness.

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