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# Design and Validation of Science Student Worksheet Based on Argument Driven Inquiry to Improve Argumentation Skills for Junior High School Students

**Lismawati*, Neni Hasnunidah, Abdurrahman**

Master Program in Science Teacher Training, FKIP Universitas Lampung,
Bandar Lampung, Indonesia

*Email: lismawatiku7@gmail.com

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**Abstract**. The survey results on teachers and students in six regencies/cities in Lampung Province showed that in science learning, teachers have not optimized the argumentative skills of students. Thus, this study aimed to develop and validate science worksheets oriented to the argumentative skills of students. This study used a 4D-study design with Argument-Driven Inquiry (ADI) learning model. A small-scale trial was conducted on 20 IX-graders at SMP 9 Krui Pesisir Barat. The large-scale trial was conducted on 50 IX-graders at SMP 9 Krui Pesisir Barat by purposive sampling with one experimental class and one control class. The control class used a worksheet from a particular publisher, and the experimental class used the developed worksheet. Based on the results, the ADI model worksheet can be declared valid in terms of content, construction, and language with an average of 92.3% with very high criteria. The practicality of the ADI worksheet model can be seen from the implementation of learning, student responses, and teacher responses had an average of 89.24% with very high criteria. The effectiveness of the ADI model worksheet can be seen from the ability to work on argumentation skills test questions, showing that the control class N-gain was 0.27 with low criteria and the experimental class was 0.57 with medium criteria. The effect size (SE) of 0.64 showed that the developed science worksheet was effective in developing argumentative skills of students with medium criteria.
**Keywords :** Worksheet, Argument Driven Inquiry

## Introduction

Science learning in junior high schools is seen not only to transform knowledge but also to build higher-order thinking skills through scientific work experience. Science learning should be carried out by inquiry to develop the ability to think, work, and behave scientifically and communicate it as an important aspect of life skills (Kemendikbud, 2013). One of the communication skills in science is scientific argumentation (Wellington & Osborn, 2001). Argumentation plays an important role in building scientific explanations and creating theories (Demircioglu & Ucar, 2012).

The PISA (Program for International Student Assessment) results in 2015 showed that the achievement of science for students in Indonesia was ranked 62 out of 70 countries evaluated (OECD, 2016). Thus, Indonesia is a country with low OECD achievements. One

of the factors causing the low level of science literacy for students is the absence of scientific literacy facilities for students. The learning done by teachers so far has not been able to develop the science skills of students, especially in explaining, evaluating, and designing scientific studies, as well as interpreting scientific data and evidence (Fatmawati & Utari, 2015). In addition, PISA test questions are very demanding on reasoning and problem-solving abilities (Wardani, 2016). One of the steps to invite students to reason is to familiarize students with scientific argumentative skills (Khusnayain, 2017). Therefore, science learning must be changed from the form of demonstration to the realm of argumentation (Schwarz & Baker, 2017).

In the learning process, teachers are an important element to achieve the success of learning objectives. The knowledge and argumentative skills of science teachers will greatly influence the success and failure of science learning in the classroom (McNeill et al., 2016). In fact, science teachers have problems integrating arguments and using scientific inquiry in the classroom, as well as involving students in scientific inquiry to help them understand important science concepts (Sampson & Gleim, 2009). Low argumentative skills of teachers can be seen from a preliminary study conducted by researchers in November 2018 on 100 science teachers from several schools in Lampung Province. 82% of teachers did not understand the components of argumentation. This causes the learning process carried out in class unable to optimize the argumentative skills of students. Generally, teachers ask opinions without supporting facts or evidence. This is clearly not in accordance with the purpose of science learning in teaching students how to think scientifically like a true scientist (Jaber & Hammer, 2016). To develop the argumentative skills of students, an appropriate learning model is needed. However, based on a study by Lazarou et al (2016) many teachers do not use appropriate learning methods to develop the argumentative skills of students.

One alternative learning model to develop the argumentative skills of students is the Argument-Driven Inquiry (ADI) model. The Argument-Driven Inquiry (ADI) learning model is designed to develop thinking habits and critical thinking skills by emphasizing the role of scientific argumentation and scientific knowledge (Driver, et al., 2000). The learning model is expected to improve the argumentative skills of students requiring appropriate teaching materials. Students can be given reading materials to understand and learn relevant information to build their arguments (Faize et al., 2018). Preliminary studies on 100 science teachers from several schools in Lampung Province showed that 87% of teachers used worksheets in the learning process, but the worksheets used were not able to facilitate the argumentative skills of students. The worksheet used contains a summary of the material and questions reminiscent of the concepts studied. Therefore, the worksheet can improve the argumentative skills of students through the ADI model for the human reproductive system topic.

## Method

This study used a 4-D study design consisting of 4 stages, namely the stages of defining, designing, developing, and disseminating (Thiagarajan et al., 1974). This study used a quasi-experimental method with the matching only pre test-post test control group design (Fraenkell & Wallen, 2008), on the experimental class (learning with developed worksheet) and the control class (learning with worksheet from certain publishers). The study design can be seen in Table 1.

Table 1. Pre test-post test control group design

| Class | Pre test | Treatment | Post test |
|---|---|---|---|
| Experiment | $O_1$ | X | $O_2$ |
| Control | $O_3$ | C | $O_4$ |

Keterangan :
$O_1$ = Pre test on experimental class
$O_2$ = Post test on experimental class
$O_3$ = Pre test on control class
$O_4$ = Post test test on control class
X = learning with developed worksheet
C = learning with worksheet from certain publishers

The population of this study were all IX-graders of SMP Negeri 9 Krui Pesisir Barat Lampung. The samples of this study were IX A and IX B-graders. Sampel was dipilih dengan purposive sampling with 25 students from IX A sebagai kelas eksperimen carried out learning with developed worksheet dan from IX B carried out learning with worksheet from certain publishers.

Data were collected through the following instruments: (1) Questionnaires for validation from experts (lecturers) and practitioners (science teachers) covering content, construction, and language, as well as questionnaires for teachers and students. The validation sheet was used to obtain expert opinions on the feasibility and quality of the developed worksheet. Questionnaires for teachers and students were used to determine their response to worksheets, especially worksheets on the human reproductive system. (2) The observation sheet measures the implementation of learning using the ADI worksheet model and student activities. (3) This study used pre-test and post-test to measure the argumentative skills of students in the form of an essay test or competitive theory. The questions given at the pre-test and post-test consisted of 5 essay questions. Argumentative skills of science students can be measured using argumentation level by Clark & Sampson (2008) (Sampson & Clark, 2008), modified from the argumentation analysis framework by Erduran et al. (2005).

## Results and Discussion

The results of this study focused on the development of teaching materials in the form of student worksheets using the Argument-Driven Inquiry (ADI) model to improve the argumentation skills of class IX students at the junior high school level. The results of the study include the validity, practicality, and effectiveness of the student worksheet developed.

**Validation.** The developed student worksheet need to be tested for validity so that it was suitable for use in the learning process. Aspects assessed include the feasibility of content, construction, and language. The results of the student worksheet product validation can be seen in Table 2.

**Table 2.** Validation of Expert Result

| No | Aspect | Percentage | | Average | Criteria |
|---|---|---|---|---|---|
| | | Expert | Teacher | | |
| 1 | Content | 80 | 87,5 | 83,75 | Valid |
| 2 | Construction | 88,8 | 97,5 | 93,15 | Valid |
| 3 | Language | 100 | 100 | 100 | Valid |
| Average Total | | | | 92,3 | Valid |

Based on the results of the student worksheet product validation that has been carried out by the validator, the overall ADI model student worksheet was declared valid with an average percentage of 92.3%. Student worksheets as one of the teaching materials used by students in the teaching and learning process must have good validity so that learning objectives can be achieved with effective results. Valid student worksheets can be applied in learning with the results of the implementation of learning in the good category so that it can achieve learning indicators (Yasir, et al., 2013). In addition to providing a score, the validator also provided several suggestions and improvements that become a reference for improving the developed student worksheet. Revisions include changing the image in the mitotic division, changing the layout of the author's name on the front cover, focusing the image on the cover, need to improve the arrangement of images, need to improve sentences, wording, and spelling. All suggestions from the validator have been implemented so that the final product of the student worksheet development was ready to be used in a limited trial.

**Limited Trial.** After making improvements based on expert recommendations and declared fit for use, the next step was to conduct a limited trial. Limited trials were given to students outside the research sample to determine the practicality of the products developed. The limited trial was conducted on 20 respondents, namely students of class IX SMP at SMP Negeri 9 Krui. The practicality of the ADI model student worksheet was viewed from three things, namely the implementation of learning using the ADI model student worksheet, student responses, and teacher responses to the developed student worksheet. Based on observations made by observers, it showed that the average score of learning implementation using the ADI model worksheet score was 91.02%. The high score of learning implementation using the ADI model student worksheet obtained from the observations showed that the learning process carried out was following the learning implementation plan prepared by the teacher. In the learning process, the teacher must have the ability to manage to learn, one of which was learning planning (Mulyasa, 2007). The practical aspect was then reviewed from the responses of students during the learning process using the developed student worksheet. Student responses were seen from three aspects, namely the attractiveness aspect, the usefulness aspect, and the readability aspect. The results obtained from the responses of students showed a positive response with an average percentage of 88.37%. In general, students responded positively and felt interested in using the developed ADI model student worksheet. The next practical aspect was seen from the teacher's response to the ADI model student worksheet used in learning. The teacher's response was seen from the aspects of attractiveness, usefulness, and readability. The results of the teacher's response that were seen from the three aspects, namely attractiveness, usefulness, and readability, get a very high criterion, namely 88.33%, this meant that the student worksheet has been developed according to its use in the learning process. The practicality test was reviewed based on three aspects, namely the implementation of learning using student worksheets with the ADI model, student responses, and teacher responses to student worksheets. The results of the data analysis of the three aspects as a whole can be seen in Table 3.

**Table 3**. Recapitulation of the results of practical data analysis

| No | Aspect | practical data analysis (%) |
|---|---|---|
| 1 | Implementation of Student Worksheet | 91,02 |
| 2 | Response of Student | 88,37 |
| 3 | Response of Teacher | 88,33 |
| | Average Percentages | 89,24 |

The average result from the three aspects of the assessment of the practicality test of student worksheet development products with the ADI model was 89.24% with the score a very high category. This indicated that the student worksheet with the ADI model met the practicality criteria.

**The effectiveness of the ADI Model student worksheet.** The effectiveness of using student worksheet was based on student activities, assessment of argumentation skills through pretest posttest assessment tests.

**Students Activities.** Observation of student activity in learning using the ADI model worksheet obtained an average score of 90.3%, with a very high category. This indicated that all aspects of the achievements obtained have an interpretation of almost all activities carried out. Most of the students at the time of learning carried out positive activities in learning such as identifying research problems, collecting data, producing tentative arguments, holding argumentation sessions, compiling written research reports, conducting peer reviews of research reports, revising reports based on the results of peer reviews, and hold explicit and reflective discussions. The stages of learning with the ADI model allowed students to be actively involved in learning (Hadiwidodo, et al., 2017).

**The average score of the pretest and posttest. The** average results of the pretest and posttest scores were also used to see the improvement of students' argumentation skills based on the analysis of Toulmin's argumentation model. The increase in the level of argumentation of students in the experimental class can be seen in Figure 1.

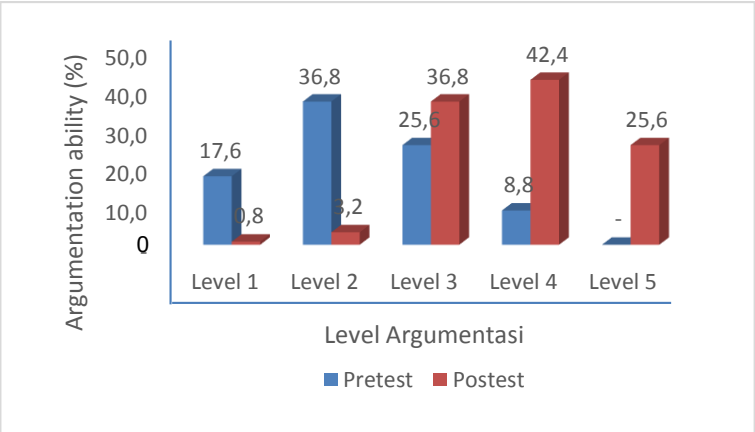


**Figure 1**. Percentage of Argumentation Ability for each Level in Experiment Class

Based on the diagram in Figure 1. In the experimental class, before the application of the ADI model, the students' argumentation skills reached level 2 and after the application of the ADI model in the learning process, the students' argumentation skills reached level 4. This showed that before the application of the ADI model in the learning process, the students were already able to write a claim accompanied by data. Although the data and reasons are written were not strong, besides that, students also cannot make rebuttals well. Students were in the stage of being able to make claims but have not been supported by warrants that are by the science concept approved by experts (Wardani, 2016). In addition, one's argument was not only in the form of a theory but must be proven true (Kuhn, 2010). Based on data analysis after the application of the ADI model, there was an increase in the level of argumentation in the experimental class, namely to level 4. The tendency to increase the level of argumentation was because students were able to provide rebuttals accompanied by relevant data or theories/concepts. One of the factors that caused an increase in the level of argumentation in the experimental class was the application of the ADI model in the learning process. The application of the ADI model in the experimental class could improve students' conceptual mastery. The ADI learning model was seen as being able to facilitate students to understand science concepts well because the ADI model learning activities emphasized the construction and validation of knowledge through investigation activities (Andriyani & Riandi, 2015). In addition, the ADI model can facilitate students to practice argumentation skills and the quality of students' argumentation, one of which was at the stage of making tentative arguments and the stage of argumentation sessions (Marhamah, et al., 2017). While the increase in the level of argumentation of students in the control class can be seen in Figure 2.

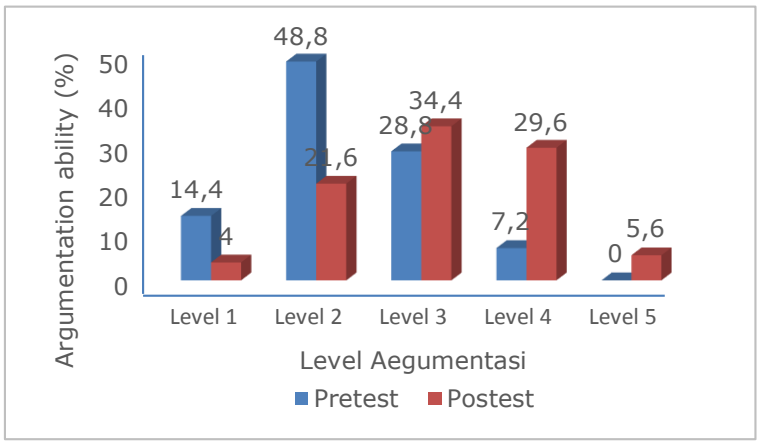


**Figure 2.** Percentage of Argumentation Ability for each Level in Control Class

Based on data analysis in the control class, there was an increase in the argumentation level from level 2 to level 3. The increase in the argumentation level in the control class was lower than the argumentation level in the experimental class. The increase in the level of argumentation in the control class reached level 3 while the experimental class reached level 4. This showed that students in the control class have been able to express their opinions in writing and write down evidence and provide justifications (warrants), but students have not been able to provide support (backing) and refutation of a statement that they considered to be untrue. Whereas in the experimental class, students were able to express their opinions in writing, wrote down evidence and provided warrants that can be said to be theoretically correct, and provided rebuttals to answers that are considered incorrect. The application of the ADI learning model in the

experimental class caused an increase in the level of argumentation in the experimental class which was higher than the control class. The argumentation in the experimental class was carried out through investigation activities. The research activity aimed to provide students with concepts that were used as a basis for arguing. Argumentation skills can develop well in students if students were able to interpret concepts well (Squire & Mingfong, 2007). Students in the experimental class were accustomed to studying the relationship between the answers to the problems presented with existing theories through the production of tentative arguments, while in the control class students only made conclusions from the problems given.

In addition, the increase in conceptual understanding that occurred in the experimental class cannot be separated from the impact of using science learning tools using the ADI model. The application of learning tools using the ADI model can improve understanding of concepts and develop students' argumentation skills (Muslim & Suhandi, 2012). The stages in science learning tools using the ADI model, especially the ADI model worksheet were designed to provide space for students to practice arguing because the ADI model worksheet is arranged systematically, questions on the worksheet were arranged so that students can come up with their arguments from hypothesizing to data processing.

The results of the calculation of the effect size obtained a score of 0.64 with a moderate category according to Cohen (1988), this showed that the argumentation skills of students are influenced by learning using the ADI model worksheet. Learning using the ADI model showed significant results in the ability to generate and evaluate scientific explanations and arguments, as measured by scientific writing assessment (Sampson, et al., 2012). In addition, the application of the ADI learning model can improve the scientific argumentation skills of junior high school students, both oral and written arguments (Ginanjar, et al., 2015).

## Conclusion

ADI model worksheet has the potential to improve students' argumentation skills. Through a stimulus that is built based on facts, concepts, attitudes, and science contexts that were designed both in minds-on and hands-on activities in student worksheets, it has been able to increase student involvement in the process of acquiring knowledge and students' argumentation skills. In addition, the various modes of representation presented in the student worksheet have been designed to stimulate students' ability to argue both orally and in writing, in addition to successfully motivating students to present their arguments, it also encourages them to complete their arguments with valid data, so that the material is easy to claim as complete knowledge by students. During the COVID-19 pandemic, the need for student worksheets to increase student involvement in science learning needs to be developed more flexibly so that students can use them anywhere and anytime in the form of electronic worksheets (e-worksheet).

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