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Developing an Argument-Driven Inquiry-Based Learning Module to Strengthen High School Students' Argumentation Skills on Renewable Energy Concepts

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Abstract

Interviews with a physics teacher at a public senior high school in Semarang revealed that students' argumentation skills were low: students lacked confidence, tended to be passive, and the available teaching materials did not train argumentation, particularly on renewable energy. This study aimed to develop an Argument-Driven Inquiry (ADI)-based teaching module and to analyze its characteristics, validity, readability, effectiveness in improving argumentation skills, and student responses. The study used a Research and Development design with the 4D model. The module was validated by five experts, the test instrument was trialed with 34 grade XI students, and the module's effectiveness was tested on 64 grade X students using a non-equivalent control group design (32 experimental and 32 control students). The instruments were validation sheets, a cloze test, a student response questionnaire, and nine essay items based on Toulmin's claim, data, and warrant indicators. The module was valid (Aiken's V = 0.88), had an independent readability level (cloze score 97.64%), and received good student responses (82.67%). The experimental class achieved significantly higher posttest scores than the control class ($p = 0.017$) and a higher N-Gain (0.74, high) than the control class (0.60, medium). Therefore, the ADI-based module is valid and effective for improving students' scientific argumentation skills. Future studies should strengthen the warrant indicator, which showed the lowest achievement, through explicit reasoning practice and complete argument examples.

Keywords: *Argument Driven Inquiry, Argumentation Skills, Renewable Energy, Teaching Module*

Pengembangan Modul Pembelajaran Berbasis Argument-Driven Inquiry untuk Memperkuat Kemampuan Argumentasi Siswa SMA pada Konsep Energi Terbarukan

Abstrak

Hasil wawancara dengan guru fisika di salah satu SMA negeri di Semarang menunjukkan bahwa kemampuan berargumentasi siswa masih rendah: siswa kurang percaya diri, cenderung pasif, dan bahan ajar yang tersedia belum melatih argumentasi, khususnya pada materi energi terbarukan. Penelitian ini bertujuan mengembangkan modul ajar berbasis *Argument-Driven Inquiry* (ADI) serta menganalisis karakteristik, validitas, keterbacaan, efektivitas dalam meningkatkan kemampuan berargumentasi, dan respons siswa

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terhadap modul. Penelitian menggunakan metode *Research and Development* dengan model 4D. Modul divalidasi oleh lima ahli, instrumen tes diujicobakan kepada 34 siswa kelas XI, dan efektivitas modul diuji pada 64 siswa kelas X dengan desain *non-equivalent control group* (32 siswa kelas eksperimen dan 32 siswa kelas kontrol). Instrumen berupa lembar validasi, *cloze test*, angket respons siswa, dan sembilan soal esai berdasarkan indikator *claim*, *data*, dan *warrant* Toulmin. Modul dinyatakan valid (Aiken's V = 0,88), memiliki keterbacaan tingkat independen (skor *cloze test* 97,64%), dan memperoleh respons siswa kategori baik (82,67%). Nilai *posttest* kelas eksperimen lebih tinggi secara signifikan dibandingkan kelas kontrol (p = 0,017), dengan N-Gain 0,74 (tinggi) dibandingkan 0,60 (sedang) pada kelas kontrol. Dengan demikian, modul ajar berbasis ADI valid dan efektif untuk meningkatkan kemampuan berargumentasi ilmiah siswa. Penelitian selanjutnya disarankan memperkuat indikator *warrant* yang capaiannya paling rendah melalui latihan penalaran eksplisit dan contoh argumen yang lengkap.

Kata kunci : *Argument Driven Inquiry*, Energi Terbarukan, Kemampuan Berargumentasi, Modul Pembelajaran

INTRODUCTION

Argumentation skills are defined as a highly significant skill for students, as they are required to construct an argument or opinion based on relevant and valid evidence, with the aim of conveying the truth, defending their views, values, or beliefs, and influencing others (Sari et al., 2025) . As Iwuanyanwu (2022) asserts, this skill can also assist students in solving complex problems logically through dialogue, thereby deepening their scientific and social understanding. In the context of argumentation, students are required to substantiate their claims with empirical evidence and data (Jimenez et al., 2024) . Therefore, it is imperative for students to develop proficiency in argumentation skills.

Preliminary observations and an interview with the physics teacher at the research site showed that most students were not yet accustomed to, and lacked confidence in, expressing their opinions during lessons. Class discussions were largely one-way and dominated by the teacher; when given the opportunity to speak, students hesitated, feared being wrong, or could not organize their arguments logically. The teaching materials in use were conventional and descriptive, and the existing modules targeted critical thinking rather than argumentation. This condition was also reflected in the pretest of this study, in which the mean argumentation scores were only 40.16 in the experimental class and 52.06 in the control class out of 100. These findings are consistent with broader evidence: Indonesia ranked 71st of 79 countries in the PISA

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2018 science literacy assessment (OECD, 2018), and high school students still struggle to construct logical arguments, identify supporting evidence, and draw valid conclusions (Ashfy & Admoko, 2024; Rahayu et al., 2020). The problem is more pronounced in contextual and complex topics such as renewable energy (Romadhoni et al., 2025), which integrates physics concepts with sustainability issues that students encounter in daily life (Abduh et al., 2024).

Ginanjar et al. (2015) posit that the Argument-Driven Inquiry (ADI) learning model is efficacious in facilitating students' comprehension of concepts, as its learning activities prioritize inquiry. The engagement of students in argumentation sessions has been demonstrated to facilitate their comprehension of academic concepts. This is due to the fact that the construction of an argument necessitates an initial comprehension of the concept (Fauziah et al., 2024) . The ADI learning model is designed to enable students to compile their own research findings, collect and evaluate research data, construct and assess arguments, and compile reports based on their research findings (Firdaos et al., 2021).

Previous studies have examined ADI from different angles. Novitasari et al. (2022) developed ADI-based student worksheets that were rated very valid (85.04%) and improved science literacy with an N-Gain of 0.81. Akili et al. (2022) developed ADI-based learning tools on electrolyte solutions with a validity of 91.7% to train argumentation in chemistry, and Sari et al. (2025) produced an ADI-based Physics Magazine with a validity of 97%. Rizkia et al. (2024) applied ADI in biology and found a significant difference in argumentation, mainly in the claim component, but not in concept mastery. Fadillah and Suyono (2024) combined ADI with structured assignment sheets and raised students' mean argumentation scores from 27.5 to 84.06. Other studies used ADI to target different outcomes: Diartika (2024) developed an ADI module that improved university students' critical thinking, and Pujianti et al. (2020) improved science process skills on simple harmonic motion.

These studies show three gaps. First, most ADI products are worksheets, magazines, or learning tools rather than complete teaching modules aligned with the Merdeka Curriculum. Second, the studies are concentrated in chemistry and biology, or they target outcomes other than argumentation, such as science literacy, critical thinking, and science process skills. Third, few studies measure argumentation explicitly through

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Toulmin's claim, data, and warrant components while also testing the product's readability and student response. To the best of our knowledge, no study has developed an ADI-based physics teaching module on renewable energy and tested both its quality and its effect on argumentation against a control class.

The novelty of this study therefore lies in three aspects. First, ADI is integrated into a complete teaching module aligned with the Merdeka Curriculum, rather than only applied as a teaching model (Rizkia et al., 2024) or as worksheets (Novitasari et al., 2022). Second, each ADI phase in the module is explicitly mapped to Toulmin's claim, data, and warrant components, so the module functions both as learning material and as a means to train and measure argumentation, unlike the ADI module of Diartika (2024), which targeted critical thinking. Third, the module uses real renewable energy problems in Indonesia as the context of inquiry, which has been shown to increase students' engagement in argumentation and investigation (Annisa et al., 2023).

A multitude of prior studies have demonstrated that instruction employing the Argument-Driven Inquiry model can enhance students' argumentation skills. This model underscores the process of constructing arguments through inquiry, discussion, and evidence-based evaluation (Noviyana et al., 2024) . However, the application of this model in the form of structured teaching materials, particularly regarding renewable energy, remains relatively limited. Moreover, research specifically designed to systematically develop this model for training students' argumentation skills has not yet been extensively conducted.

In light of these challenges, there is a pressing need for instructional materials that not only present content but also facilitate the construction of scientific arguments by students in a structured manner. The development of teaching modules based on the Argument Driven Inquiry learning model is expected to serve as a solution to enhance student engagement in the learning process while simultaneously honing their argumentation skills. Therefore, this study aimed to develop an ADI-based teaching module on renewable energy and to analyze its characteristics, validity, readability, effectiveness in improving students' argumentation skills, and student responses to the module.

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RESEARCH METHODS

The present study employs the Research and Development (R&D) method using the 4D development model, which comprises the Define, Design, Development, and Dissemination phases. The selection of this method was predicated on the premise that its steps are characterized by simplicity and systematicity, thereby ensuring the creation of a product that is devoid of any validity issues (Sugiyono, 2015).

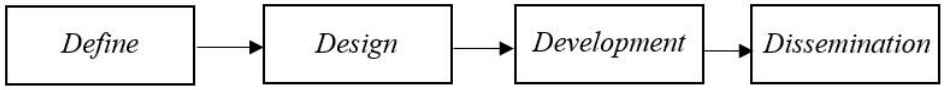


Figure 1. 4D Development Model Scheme

The development process for this instructional module follows the 4D model, which consists of four systematic stages: definition, design, development, and dissemination (Thiagarajan et al., 1974). The definition stage encompasses preliminary and concluding analyses, student analysis, task analysis, concept analysis, and the establishment of learning objectives to be employed in instruction. The design stage entails the preparation of the instructional module framework, the development of an initial draft, and the creation of research instruments such as validation sheets and questionnaires.

During the development phase, the instructional modules that had been drafted were further developed and validated by experts to determine their validity. Following validation, the modules were subjected to a pilot test with high school students to assess their effectiveness in enhancing argumentation skills. The dissemination phase was conducted on a limited scale through the implementation of the instructional modules in the classroom.

The study was conducted at SMA Negeri 11 Semarang in the even semester of the 2025/2026 academic year. In the define phase, problems were identified through classroom observation and an interview with the physics teacher, followed by learner, task, and concept analysis. The concepts covered were forms of energy, the law of conservation and conversion of energy, energy needs, energy sources, and renewable and non-renewable energy. In the design phase, nine essay test items, a printed module containing text, images, and QR codes linked to learning videos, and the validation sheets were prepared.

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In the development phase, the module was validated by five experts (three physics lecturers from Universitas Negeri Semarang and two physics teachers from SMA Negeri 11 Semarang) using 26 items on a 1–4 Likert scale covering content, language, readability, and graphics. The test instrument was validated by the same experts using a 1–5 Likert scale. Both validations were analyzed with Aiken's V (Aiken, 1985), with $V > 0.80$ categorized as valid, $0.40 < V \leq 0.80$ as fairly valid, and $V < 0.40$ as not valid. The instrument was then trialed with 34 grade XI students who had studied renewable energy, to analyze item validity (r-table = 0.349), reliability (Cronbach's alpha), difficulty level, and discriminating power. Readability was measured with a cloze test, with scores > 60% categorized as independent, 40–60% as instructional, and < 40% as frustration.

In the dissemination phase, a non-equivalent control group design was applied to grade X students. Class X-9 (32 students) was the experimental class using the ADI-based module, and class X-1 (32 students) was the control class using the regular textbook. The classes were selected by purposive sampling because renewable energy is grade X material. Learning took place in three meetings of 3 × 45 minutes each: a pretest and initial argument construction in the first meeting, argumentation sessions and peer evaluation in the second, and a posttest in the third.

The enhancement in students' argumentation skills is evaluated through a comparative analysis of pretest and posttest results, employing test items that have undergone rigorous normality and reliability assessments. The effectiveness of the module is determined through a t-test and an N-Gain test. The N-Gain calculation is derived using the following formula:

$$\langle g \rangle = \frac{\langle Skor\ Posttest \rangle - \langle Skor\ Pretest \rangle}{100\% - \langle Skor\ Pretest \rangle}$$

The statistical test known as the t-test is used to determine whether there is a significant difference in the performance of students when the significance level (Sig.) is less than 0.05. However, the N-Gain criteria in this study refer to the classification proposed by Hake (1998), as presented in Table 1.

Table 1. N-Gain Test Criteria

N-Gain Value	Criteria
$\langle g \rangle \geq 0{,}70$	High
$0{,}30 < \langle g \rangle < 0{,}70$	Medium
$\langle g \rangle \leq 0{,}30$	Low

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The analysis of student responses to the instructional module was conducted based on the results of a response questionnaire completed by students using a Likert scale. The final percentage was subsequently calculated using the percentage formula according to (Arikunto, 2013).

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

Argumentation skills were measured with nine essay items developed from Toulmin's argument pattern (Toulmin, 2003; Admoko et al., 2021) and scored with an analytic rubric. The indicators are presented in Table 2. Normality was tested with the Shapiro-Wilk test and homogeneity with Levene's test, followed by an independent samples t-test on posttest scores and an N-Gain analysis (Hake, 1998).

Table 2. Indicators of Argumentation Skills

Indicator	Description
Claim	A statement or position that answers the problem presented
Data	Facts, figures, or graph information used as evidence to support the claim
Warrant	Reasoning that logically connects the data to the claim

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RESULTS AND DISCUSSION

Prior to conducting the validity test, an ADI-based instructional module was first developed systematically in accordance with the established instructional design. The instructional module's structure commences with introductory components, including the cover page, table of contents, instructions for utilizing the module, and an exposition of the ADI model syntax employed in the instruction.



Figure 2. Cover Page and User Guide for the Learning Module

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Based on Figure 2, the module opens with a simple cover showing the module title and author, followed by a user guide that directs students on how to use the module in each ADI phase..

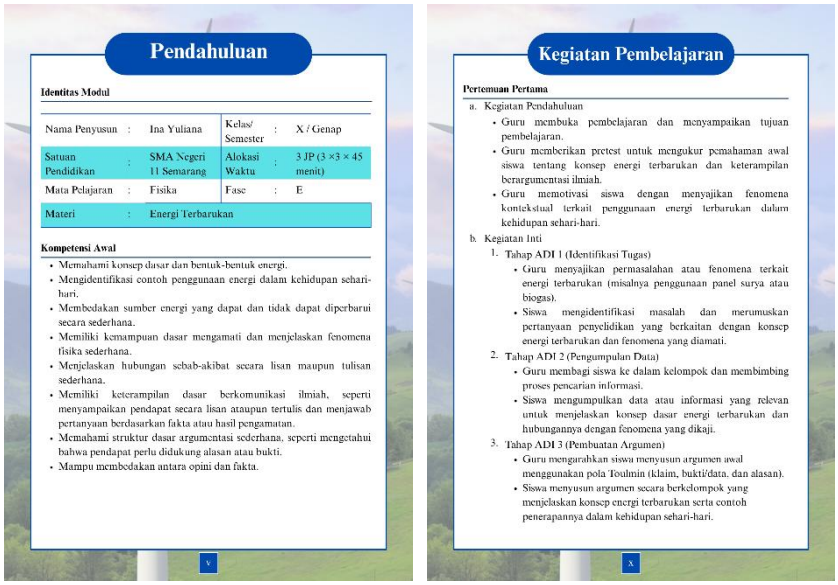


Figure 3. Introduction Page and Learning Activities

Figure 3 shows that the module contains the lesson plan, including the learning framework, design, and steps of activities, so that the teacher has a single reference for implementing each ADI phase. Including objectives, activities, and assessment in one module gives teachers and students a structured and directed reference (Famulaqih & Lukman, 2024).

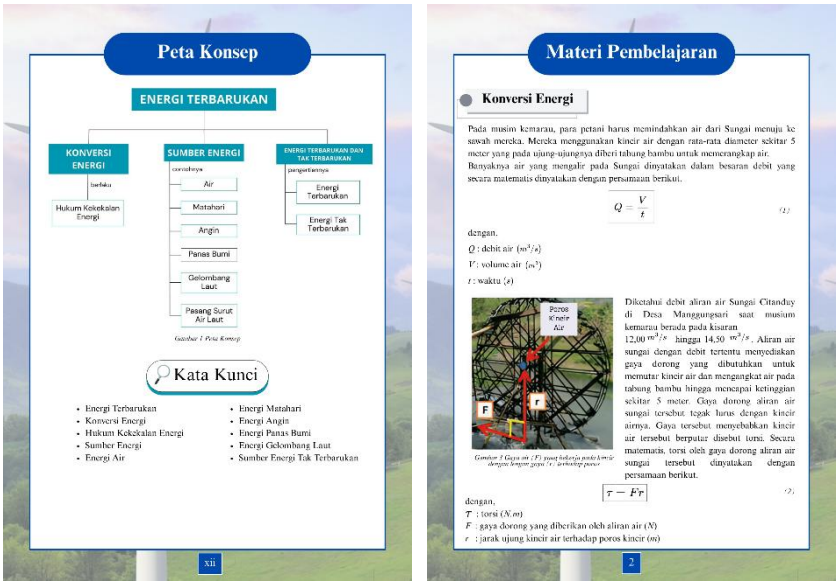


Figure 4. Concept Map and Learning Materials Page

Based on Figure 4, the concept map is presented as a flow diagram linking forms

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of energy, energy conversion, and renewable and non-renewable energy sources, so students can see how the concepts relate before studying the material. Visual elements such as diagrams, icons, and colors help students understand module content and increase their participation (Tarusu & Wongkar, 2024).



Figure 5. Activity Page and Workbook Cover

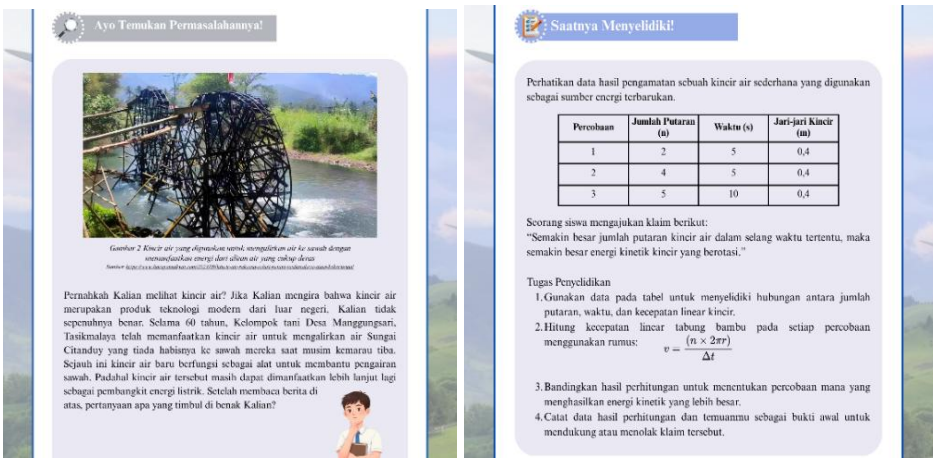
Figure 5 shows the activity page and the worksheet, which present contextual renewable energy problems in Indonesia accompanied by QR codes linking to learning videos. Contextual problems connect the material to students' prior experience and environment, making learning more meaningful (Annisa et al., 2023), while the worksheet provides the space in which students write their arguments, as required in the ADI model (Sampson et al., 2011).

The instructional module developed has the key advantage of implementing the Argument-Driven Inquiry (ADI) learning model, which is systematically integrated with the Merdeka Curriculum. This integration supports a more systematic learning process aligned with the targeted learning outcomes. Furthermore, this module has been developed to facilitate the development of students' critical thinking skills and scientific argumentation abilities through a series of activities that have been meticulously structured to promote learning. A notable strength of the program is the contextual presentation of material, which is tied to real-world problems. This approach makes learning more meaningful, encourages active student participation, and helps to strengthen science literacy skills. This is in line with Diartika (2024), who found that ADI-based modules support understanding through investigation and evidence-based

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argument, and with Satriya and Atun (2025), who reported that ADI improves argumentation while strengthening concept understanding.

Furthermore, the objective of this instructional module is to cultivate students' argumentation skills. To this end, it incorporates components based on the Toulmin framework, namely claim, data, and warrant. These components are integrated into the module's presentation of content, learning activities, sample questions, and exercises. These indicators are also embodied through the ADI model syntax so that students not only understand the concepts but are also directly engaged in the process of constructing, testing, and revising arguments. The integration of ADI syntax with argumentation skill indicators aims to provide a structured learning framework so that students can develop their argumentation skills in a systematic manner. This integration enables students to construct, evaluate, and communicate arguments using claims, data, and warrants logically, thereby making learning more meaningful and enhancing students' engagement and critical thinking skills. This design follows Sampson et al. (2011), who showed that ADI helps students participate in scientific argumentation and craft written arguments, and Admoko et al. (2021), who found that implementing ADI improves high school students' scientific argumentation skills.



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Figure 6. Components of Argumentation Skills

As illustrated in Figure 6, the module incorporates multiple sections that address aspects of argumentation skills, including “Ayo Temukan Permasalahannya!” (hereafter referred to as “Let’s Find the Problem!”) and “Saatnya Menyelidiki!” (hereafter referred to as “Time to Investigate!”). The “Let’s Find the Problem!” component is the task identification stage in the ADI framework. In this stage, students are guided to carefully observe and analyze information to identify the core issue and formulate a logical response. This activity is designed to assess comprehension and cultivate critical and systematic thinking skills. Concurrently, the “Time to Investigate!” segment constitutes the data collection phase. In this phase, students proactively seek, gather, and select pertinent information as substantiating evidence to validate their assertions. Concurrently, they hone their aptitude to evaluate the precision and pertinence of data in formulating arguments. Observing problems and selecting relevant data train students to evaluate information critically, because scientific argumentation and critical thinking are closely related (Fauziah et al., 2024). Inquiry based on real-world issues has also been shown to enhance students’ argumentation skills (Nugroho et al., 2024).

Subsequently, other sections of the module include “Saatnya Menyusun Argumen Awal!” (hereafter referred to as “Time to Construct Initial Arguments!”) and “Saatnya Menyampaikan Argumenmu!” (hereafter referred to as “Time to Present Your Argument!”). The “Time to Construct Initial Arguments!” segment is the argument-building stage, wherein students collaborate in groups to construct a coherent argument by logically connecting claims, data, and warrants. This activity is designed to equip students with the ability to construct arguments grounded in empirical evidence and to cultivate critical thinking, collaborative skills, and systematic thinking processes. The

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"Time to Present Your Argument!" component is the communication stage within the ADI framework, where students write the results of their group discussions into the worksheet in a structured manner by linking claims, data, and warrants. This training of scientific writing skills also enhances communication skills in presenting arguments clearly and logically. Group discussions in which students exchange and evaluate arguments create an interactive and participatory classroom (Rahayu et al., 2020), and writing arguments that connect claims, data, and warrants is the core activity through which ADI improves argumentation skills (Arfiany et al., 2021; Sampson et al., 2011).

The development of instructional modules based on the Argument Driven Inquiry learning model focuses not only on content validity but also on ensuring that the resulting products are easily legible and effective in improving students' argumentation skills. The developed teaching modules were subsequently validated by a panel of expert validators consisting of three physics lecturers and two high school physics teachers. The objective of this validation process was to ensure that the developed materials met the established validity criteria, which encompassed content, language, readability, and graphic design. The results of the expert validation are presented in Table 3 below. Expert validation is required to ensure that a developed product meets the established standards before it is used in the classroom (Akili et al., 2022).

Table 3. Results of the Validation of the Instructional Module by Experts

Validator Expert	**Institution**	**Index Aiken's V**	**Criteria**
Validator 1	Semarang State University	0,77	Fairly Valid
Validator 2	Semarang State University	0,94	Valid
Validator 3	Semarang State University	0,88	Valid
Validator 4	State Senior High School 11 Semarang	0,88	Valid
Validator 5	State Senior High School 11 Semarang	0,95	Valid
	Overall	0,88	Valid

Based on Table 3, the Aiken's V values of the five validators ranged from 0.77 to 0.95, with an overall value of 0.88, which falls into the valid category (Aiken, 1985).

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Validator 1 gave the lowest score (0.77, fairly valid), and at item level, items 3, 15, and 24 (V = 0.67–0.73) were also in the fairly valid category, mainly related to font size, symbol consistency, image clarity, and QR code instructions. These aspects were then revised: the font size, which was initially too large, was reduced; symbols were made consistent in italics; the bar charts were redrawn for clarity; and instructions were added to guide students in scanning the QR codes. The test instrument was also validated by the same experts, with an overall Aiken's V of 0.87 (valid). The validity of the module (0.88) is comparable to previous ADI-based products, such as worksheets with a validity of 0.85 (Novitasari et al., 2022), learning tools with 0.917 (Akili et al., 2022), and a Physics Magazine with 0.97 (Sari et al., 2025). The slightly lower value in this study can be explained by the 1–4 rating scale without a middle option, which required validators to make firmer judgments, and by the fact that the module was evaluated on four aspects at once: content, language, readability, and graphics. Nevertheless, the module offers added value because it integrates the scientific argumentation process into every learning phase, training students to construct claims, organize evidence, and develop reasoning, which is still rarely applied at the high school level (Fakhriyah et al., 2021).

The instrument was trialed with 34 grade XI students. All nine items were valid (r-count > 0.349), the reliability was high (Cronbach's alpha = 0.76), six items were easy and three were moderate, and the discriminating power ranged from poor (items 1, 2, and 4) to very good (item 9). The achievement of each argumentation indicator in this trial is presented in Table 4.

Table 4. Achievement of Each Argumentation Indicator in the Small-Scale Trial

Indicator	Mean Score	Percentage (%)	Criteria
Claim	26,17	76,98	Good
Data	25,29	74,39	Good
Warrant	25,23	74,22	Good

Based on Table 4, the claim indicator had the highest achievement, while warrant had the lowest, only 0.17 percentage points below data. Many students did not yet connect their evidence to their claims through concept-based reasoning, which is the most demanding component of an argument (Jimenez et al., 2024). This pattern is consistent with Rizkia et al. (2024), who found that the improvement in argumentation through ADI was most evident in the claim component.

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The mean cloze score was 97.64%, which falls into the independent category, indicating that students could understand the module without teacher assistance. This result is higher than that of the science module developed by Melya et al. (2022), with 88% in individual testing and 92% in small-group testing, and higher than the textbooks analyzed by Huda and Masfufah (2021) and Sa'adah et al. (2024), which were close to the instructional level. However, the cloze test was administered to grade XI students who had already studied renewable energy, so their prior knowledge may have contributed to the high scores.

The objective of this study is to enhance students' argumentation skills through the development of a teaching module based on the Argument Driven Inquiry learning model. The implementation of the teaching module occurred at State Senior High School 11 Semarang, encompassing two classes: The experimental class was designated as Class X-9, while the control class was designated as Class X-1. Each class consisted of 32 students. The learning process in both classes transpired over the course of three sessions.

The enhancement in students' argumentation skills was examined by analyzing the mean difference between pretest and posttest scores in classes that employed a teaching module based on the Argument-Driven Inquiry learning model. The assessment instrument comprised nine essay questions, which were developed based on Toulmin's argumentation indicators. The mean pretest and posttest scores for the control and experimental classes are presented in Table 5 below.

Table 5. Pretest and Posttest Results

Class	Test Type	Average	Highest	Lowest
Control	Pretest	52,06	67	35
	Posttest	81,62	89	73
Experiment	Pretest	40,16	67	12
	Posttest	84,81	97	69

As shown in Table 5, the mean score of the experimental class increased from 40.16 to 84.81, while that of the control class increased from 52.06 to 81.62. Although the experimental class started with a lower pretest score, it achieved a higher posttest score. This is because the module guides students through the ADI phases, in which they repeatedly construct, defend, and revise arguments based on data (Sampson & Gleim, 2009; Fakhriyah et al., 2021).

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Subsequent to the collection of the empirical data, the results were analyzed using a variety of statistical tests. These included normality tests, homogeneity tests, t-tests, and N-Gain tests. Prior to conducting the t-test, normality and homogeneity tests were performed to ascertain that the data satisfied the requisite assumptions. The t-test was then utilized to ascertain whether there was a significant difference in student learning outcomes between the experimental class, which employed an ADI-based instructional module, and the control class, which utilized only the standard textbook. Concurrently, the N-Gain test was utilized to evaluate the enhancement in student learning outcomes following the intervention. The Shapiro-Wilk test was used because each group consisted of fewer than 50 students (Winarti et al., 2024). As shown in Table 6, all data had significance values above 0.05, so the data were normally distributed.

Table 6. Shapiro-Wilk Normality Test

Data	Statistic	df	Sig.	Result
Pretest, control	0,979	32	0,761	Normal
Posttest, control	0,934	32	0,051	Normal
Pretest, experimental	0,940	32	0,076	Normal
Posttest, experimental	0,961	32	0,300	Normal

Levene's test on the posttest data yielded F = 0.298 with a significance of 0.587 (> 0.05), so the variances of the two classes were homogeneous and the independent samples t-test could be performed. The results of the t-test are presented in Table 7.

Table 7. Independent Samples T-Test

t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Description
-2,46	62	0,017	-3,19	1,29	Significant

The independent samples t-test (Table 7) yielded t (62) = −2.46 and p = 0.017 (< 0.05), so there was a significant difference between the two classes. The negative mean difference (−3.19; 95% CI −5.78 to −0.60) indicates that the control class mean was lower than the experimental class mean, so the use of the module had a significant effect on students' argumentation skills. The t-test is an appropriate method for assessing improvements in argumentation skills, as also used by Fadillah and Suyono (2024).

Subsequent to the t-test analysis, an N-Gain test was administered to ascertain the extent of enhancement in argumentation skills following the implementation of the instructional module.

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Table 8. N-Gain Test for the Experimental Class and the Control Class

Class	Pre-test Average	Posttest Average	N-Gain	Category
Experiment	40,16	84,81	0,74	High
Control	52,06	81,62	0,60	Medium

The results of the N-Gain analysis are presented in Table 8. The experimental class attained a score of 0.74, which is classified as high, while the control class achieved an N-Gain score of 0.60, classified as moderate. This finding indicates that the enhancement in students' argumentation skills in the experimental class surpassed that of the control class. Therefore, it can be concluded that the intervention administered to the experimental class was more effective in improving students' argumentation skills compared to the control class. These findings are consistent with the results of previous studies, including that of Fadillah & Suyono (2024) , which demonstrated that the implementation of the ADI model significantly improved students' argumentation skills, as evidenced by an increase in scores from the pretest to the posttest. Furthermore, Rizkia et al. (2024) reported an enhancement in argumentation skills, as evidenced by t-test results with a significance level of $0.00 < 0.05$. Additionally, Fakhriyah et al. (2021) have asserted that the ADI learning model is effective in improving argumentation skills because it provides students with the opportunity to actively construct, defend, and revise arguments based on data and investigation results.

The higher improvement in the experimental class can be attributed to the ADI phases in the module, which require students to identify problems, collect data, construct arguments in groups, and communicate them in writing, so that argumentation is practiced repeatedly rather than only explained (Fakhriyah et al., 2021; Admoko et al., 2021). The control class also improved (N-Gain 0.60) because students studied the same material with the textbook, so the difference in posttest scores between the classes was relatively small (3.19 points).

This study has several limitations. The two classes had different initial abilities, as the pretest of the control class was higher, so the comparison relied on posttest scores and N-Gain. The long ADI phases also required more time than was available, as lesson hours were shortened during Ramadan, so some phases could not be carried out optimally. In addition, six of the nine items were in the easy category and three items

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had poor discriminating power, which may have limited the test's ability to distinguish students' levels. Despite these limitations, the results imply that teachers can use the module as a ready-to-use resource to train argumentation in physics, and that the warrant component needs more explicit scaffolding (Candra et al., 2024).

The final step involves the analysis of student responses to the teaching module based on the Argument Driven Inquiry learning model. The objective of this analysis was to ascertain how students responded to the implementation of the teaching module based on the Argument Driven Inquiry learning model. The evaluation of the teaching module encompassed four domains: instructions, content, relevance, and linguistic accuracy. The results of the analysis of student responses are presented in Table 9 below.

Table 9. Analysis of Student Response Surveys

Indicator	**Item No.**	**Percentage**	**Criteria**
Guidelines	1,2,3,4	84,01	Good
Content	5,6,7,8	82,36	Good
Relevance	9,10,11,12	81,98	Good
Linguistic Accuracy	13,14,15,16	82,35	Good
Average		82,67	Good

As illustrated in Table 9, student responses to the instructional module indicated a "good" rating across all aspects, including user instructions (84.01%), content presentation (82.36%), relevance (81.98%), and language use (82.35%). This observation suggests that the module is structured in a clear, coherent, and contextual manner, employing language that is readily comprehensible, thereby facilitating optimal engagement in learning by students. A thorough analysis of the responses from students revealed that the ADI-based instructional module attained an average percentage of 82.67%, thereby falling within the "good" category. This outcome signifies a favorable response from the students, indicative of its effectiveness in meeting their learning objectives. These results align with the findings of Devy et al. (2020) , which demonstrated that students' responses to worksheets based on Toulmin's Argument Pattern (TAP) achieved a "very good" average score of 97.7%. In addition, the study by Rizkia et al. (2024) revealed that the highest percentage score was found in the second indicator at 85%, while the lowest score was in the fifth indicator at 66.3%. This finding is consistent with the results of the ADI learning model, which was also implemented in the study. These variations in achievement are believed to be influenced by the extent of

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student interest in participating in the learning process. Consequently, there are students who have not demonstrated optimal engagement when the ADI learning characteristics are applied. While relevance received the lowest score (81.98%), suggesting that the connection between the material and students' daily lives can still be strengthened through more local contexts (Annisa et al., 2023).

CONCLUSION

This study produced an ADI-based teaching module on renewable energy whose activities "Let's Find the Problem!", "Time to Investigate!", "Time to Construct Initial Arguments!", and "Time to Present Your Argument!" explicitly train Toulmin's claim, data, and warrant components. The module is valid according to experts, has an independent readability level, receives good responses from students, and is more effective in improving students' scientific argumentation skills than conventional textbook-based learning. Future research should strengthen the warrant component through explicit reasoning practice and complete argument examples, manage time more efficiently for the long ADI phases, and test the module with equivalent groups in more schools.

DECLARATION:

Phenomenon: Jurnal Pendidikan MIPA was selected as the target journal for the publication of our paper because this journal strives to promote the implementation of high-quality mathematics and science education at all educational levels, an objective that aligns with the aims and scope of this internationally reputable journal. We confirm that both authors have approved the manuscript for publication in your journal.

Availability of Data and Materials: The data supporting the study was classified according to the institutions' authorities; therefore, the participants only agreed to participate in the study based on anonymity, and a confidentiality agreement was reached. The data can therefore not be divulged to any third party without official permission granted from the institutions which can either be accepted or declined.

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drafting process, conducting a final review (proofreading), editing the manuscript, and performing data analysis.

Declaration Of Generative Ai Use During the preparation of this manuscript, the authors used ChatGPT, developed by OpenAI, to assist with translation, grammatical revision, and improvements to writing clarity. All AI-generated output was reviewed, verified, and edited by the authors to ensure accuracy and consistency with the research data and objectives. The authors take full responsibility for the content and scientific integrity of the final manuscript.

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