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The Impact of the Argument-Driven Inquiry (ADI) Instructional Model on Biodiversity Topics to Enhance Students' Argumentation Skills

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Abstract

This study aims to investigate the impact of Argument-Driven Inquiry (ADI) based biology instruction on students' argumentation skills in the topic of biodiversity. The research is a quasi-experimental study using a pretest-posttest nonequivalent control group design. The independent variable in this study is the use of the Argument-Driven Inquiry (ADI) instructional model. The population consists of all 10th-grade students at SMAN 5 Padang. The sample includes two classes: class X IPA 1, chosen as the experimental group, and class X IPA 2, chosen as the control group. Data on students' argumentation skills were collected using essay tests. The data analysis techniques employed are the Mann-Whitney test, Wilcoxon Signed-Rank test, Independent Sample t-test, and Effect Size test. The Mann-Whitney test results for non-parametric data yielded a value of 0.326, indicating no significant difference in the initial argumentation skills of the students. The Wilcoxon test result was 0.000 < 0.05, indicating a significant difference between the pretest and posttest scores. The Independent Sample t-test result was 0.003, suggesting a significant effect of the Argument-Driven Inquiry instructional model on students' argumentation skills. The effect size test for the experimental group resulted in a value of 3.575, categorized as high. Overall, the findings indicate that the use of the Argument-Driven Inquiry (ADI) instructional model significantly enhances students' argumentation skills in the topic of biodiversity. This means that students successfully achieved the targeted learning objectives with the ADI instructional model.

Keywords: *learning model, ADI, argumentation, biology, experiment*

INTRODUCTION

One of the essential skills to face the challenges of the 21st century is students' scientific argumentation ability. According to Fatmawati et al. (2018), argumentation involves expressing opinions supported by scientific evidence. Viyanti et al. (2016) describe argumentation as an activity that facilitates the understanding of cognitive processes in constructing scientific knowledge. Developing argumentation skills in the learning process is crucial because it trains students' thinking, helps form new knowledge, encourages student engagement, aids in problem-solving, builds socio-cultural activities through presentations and critiques, makes students more confident in expressing their ideas, facilitates easier concept

comprehension, and promotes critical and logical thinking. Ekanara et al. (2018) suggest that students with strong scientific argumentation skills are expected to be more resilient, as they will always weigh every decision they make. Given the importance of students' argumentation skills, mastering this ability is highly necessary.

In the 21st century, argumentative communication skills are a crucial soft skill that students need to develop. Argumentation can be described as the process of explaining or confirming claims by conducting a critical analysis of evidence that contains facts or objective conditions accepted as truth and supported by logical reasons. Argumentative skills can be observed through indicators, one of which defines an argument as a statement supported by components of arguments or ideas (claims). These must be backed by data (grounds/data) to serve as a bridge between the statement and the data, with conditional elements (qualifiers) used when justification is not universally accepted, along with support (backing) and rebuttal (Toulmin, 2003). Interviews with biology teachers at the school revealed that students still struggle to present arguments, ask questions, and draw independent conclusions about the material taught. Students tend to be silent and require guidance from teachers to make conclusions when asked to argue or inquire. Although teachers sometimes incorporate discussions and pose questions during lessons, students still find it challenging to express arguments and answers scientifically. This indicates that the argumentation skills of students at SMAN 5 Padang are still relatively low. According to Probosari et al. (2016: 29), students who can fully understand science or material are those who actively participate in scientific activities such as observation and argumentation.

Many factors influence students' argumentation skills. According to Devi et al. (2018), the role of teachers and the quality of teaching significantly impact the improvement of students' argumentation skills. Additionally, the willingness of students and their opportunity to present their arguments also affect their argumentative abilities. If the quality of learning is poor, the learning process will not be well facilitated, leading to suboptimal development of students' argumentative skills. One reason for the low argumentation skills among students is the continued use of conventional, teacher-centered teaching methods, which result in less active student participation and limited development of their abilities. This is supported by Anwar et al. (2019), who stated that one-way learning activities hinder effective communication between students and teachers, thereby preventing students' communication skills, such as argumentation, from being adequately honed.

Innovations in teaching by teachers, such as determining appropriate strategies or learning models, can help achieve learning objectives and maximally develop students'

argumentation skills. According to Amiroh & Admoko (2020), the Argument-Driven Inquiry (ADI) instructional model can train argumentation skills as it enables students to provide justifications based on theory. Farida et al. (2018) found that implementing the ADI model significantly affects argumentation skills. This is also supported by Marhamah et al. (2017), who stated that the ADI model can train argumentation skills through argumentation sessions (discussions) and the creation of investigation reports. Based on these statements, it can be concluded that the use of the ADI model in biology learning effectively enhances students' argumentation skills.

One of the topics covered in the tenth-grade biology curriculum at SMAN 5 Padang is the basic competency (KD) 3.2 and 4.2. In these competencies, students are required to analyze and present observation results regarding various levels of biodiversity in Indonesia, along with the threats and conservation efforts (Kemendikbud, 2018). The activities of analyzing and presenting observation results are part of the ADI learning model and are effective for training students' argumentation skills (Sampson & Gleim, 2009). Moreover, this topic is chosen because it involves material related to everyday life, which is suitable for argumentation, facilitating students in practicing scientific argumentation. Ultimately, this topic is essential for students as it helps them understand the wise utilization of biodiversity and ways to conserve increasingly threatened biodiversity.

Based on the introduction above, the researcher is interested in conducting a study on "The Impact of the Argument-Driven Inquiry (ADI) Instructional Model on Biodiversity Topics to Enhance Students' Argumentation Skills."

RESEARCH METHODS

This research is a quasi-experimental study using a nonequivalent pretest-posttest control group design. The study was conducted at SMAN 5 Padang, with the population consisting of tenth-grade students. The sample for this study included students from Class X IPA 1 and X IPA 2, selected through simple random sampling, with Class X IPA 1 serving as the experimental group and Class X IPA 2 as the control group. Data collection was conducted using essay-type tests. Data analysis techniques included the Mann-Whitney test to determine differences in students' initial abilities, the Wilcoxon Signed-Rank test to assess improvements after the instructional intervention, the Independent Sample t-test to evaluate whether the ADI instructional model influenced the enhancement of students' argumentation skills, and the Effect Size test to measure the extent of the ADI model's impact on improving students' argumentation skills.

RESULTS AND DISCUSSION

The results of this study on the instructional model align with the research by Siregar & Pakpahan (2020), which states that ADI learning significantly impacts students' argumentation skills. This is because the ADI learning process involves investigative activities through practical experiments, which foster students' ability to make claims, interpret data, provide justifications or reasons (warrants), and challenge differing ideas from the classroom discussion community during both tentative and interactive argumentation sessions.

Table 1. Argumentation Skill Measurement Result

Description	Experiment Group		Control Group	
	Pretest	Posttest	Pretest	Posttest
Average	47,7	66,3	51,6	61,1
Total Sample	35	35	35	35

Table 1 illustrates the argumentation skill measurement results for both the experiment and control groups. The data show a notable improvement in the argumentation skills of the experiment group, which was subjected to the Argument-Driven Inquiry (ADI) learning model. Specifically, the average score of the experiment group increased from 47.7 in the pretest to 66.3 in the posttest. Conversely, the control group, which did not employ the ADI model, exhibited a smaller increase, with average scores rising from 51.6 in the pretest to 61.1 in the posttest. Both groups consisted of 35 students each.

The significant improvement observed in the experiment group aligns with the findings of Nasution et al. (2019), who reported that the ADI model enhances students' scientific argumentation skills more effectively than traditional methods. Prihandayu and Paidi (2021) also emphasized the ADI model's role in developing critical thinking skills through structured argumentation exercises. Additionally, the revised ADI (rADI) model, as introduced by Songsil et al. (2019), has shown effectiveness in improving students' argumentation skills, particularly in socio-scientific contexts. These results confirm the potential of the ADI model to substantially elevate argumentation skills in educational settings.

The application of the ADI model has been explored across various subjects and educational contexts. For instance, Admoko et al. (2022) conducted a bibliometric analysis of the ADI model's use in physics education, illustrating its effectiveness in improving students' scientific argumentation abilities. Fitri et al. (2022) also demonstrated the model's success in enhancing science process skills and argumentation abilities. Additionally, Lismawati et al. (2021) focused on developing student worksheets based on the ADI model to promote argumentation skills among junior high school students. These studies collectively affirm the

robustness of the ADI model in various educational settings, further validating the improvements observed in the experiment group.

The extensive implementation of the Argument-Driven Inquiry (ADI) learning model across various subjects has consistently demonstrated its efficacy in enhancing students' argumentation skills. Research by Admoko et al. (2022) illustrated the utilization of the ADI model in physics education through a bibliometric analysis, confirming its significant impact on students' understanding and argumentation abilities. Fitri et al. (2022) also reported the ADI model's effectiveness in improving science process skills and scientific argumentation abilities, providing further validation of the model's benefits.

Moreover, Lismawati et al. (2021) highlighted the development of student worksheets based on the ADI model, which were specifically designed to foster argumentation skills among junior high school students. This initiative aligns with findings by Safira et al. (2018) and Amielia et al. (2018), both of whom emphasized the positive impact of the ADI model on students' argumentation skills across different academic abilities.

A systematic review by Fakhriyah et al. (2021) affirmed the significance of integrating argumentation and inquiry through the ADI model in scientific education. This comprehensive review underlines the consistent findings across multiple studies that the ADI model effectively enhances critical thinking and argumentation skills. Additionally, Andriani et al. (2022) explored the use of e-worksheets in conjunction with the ADI model to improve students' argumentation skills in eco-friendly technology, further expanding the application of the ADI model into new educational contexts. These findings collectively demonstrate the robust impact of the ADI model on enhancing students' argumentation skills across diverse subjects and educational settings.

To find out whether students' initial argumentation skills are different or tend to be uniform before learning, a two-sample mean difference test was conducted. Previously, a prerequisite test was carried out to determine whether the research data met the requirements for parametric tests or not.

Table 2. Pretest Data Normality and Homogeneity Test Results

Test Type	**Significant Value**		**Data Distribution Conclusion**	
	Control	Experiment	Control	Experiment
Normality	.011	.000	Not Normal	Not Normal
Homogeneity	.038		Not Homogeneity	

Table 2 presents the pretest data normality and homogeneity test results, which are crucial for validating the assumptions necessary for accurate statistical analyses in educational

research (Sari et al., 2022; Sinon et al., 2022). The normality test results indicate significant values of 0.011 for the control group and 0.000 for the experimental group, suggesting that the data from both groups do not follow a normal distribution. This deviation from normality necessitates the use of non-parametric statistical tests, such as the Mann-Whitney test, for further data analysis to ensure valid results (Zakiyah & Dwiningsih, 2022).

Additionally, the homogeneity test shows a significant value of 0.038, indicating that the variances between the control and experimental groups are not equal. This lack of homogeneity implies that assumptions required for certain parametric tests, such as the t-test, are violated, thus affecting the choice of appropriate statistical methods for analyzing the data (Zulhamdi et al., 2022). The results of these tests underscore the importance of selecting suitable statistical techniques to accurately interpret the data and draw reliable conclusions about the effectiveness of educational interventions (Nurhaedah et al., 2022; Alfiyandri et al., 2023).

Based on the normality and homogeneity tests, it is known that the pretest data of students' argumentation skills are not normally distributed and not homogeneous. Therefore, the mean difference test of two independent samples through non-parametric pathways using the Mann-Whitney Test was conducted. The significance value of the pretest data for the argumentation ability variable was found to be greater than 0.05 ($p > 0.05$), namely 0.326 which means H_0 is accepted. This shows that there is no significant difference in the initial ability of students' argumentation between the control class and the experimental class or the initial ability of students tends to be the same.

Furthermore, after the pretest activity took place, it was continued with learning activities. To determine the level of learning implementation, data from the learning observation sheet filled in by the observer at the time of data collection was used. The analysis of learning implementation was carried out to find out whether the learning was carried out according to the lesson plan or not. In this study, students were directed to follow a series of learning stages as arranged in the lesson plan with the help of LKPD. Research by Khusnayain et al., (2013) the use of LKPD in the ADI model can provide higher scientific argumentation skills than conventional models.

Table 3. Average of lesson plan implementation

Group	Average of lesson plan implementation
Experiment	92%
Control`	98%

The role of the teacher in the success of learning using the ADI model is also very important, especially in encouraging reflection and building arguments. When learning in class, the teacher focuses on assisting and helping students in understanding the importance of contemplating problems, analyzing, and answering these problems, and daring to express their opinions or arguments accompanied by evidence. The results of Table 3 regarding the percentage of learning implementation, for the implementation of experimental class learning, the results are 92%, this shows that if the percentage of learning implementation is more than 80%, it can be said that the success of learning implementation is classified as very good (Ekosari, 2018). This is very relevant to the research of Devi et al. (2018) which states that the role of the teacher and the quality of teaching greatly affect the improvement of students' argumentation skills. In addition, the willingness of students and the opportunity for students to be able to convey their arguments is also one of the factors that affect students' argumentation skills.

To determine the significance of the difference in pretest and posttest scores between the control and experimental groups, a two-sample paired test was conducted. Previously, a prerequisite test was conducted to determine the normality of data distribution and homogeneity of variance.

Tabel 4. Posttest Data Normality and Homogeneity Test Results

Test Type	Significance values		Data distribution summary	
	Control	Experiment	Control	Experiment
Normality	.131	.072	Normal	Normal
Homogeneity	.542		Homogen	

In Table 4, the results of the normality test in the control class show a significance value greater than 0.05 (p> 0.05), which is 0.131 and in the experimental class shows a significance value greater than 0.05 (p> 0.05), which is 0.072 which means that from the results of the normality test the posttest data of both classes, both control and experimental classes are normally distributed because the significance value is greater than 0.05 (p> 0.05). Meanwhile, the homogeneity test results show a significance value greater than 0.05 (p> 0.05), which is 0.542 which means that the posttest data of the two classes are homogeneous.

The two-paired sample test was carried out using a non-parametric statistical test in the form of the Wilcoxon test because the pretest data showed that the data was not normally distributed and not homogeneous. Because one of the data does not meet the requirements of a parametric test, a non-parametric test is used, namely the Wilcoxon Test. In Table 6, it is known that the value of Asymp. Sig. (2-tailed) data on argumentation skills of experimental and control class students is 0.000. This means that the significance value is smaller than 0.05 ($p < 0.05$). Thus it can be concluded that there is a significant difference in either the experimental class or the control class between the pretest and posttest scores, which means that there is a significant effect on students' argumentation skills between before and after learning.

Tabel 5. Wilcoxon Test Results of Student Argumentation Ability Data

Description	Experiment Group	Control Group
Negative Rank	0	2
Positive Rank	35	30
Ties	0	3
Total	35	35
Asymp. Sig. (2-tailed)	0,000	0,000

Furthermore, to determine whether or not there is a significant effect of using the Argument-Driven Inquiry learning model on students' argumentation skills in the experimental class, an Independent Sample t-test was conducted. This test was chosen because the data used was posttest data from the experimental class and control class where the posttest data from both classes was normally distributed and homogeneous, so it met the requirements of parametric statistical tests.

Tabel 6. Independent Sample t-test Results

Variabel	Significance Value
Argumentation Skill	0,003

Table 6 shows that the results of the Independent Sample t-test of the posttest value of the argumentation skills of experimental and control class students, obtained a sig value. (2-tailed) is smaller than 0.05 ($p < 0.05$), which is 0.003, so it can be concluded that there is a significant effect of using the Argument-Driven Inquiry learning model on students' argumentation skills. Based on the Wilcoxon Test and Independent Sample t-test, it can be

concluded that the use of the ADI learning model in learning biology is proven to support the improvement of argumentation skills. This is in accordance with the research of Marhamah et al. (2017) and Safira et al. (2018) which showed that the use of the Argument-Driven Inquiry learning model had a significant effect on students' argumentation skills.

To find out how much influence the use of the ADI learning model has on students' argumentation skills, the effect size test was conducted. Table 7 shows that learning biology by using the ADI learning model provides a greater influence on the argumentation skills of students in class X SMAN 5 Padang.

Table 7. Effect Size Test Result

	Z value	N	Cohens'd	Category
Experiment	92%	35	3.575	High
Control	98%	35	2.489	High

The results of Table 7 show that learning biology by using the ADI learning model gives a greater influence on the argumentation skills of students in class X SMAN 5 Padang. This is in accordance with the opinion of Nurrahman et al. (2018) where the ADI learning model is more effective in improving students' argumentation skills compared to learning using conventional methods. In addition, according to research by Devi et al. (2018) and Rahman et al. (2018: 904) state that the achievement of students' argumentation ability level is influenced by students' prior knowledge of the material presented.

The improvement of argumentation itself can be seen from the achievement of students' argumentation levels. Each level has an array of argumentation elements that vary in complexity. The higher the level of a student's argumentation ability, the more complex the argument given by the student. The level of argumentation can be categorized into four levels, namely level 1 students can convey simple claims. At level 2, students can provide argumentation in the form of claims accompanied by data and or reasons, for level 3 students can convey arguments in the form of claims accompanied by data or reasons (warrant) and backing that contains a very weak rebuttal. At level 4, students can convey arguments in the form of claims with data / reasons and rebuttals with sentences that can convince others (qualifiers) (Erduran et al., 2004; Osborne, 2005; and Devi et al., 2018). Ginanjar et al.'s research (2015) in his research stated that there was an increase in the level of argumentation

from level one to level 2, 4 and 5, and this shows that the methods developed in the ADI model can train students' scientific argumentation skills.

Students' improved argumentation skills also foster students' critical and creative thinking processes, and this can be seen when students are able to write their findings scientifically in accordance with the opinion expression scheme. The results of this study are also supported by research conducted by Sampson et al. (2012), which states that the use of the ADI model in the learning process can improve students' ability to argue scientifically. According to Kadayifci et al., (2012) in his research also stated that through the ADI model in learning can improve students' argumentation skills, in addition, a close relationship was found between students' weaknesses in arguing with their critical and creative thinking skills, where students who are able to think critically in solving problems, then their argumentation skills also increase.

CONCLUSION

Based on the data analysis and discussion in this study, it can be concluded that the use of the ADI model can improve students' argumentation skills because in ADI learning there are activities that can train students' argumentation skills, such as topic identification activities, data collection through investigation, analyzing and interpreting data into an argument in groups, responding to each other and criticizing other groups' arguments through the interactive argumentation stage with presentation activities, and making reports that can bring up elements in argumentation, namely claims, data / evidence, warrant, backing, qualifiers, or rebuttal.

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