Using argument-driven inquiry to promote students’ concept mastery in learning global warming

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Abstract. The process of learning science in some schools is still in the form of direct transfer from teacher to student. The learning process will be meaningful if the students involved and explore more in building a concept. The aim of this study is to investigate the impact of Argument-Driven Inquiry on students' concept in learning global warming. The method that is used in this research was quasi-experiment. The study used two classes with one experimental group that used Argument-Driven Inquiry and one control group that used Inquiry-based Learning. The population of this study is seventh-grade students in one of Secondary School in Bandung, Indonesia. The sample is chosen by purposive sampling technique. The participants consist of 52 students from the experimental group and the control group. Each group consists of 26 students. The result of this study shows the improvement of students’ concept mastery in the experimental group is obtained as 0.45 and for the control group is 0.28. Based on the result, Argument-Driven Inquiry gives the better impact in improving students’ concept mastery. Argument-Driven Inquiry can be considered as one of the teaching models that can be implemented in Junior Secondary School.

1. Introduction

Argument-Driven Inquiry is the learning model where the argumentation session is included in the learning activity. Argument-Driven Inquiry is designed to give a more place to the role of argument during the inquiry process. The use of scientific argumentation is one of the ways to recover the students' concept mastery and balance the learning objectives of science [1]. The inquiry is the basic way in the learning process and argumentation is one of the important processes that support inquiry activities. Argumentation has an important role in constructing a scientific explanation of any theories. Although argumentation has an important role in science education, the argumentation is rarely used in science courses or laboratory activities [2]. Most of school already use inquiry as the learning model, but not utilizing argumentation session. The common inquiry activity is still in the form of transferring knowledge and present the data directly. This may allow the student to partially understand and leads to a lack of ability in mastery the concept. [3]. Students are coming to the class only with the prior knowledge of the topic as a foundation for further knowledge. Those factors can also lead to the barriers for the further learning of the topic [4]. This can be a challenge for educators to improve the concept mastery of the student in leaning global warming. The students should have a capability and given an opportunity to learn how to construct and participate in scientific arguments. Knowledge can not simply
be transferred but must be constructed or at least interpreted by the students themselves through the experiences [3]. The students should be able to have a reason in science, so they can relate the concept and daily phenomenon [5].

In recent years, many studies have been carried out the implementation of Argument-Driven Inquiry in learning science. The analysis from the previous study showed that: (a) when engaging in argumentation students will use their prior experiences and knowledge; (b) argumentation activity enables students to relate the existing knowledge and elaborate their science understanding [6]. By using Argument-Driven Inquiry will allow students to have their own reason to explain the scientific phenomenon based on the evidence or data from the investigation process. The students may have the different idea to be argued. The student has more opportunity to explore more about the topic and find the best decision to determine the solution or answer to the problem [7].

Argument-Driven Inquiry (ADI) has been implemented in many schools in the different country. Through this model, many researchers have investigated students' achievement by using Argument-Driven Inquiry (ADI) in sound, magnetic force, capillarity, light, gravity, and static electricity topic [8]. Another study was measured by the students' argumentation skill through Argument-Driven Inquiry in the physics subject [2]. The previous study also measured the argumentation and critical thinking skill by implementing Argument-Driven Inquiry in biology subject [9].

One of the requirements in secondary school is that the curriculum should fulfill the topic of global warming. However, the research that investigates students' concept mastery through Argument-Driven Inquiry in the topic of global warming has not been researched. Therefore, this study engaged the concept of climate change, greenhouse effect, and the impact of global warming that utilize argumentation during the learning process. There are seven steps of Argument-Driven Inquiry that can be adopted by the researcher, which are identified the task and guiding question, design a method and generate data, production of tentative argument, argumentation session, write an investigation report, double-blind group peer review, revise and submit a report. The aim of this study is to investigate the impact of Argument-Driven Inquiry on students' Concept Mastery in learning global warming.

2. Methods
The method that is used in this study is quasi-experiment. The study used a control group pretest-posttest design. In this method, there were two groups which are control and experimental group. The control group is used as the standard to compare the improvement of students’ concept mastery. The research design can be shown in Table 1.

| Select Control Class | Select Experimental Class | Pre-test | Inquiry-Based Learning | Post-test | Argument-Driven Inquiry | Post-test |
|----------------------|---------------------------|---------|------------------------|----------|-------------------------|----------|

The sample of this study consist of 52 students: 26 (12 female, 14 male) in experimental groups and the other 26 (13 female, 13 male) in a control group. This study was implemented in one of Junior Secondary School which implements curriculum 2013 in Bandung, Indonesia. The study was conducted on seventh-grade students. Their ages ranged between 13-14 years old. The sample was taken by purposive sampling. Purposive sampling is defined where the researcher uses their judgment to select a sample that they believe, based on prior information, will provide the data they need [10]. The data of the sample can be seen in Table 2.

| Group     | Population | Sample | Percentage (%) | Total (%) |
|-----------|------------|--------|----------------|-----------|
| Control   | 7th grade  | Male   | 50.00          | 100       |
|           |            | Female | 50.00          |           |
| Experiment| 7th grade  | Male   | 53.80          | 100       |
|           |            | Female | 46.20          |           |
In this study, the experimental group was given Argument-Driven Inquiry that includes identifying the task and guiding question, design a method and generate data, production of tentative argument, argumentation session, write an investigation report, double-blind group peer review, revise and submit a report. While the control group was given Inquiry-Based Learning that includes Identification of the problem, questioning, making a hypothesis, collecting data, analyzing data, and making a conclusion. Both groups were given the topic of global warming. The subtopic of global warming is greenhouse effect, the impact of global warming, and the prevention of global warming. Students' concept mastery from both groups was measured before and after the intervention to determine the effectiveness of the implemented given Argument-Driven Inquiry and Inquiry-Based Learning. The research was done in four meetings. The first meeting was for pre-test, the second until the third meeting was for implemented Argument-Driven Inquiry and Inquiry-Based Learning, and the fourth meeting was for post-test. Data gathering method is done by giving the objective test to students in the form of multiple choice that consist of 20 questions. Students' concept mastery was measured in pre-test and post-test for both groups.

### 3. Result and Discussion

Students' concept mastery data was collected by conducting pre-test and post-test that consist of 20 multiple choice question. Students' concept mastery was analyzed by the parametric statistic. Independent t-test is used to test the hypothesis whether there is the difference in students' concept mastery in learning global warming after implementing Argument-Driven Inquiry. The requirements for using the independent t-test are the data should be normally distributed and homogenous. The recapitulation hypothesis test of students' concept mastery is shown in Table 3.

| Group      | Signification (sig.α = 0.05) | Conclusion                                                                 |
|------------|------------------------------|-----------------------------------------------------------------------------|
| Experiment | 0.189                        | Normally Distributed                                                          |
| Control    | 0.167                        | Normally Distributed                                                          |

| Homogeneity Test |
|------------------|
| Signification (sig.α = 0.05) | 0.086 |
| Conclusion        | Homogenous |

**Independent t-Test**

| Signification (sig.α = 0.05) | 0.003 |
|------------------------------|-------|
| (Asymp. Sig.(2-tailed) < 0.05, H₁ = Accepted) |
| Conclusion                 |
| H₁ = accepted, H₀ = rejected |
| There is a significant difference |

The result of Argument-Driven Inquiry implementation showed the significant difference between the experiment and control group. The result of normality test of the data by Shapiro-Wilk is obtained as 0.189 > 0.05 for the experiment group and for the control group is 0.167 > 0.05 which means that the data in both groups is normally distributed. Then the data continued to the homogeneity test with the result 0.189 > 0.05 which means the data of both groups is homogenous. Since the data is normally distributed and homogenous, then continued to the independent t-test to test the hypothesis. The result is obtained as 0.003 which means H₀ is rejected and H₁ is accepted because of 0.003 < 0.05. This means that there is a significant difference in students' concept mastery in learning global warming or there is the positive and significant effect of the method on the students' concept mastery in experiment group.

It has been proved in some studies that argumentation session during the learning process is one of the factors that influence student' concept mastery. Argumentation will give the space for the student to explore and stimulate thinking skill to that is needed to master [11]. Therefore, the statistical test was done in order to calculate the difference between students' concept mastery in learning global warming between the experimental and control group. The Figure 1 below is the recapitulation of the overall
result from the pre-test average, post-test average and N-gain in the form of percentage in the experiment group and control group.

![Graph showing pre-test, post-test, and N-Gain for experiment and control groups.](image)

**Figure 1. Students' Concept Mastery**

Based on Figure 1, the average of pre-test in experiment and control class is 37.3 and 34.4, while the average of post-test in experiment and control class is 66.3 and 53.2. The analysis of N-Gain on control and experiment group shows that the method that was implemented in both groups give the impact on the improvement of students' concept mastery in learning global warming. The Figure 1 also shown the N-gain of experiment class and control class. The N-Gain score from control group is 0.28 which is categorized as a low improvement, while N-Gain from experiment group is 0.45 which is categorized as a medium improvement. The result of pre-test and post-test for each cognitive level in each group is shown in Table 4.

| Group     | Score of Cognitive Level | C4   | C5   | C6   |
|-----------|--------------------------|------|------|------|
|           | Pre-test                 | 50.4 | 34.0 | 17.6 |
| Experiment| Post-test                | 73.0 | 70.8 | 50.0 |
|           | <g>                      | 0.4  | 0.54 | 0.38 |
|           | Category                 | Medium | Medium | Medium |
| Control   | Pre-test                 | 42.3 | 36.8 | 18.4 |
|           | Post-test                | 63.9 | 56.0 | 40.7 |
|           | <g>                      | 0.37 | 0.26 | 0.25 |
|           | Category                 | Medium | Low | Low |

Based on Table 4, it can be seen that each cognitive domain shows different results on students' concept mastery in pre-test and post-test. In the experiment group, the N-Gain of each cognitive level from C4 until C6 is medium. While in control group, the N-Gain on analyzing (C4) is medium and the N-Gain on evaluating (C5) and creating (C6) is low. The comparison of N-Gain based on the cognitive level of Blooms' Taxonomy between control and experiment group can be seen in Figure 2.
Based on Figure 2, it can be seen the experiment group has higher N-Gain in all cognitive level than the control group. For analyzing (C4), the difference improvement of experiment and control group is not really significant. Both groups have medium improvement in C4. For evaluating (C5), the difference improvement of experiment and control group is very significant. The N-gain of C5 in the experiment group is 0.54 which means medium improvement and in the control group is 0.26 which means low improvement. For C6, the difference improvement of experiment and control group is also quite significant. The N-gain of C6 in the experiment group is 0.38 which means medium improvement and in the control group is 0.25 which means low improvement.

The difference between the result of experiment and control group is caused by the model that was implemented in the learning process. In the experiment group which used Argument-Driven Inquiry, the learning process involved student to build up and explores knowledge by themselves. The use of inquiry process increases students' self-concept in learning science [12]. The students have done the inquiry process in constructing procedure of the experiment by themselves. The students have to do the experiment which only guided by the guiding question on the worksheet. The activities can lead students to think more about the strategies to make the experiment works. The inquiry also creates a more engaging learning environment [13].

In the experiment group, the inquiry process was supported by the argumentation of the students. The students actively participated in a group discussion with their peers during argumentation session. The students have more opportunity to explore the idea. Each group of students gives an argument about the problem that happens during global warming. The student is forced to have any argument or reason in explaining phenomena such as greenhouse effect and the impact of global warming. Then, the teacher clarified their understanding. In argumentation session, students had more opportunity to share and exchange ideas with their peers [2]. The activities in Argument-Driven Inquiry is effective in improving the academic achievement and appropriate for laboratory classes [2]. In double blind-peer review, the students are asked to make an article that discusses alternative energy, what activity that can be done to maintain our surrounding at home and school, and what simple activity that can be done routinely to reduce the global warming. Then, the article will be reviewed or given any feedback from their classmate.
without knowing whose article they assessed and who assessed their article, then the article will be given back to the author to be revised and submitted. While in the control group there is no double-blind peer review. It helps students to improve their ability to write in science and were able to evaluate the quality of their peers’ writing [14]. The result is shown that Argument-Driven Inquiry model during the learning process has the potential to produce greater improvement in mastery the science concept [15].

4. Conclusion
Argumentation in the inquiry process help student in explaining how and why the phenomenon happens. The students in the experimental group have N-Gain scored better than students in the control class. It can be concluded that Argument-Driven Inquiry improved students’ concept mastery in all cognitive level. Argument-Driven Inquiry can be one of the alternative teaching models that give more impact on students’ concept mastery in learning global warming.

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