Indonesian Science Education Research (ISER)
Available online https://jurnal.unimed.ac.id/2012/index.php/iser
ISSN Online: 2715-4653

IMPLEMENTATION OF ARGUMENT-DRIVEN INQUIRY (ADI) LEARNING MODELS ON ENVIRONMENTAL POLUTION TOPIC TO ENHANCE SEVENTH GRADE STUDENTS' LEARNING OUTCOMES

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Accepted: June 15th, 2023. Published: July 31th, 2023

Abstract

Science lessons are designed to help students understand natural phenomena and how to live side by side with nature. To build up such understanding, students need to acquire sufficient inquiry skills as part of the expected learning outcomes. However, science learning outcomes of seventh graders at SMP Negeri 1 Payakumbuh for the academic year 2021/2022 are still below the minimum mastery criteria. From observation, we found that students do not participate actively in classroom teaching, teacher do not implement suitable learning model and do not use supporting instructional materials. Environmental pollution is one of the topics in secondary school science that could serve as a context for students to apply their knowledge and 4C skills. This study aims to see the effect of applying the Argument-Driven Inquiry (ADI) learning model assisted with ADI worksheet on science learning outcomes. This quasi-experiment research use Pretest-Posttest Control Group Design. Data were collected through multiple choice items and observation sheets, then analyzed with descriptive statistics. Our findings suggest that the use of ADI learning model influenced the science learning outcomes of seventh grade students of SMP Negeri 1 Payakumbuh. This is indicated by the 0.566 N-Gain of experimental class which is significantly higher than 0.290 of the control class.

Keywords: Argument-Driven Inquiry, Environmental Pollution, Science Learning, Learning Models.
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Introduction

Important of 21st Learning Competence

Education in the 21st Century has to keep up with the demands of good quality human resources who are able to deal with problems in everyday life (Dewi, 2019). This requires students to manage their own knowledge well and use it properly and wisely. These skills nowadays are commonly known as 4C-skills, which stands for Creativity, Critical Thinking, Collaboration, and Communication skills (4C's). Students need to creatively and critically find ways to build up and use their own knowledge, and then collaborate and build good communication with other students and teacher as well,

As a matter of fact, 4C skills has been embedded the national curriculum of education in Indonesia, which is Kurikulum 2013 (from 2013 to 2022), and now in Kurikulum Merdeka (2022 – present). Curriculum 2013 demanded students to apply 4C-skills in everyday lesson (Sugiyarti, Arif and Mursalin, 2018). Wagner (2010) stated that there are seven skills needed in 21st century education, one of which is the ability to think critically. Critical thinking is a thinking process ability which allows someone to evaluate or look for evidence, assumptions, and logic underlying the ideas of others (Ramdani *et al.*, 2020). This ability is essential to achieve the goals of science learning in Indonesia.

Science lessons are designed to help students understand natural phenomena and how to live side by side with nature (Kemdikbud, 2017a). One of the strategies to teach students to live well in the 21 century is by teaching them how to value feedback and to respond to it positively (Kivunja, 2014). By applying the concept of science, students in Indonesia are expected to be able to solve real-life problems in the 21st Century (Pratiwi, Cari and Aminah, 2019). Through science learning, students are expected to play an active role in using advanced technology so that they can provide benefits for themselves and the community.

To develop students' critical thinking skills in science lessons, it is necessary to use the proper strategies. One of the options is by practicing argumentation skills (Roviati and Widodo, 2019). Argumentation is the process of strengthening a claim through critical thinking analysis based on the support of evidence and logical reasons (Ginanjar, Utari and Muslim, 2015). The quality of a one's argument describes how much he understands the concept and reasoning (Sarira, Priyayi and Astuti, 2019). Students' understanding of science concepts can be seen through the argumentation (Muslichatun, Ellianawati and Wardani, 2021), for instance when they provide answers to the assessment problems. Therefore, students need to acquire skills to present scientific argumentation during the learning process, which it will shows on their learning outcomes. With good argumentation skills, it will help students to practice their logical reasoning, bright views and rational explanations of the topic being studied.

The observations at SMP Negeri 1 Payakumbuh revealed that students' ability to understand concepts is still relatively low based on the results of the mid-term assessment of class VII students in the 2021/2022 academic year. The average score for science subjects is 62.8 out of 9 classes, with 5 classes failed to surpass the Minimum Mastery Criteria, which is 77. This data led to the interpretation that the low learning outcomes is related to the lack of conceptual understanding. Insufficient understanding makes the learning objectives to be difficult to achieve, and eventually will have an impact on students learning outcomes.

Another finding from observation is that teacher do not consider thoroughly before choosing a learning model to implement. In fact, learning model serves as a guide for planning the teaching and teachers in carrying out learning (Djalal, 2017). For Kurikulum 2013, learning process is expected to be designed based on scientific approach (Kemdikbud, 2017b), which implies a lot of scientific inquiry activities throughout the lesson. These scientific inquiry activities are expected to facilitate students learning and knowledge building.

One of the learning models that applies scientific inquiry activities is the Argument-Driven Inquiry (ADI) model. The ADI learning model is effective in increasing

students' mastery of concepts, both high and low academic ability students (Prasinta, Kadaritna and Tania, 2018). Based on that data, it can be concluded that ADI can be used as a learning model that is able to help students in mastering concepts.

Basically, ADI model was developed from a series of laboratory activities, which can add up to 15 activities (Sampson, Grooms and Walker, 2011). As an instructional approach, ADI helps teacher to design the lesson by giving students the chance to create their own investigations, collect and analyze data, participate in structured and interactive argumentation sessions, write investigation reports to share and document their work, and engage in peer review during a laboratory investigation (Sampson, Grooms and Walker, 2009).

The learning objectives after studying the topic of environmental pollution is to describe the pollution and its impact on living things (Kemdikbud, 2017b). In this topic, students will learn about the three kinds of pollution, namely water, air, and soil pollution, together with them sources and impact they pose on environments. At the end of the lesson, students were directed to propose solutions to the emerging problems caused by pollutions. The solutions are suggested to be depicted in the form of posters. Students' creativity in designing the posters reflect their thinking.

The application of the ADI model in learning environmental pollution material is proven to be able to increase students' argumentation abilities from level 1, namely to level 3, that is, students are able to present arguments containing a series of claims, both contrary to supporting data and not with a little rebuttal (Marhamah, Nurlaelah and Setiawati, 2017).

Research has shown that learning with ADI model helped students to improve their argumentation skills especially when they build up their arguments (Marhamah, Nurlaelah and Setiawati, 2017). After intervention with ADI, students were able to produce more effective written argument with ADI by providing more comprehensive justification and strengthening their arguments with more data and logic (Sampson, Grooms and Walker, 2011).

Research Method

This quasi-experimental study used pretest-posttest control group design. The population of the study was all enrolled seventh grade students of SMP Negeri 1 Payakumbuh in 2021/2022 academic year. The sample of this study was 37 students of class VII-5 as the experimental class and 37 students of class VII-1 as the control class. Therefore, the total sample of the study is 74 students.

Data collection was conducted with paper-and-pencil test to assess students' cognitive learning outcomes. A pretest was given prior to the treatment while posttest was administered at the end. A set of 15 multiple choice questions was prepared and tested for validity and reliability before being used. Psychomotor learning outcomes was assessed through classroom observation with scoring rubrics.

Data analysis was conducted with both descriptive and inferential statistics. Descriptive statistics presents the score of both experiment and control class while the inferential statistics was used to test the hypothesis, with normality, homogeneity, t-test, and N-Gain score calculation. The hypothesis of this study is that there is

Result and Discussion

The findings of this study will be discussed in three parts, started from the implementation of ADI learning model, the result of cognitive learning outcomes and then followed by psychomotor learning outcomes.

1. Implementation of ADI Learning Model

ADI learning model has seven steps in its syntax (Figure 1). These seven steps have their roots from Guided Inquiry (Sampson, Grooms and Walker, 2011). In this study, the treatment in experiment class took four weeks including pretest and posttest administration. Each week, both experiment and control class study science in 5 lesson hours, which are divided for two days, a 2-hours and 3-hours for each. Both classes

study with the same teacher, for the same topic, and tested with the same problem set. The only difference between the two classes are the learning models and the learning resources. Experiment class experience learning with ADI model assisted with a worksheet, meanwhile control class experience conventional teaching with government standardized textbook as main learning resource.

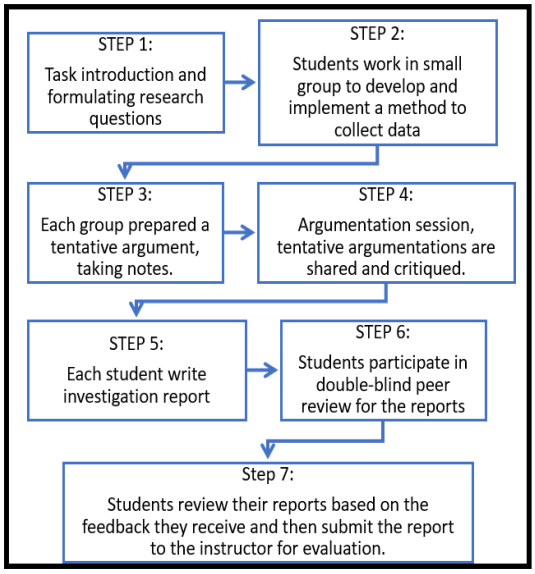

Figure 1. Syntax of ADI Learning Model (Sampson, Grooms and Walker, 2011)

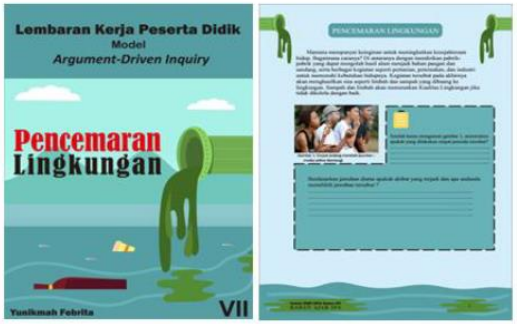

Figure 2. The sample page of students' worksheet for ADI learning Model

The student worksheet was designed based on ADI learning model (Febrita and Sari, 2021) and has been tested for validity and practicality before being used in this study. The students; worksheet contains 4 issue of pollution that occurs in water bodies, soil, and air. Each issues requires students to work in group to develop their arguments regarding the issues. Which issues being discussed in class depends on the lesson designed for experiment and control class.

For experiment class, the topic of environmental pollution is discussed in four meetings. For the first meeting, students learned about the basic concept of environmental pollution, and in the next three meetings, they discussed each of air, water, and soil pollution. In each meeting, students experienced the seven steps of ADI learning model and work in group using the worksheet. Also, in each meeting, students are presented with triggering questions for their curiosity before they work with the worksheet. For example: How plastic garbage and other kind of wasted materials cause environmental pollution; Why do we have to boil ground water before drinking it? What are the characteristics of ground water that are safe for drinking?

The same questions are also given in the control class, however they did not work with worksheet and not required to develop and present their argument. The students in control class discussed the topic also in four meetings, also work in group in scientific inquiries learning activities, present their discussion report, but were not required to present their arguments.

Both experiment and control class were tested based on eleven indicators for Basic Competence 3.8 which contain the topic of Environmental Pollution. The indicators are presented in Table below.

Table 1. Learning Indicators of Basic Competence 3.8. and 4.8

No.	Learning Indicators
BC	3.8: To analyze the cause behind environmental pollution and the impacts on the ecosystem
1.	To define the concept of environmental pollution
2.	To describe each kind of environmental pollution
3.	To define the concept of water pollution
4.	To analyze the factor behind water pollution
5.	To analyze the impact of water pollution on ecosystem and its solutions
6.	To define the concept of air pollution
7.	To analyze the factor behind air pollution

No.	Learning Indicators
8.	To analyze the impact of water pollution on ecosystem and its solutions
9.	To define the concept of soil pollution
10.	To analyze the factor behind soil pollution
11.	To analyze the impact of water pollution on ecosystem and its solutions
BC 4.8: To write a paper/poster containing solution to environmental issues	
1.	To present written idea on how to minimize the impacts of environmental pollutions

Based on the learning indicators in Table 1, it can be seen for every type of pollution, students are expected to be able to explain the basic concepts, analyze the factor behind the pollution and its impact on ecosystem, then come up with ideas for the solutions. Then, following the discussion on the topic, students were asked to create a poster as a campaign against environmental pollution.

2. Cognitive Learning Outcomes

To measure students' conceptual understanding on the topic of environmental pollution, we prepared a-40-multiple choice items which cover eleven learning indicators. On average, each learning indicators is represented by two to four test items. The test is administered at the end of the lesson, as a part of students' monthly evaluation.

Table 2. Pretest scores

Class	Max Value	Min Value	Average
Experiment	86.67	46.67	**72.435**
Control	80	40	**54.772**

Table 2 presented the pretest score from experiment and control class. Both classes still fall under the minimum criteria of completion which 77. However, to surpass the minimum criteria, the control class has higher gap of 23 points from 54.772 than the experiment class which is 5 points apart from 72.435. Looking closer to the highest score, experiment class is six points higher than control class at 86.67 than control class at 80.00. Similar trend also appears at the lowest score. The lowest score at experiment class is six points higher at 46.67 than control class at 40.00. Therefore, there is a significant gap between the two classes before the treatment where experiment class has higher pretest score than control class.

At the end of the treatment, a post test was administered in both classes, and the scores are presented in Table 3. There is the same trend at which experiment class achieve higher score than control class. The average score of experiment class surpassed the minimum completion criteria at 88.649 with an 18-points gap while control class still fall below the minimum score by 10 points at 67.655.

Table 3. Posttest scores

Class	Max Value	Min Value	Average
Experiment	100	66.67	88.649
Control	93.33	46.67	67.655

There are some interesting findings from the highest and lowest scores from both classes. After the treatment, there is a perfect 100 score in experiment class compared to 93.33 at control class. Experiment class experienced significant improvement from the lowest score which is 20 points higher than pretest score, while control class remain at 40's, six point higher than its' pretest score.

Since both classes started with different pretest scores prior to the treatment, we calculate the N-gain score to see the improvement in each at the end of the treatment. The calculated N-gain score is presented in Table 4.

Table 4. N-gain Value based on Test Results of Learning Outcomes

Class	Experimental class	Control Class
S pretest	72.4351351	54.7724324
S posttest	88.1054054	67.6548649
Gain	0.56614502	0.29080752
Result	**Medium**	**Low**

For the experiment class (VII-5), the N-gain was calculated based on the average score of at 72.43 and the average score of posttest at 88.10. The obtained N-gain value is 0.566, which means experimental class experienced an increase in learning outcomes in the medium category because the calculation of 0.7 > g 0.3. For the control class (VII-1), the average score of pretest is 54.77 and the average score of posttest is

67.65. The obtained N-gain is 0.290 which falls on the low category because the calculation of g < 0.3.

To test the hypothesis of the study, a t-test is conducted to the posttest scores. Kolomogorov-Smirnov and Levene test revealed that the average posttest scores of experiment and control class were normally distributed but not homogeneous. Therefore, the hypothesis testing was done using the t'-test. The results of the similarity test of the two averages scores are shown in Table 5 below.

Table 5. The results of hypothesis testing with t' test for cognitive learning outcomes

Class	Experiment	Control
$\bar{X}$	88.105	67.655
S^2	81.8206977	3355.68525
$t_{calculaated}$	2.12169975	
t_{table}	1.99346	

From calculation, we found that $t_{calculated}$ is 2,11 that is higher than t_{table} which is 1,99. This means that the value of $t_{calculated}$ is fall within the rejection region of H_0, which indicates that experimental class's cognitive learning outcomes is better than the control class after the implementation of Argument-Driven Inquiry (ADI).

This result agreed with previous studies which suggest that ADI learning model could enhance students' conceptual understanding (Kalay, Subandi and Budiasih, 2017), and this apply not only to high-achieving students but also to the low-achieving ones (Prasinta, Kadaritna and Tania, 2018).

3. Psychomotor Learning Outcomes

According to Kurikulum 2013, students psychomotor learning outcomes is measured through posters, which is stated in the Basic Competence. Students' posters were assessed with a scoring rubric. The scoring rubric measure four aspects, namely: content/ text, Design, Illustrations, and Message delivery. Content aspect measures students' poster in terms of clarity of information, legibility, originality and aye-catching layouts, and message delivery. Each aspect are represented by two to three indicators, and each indicators are scored from 1 to 4, with 1 being the least and 4 being the highest according to each descriptors.

Students' total score were calculated to find average and variation. A description of students' psychomotor skills can be seen in Table 6.

Table 6. The Results of Students' Psychomotoric Learning Outcomes

Class	Max Value	Min Value	Average	S
Experiment	100	50	78.716	11.299
Control	100	62.5	73.818	8.938

The score of psychomotor skill experimental class score is higher than the control class. The variance value of experimental class is also higher than the control class, it means that the distribution of the experimental class's psychomotor skill is more diverse than the control class.

To see if there is a difference between the skill results of the two sample classes, a similarity test of the two averages is carried out as shown in table 7 below.

Table 7. The results of the similarity test of the two skill domain averages

Class	Experiment	Control
$\bar{X}$	78.716	73.817
S^2	131.2054242	82.11336336
t_{count}	2.04015235	
t_{table}	1.993463567	

Based on the t value obtained, it turns out that $t_{calculated} > t_{table}$ is 2,040 > 1,99 . This means that $t_{calculated}$ is in the rejection region of H_0. This proves that there are differences in learning outcomes in the realm of psychomotor between the experimental class and the control class.

Even though the findings suggest positive result from ADI implementation, we acknowledge some limitations in this study. The time of intervention could be extended to 10 or 15 weeks to enable researcher gather more data. In addition, similar to the study by (Sampson, Grooms and Walker, 2011), we did not measure students' conceptual quality of the explanation thoroughly. Therefore, we recommend of taking the assessment on conceptual mastery in the future study.

Conclusion

Based on the research that has been carried out, it can be proven that the implemention of the Argument-Driven Inquiry (ADI) learning model can improve student learning outcomes both in the cognitive (knowledge) and psychomotor (skills) domain. Therefore, it is concluded that the findings of this study have confirm the research problems.

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