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Implementation of Argument-Driven Inquiry Learning Model to Enhance Student's Science Process Skills and Self-Efficacy

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ABSTRACT
This study aims to improve students' science process skills and self-efficacy in light wave and optical instruments learning. The research design used was a pretest-posttest control group design. The study population was 8th-grade students of SMP Negeri 8 Banda Aceh, totalling 7 classes. The samples were selected by purposive sampling so that one experimental class and one control class were selected. Data analysis used non-parametric statistics with the Mann-Whitney U test and the calculation of the n-gain score. The results showed that there were significant differences between SPS and self-efficacy students between the implementation of ADI learning model and learning model applied in schools. The n-gain score of SPS and the self-efficacy of the experimental class was higher than the n-gain score of the control class. Therefore, it can be concluded that ADI learning model is effective in enhancing student's SPS and self-efficacy.

INTRODUCTION

Changes globally occur in the 21st century, both in technology, and human competitiveness. Scientific literacy is very important to be developed in 21st-century education [1]. Scientific literacy is also one of the abilities measured in the Program for International Student Assessment (PISA) survey by the Organization for Economic Cooperation and Development (OECD). The scientific achievements of students in Indonesia lag behind other countries [2]. It can be seen from the results of the PISA survey in 2018 that the average score of Indonesian scientific literacy is still below standard. Indonesia has a scientific literacy score of 396, while the standard score set by the OECD is 489. The scientific literacy of PISA is divided into four domains: context, knowledge, competence, and scientific attitudes. PISA assesses the domains of knowledge, competence, and attitudes that are linked to context. Context domain refers to personal, local/national, and global. Meanwhile, the competency domain is in the form of an assessment of the ability to explain scientific phenomena, evaluate and design scientific experiments, and interpret scientific data and evidence. The knowledge domain assesses content, procedural, and epistemic knowledge. Meanwhile, the attitude domain assesses how interest, attention, and students respond to science and issues that influence life [3]

People are required to have variety of thinking skills to compete with current development. The manifestation of the government's efforts to meet these global demands which refers to curriculum 2013. The 2013 curriculum expects students to gain a learning experience directly through learning emphasizing the process of students' attitudes development, knowledges, and skills. The 2013 curriculum emphasizes discovery/inquiry-based learning supporting a scientific approach. Learning generates students to participate actively and cultivate learning motivation. Inquiry learning trains students to follow the scientific process of science understanding and applications. Besides that, the skills of students can be honed through the process of observing, questioning, trying, reasoning, presenting, and creating.

Science is based on scientific processes, products and attitudes. However, science learning in Indonesia is not implemented according to the characteristics of science [4]. Learning science still prioritizes cognitive aspects, but aspects of science process skill has not optimal yet. Even though science process skills (SPS) leading students actively participate in learning science, train students to think, and work like scientists [2]. Also, SPS is a very essential part of scientific literacy to be developed [5]. SPS is the ability of students to apply scientific methods in understanding, develop science, and discover knowledge [6].

SPS can be developed by applying inquiry-based learning models in practicum activities in the laboratory. One of inquiry-based learning model that can improve science skills in the laboratory, namely argument-driven inquiry (ADI) [7]. ADI learning model can train students to identify similarities and differences in an observation, solve problems, conclude, and summarize [8]. In addition, students get the opportunity to design experiments and find the results of their own experiments [9]. So it can be said that this model can develop students' SPS in science experiments.

Teachers should be encouraged to use student worksheets with ADI learning model in practicum activities that will facilitate science experimentation, argumentation, reading, and writing activities. This is important because students have to be be accustomed to working with the scientific method. Furthermore, scientific attitudes can also be trained in students [10]. The results of the national examination in science subjects among students in Indonesia, especially in Aceh showed the scores at 40.95 compared to 47.77 of student's overall national score. Thus, Aceh was categorized as low score of 55 range. This shows that students have not mastered science lessons as expected [11].

The results of observations in science learning at SMP Negeri 8 also found that students did not participate in experimental activities in the laboratory less. They tend to rely on a few of their group mates to carry out experimental steps. This shows that students are less interested in learning science. Learning interest can be seen from the special attention of students to solve a problem without coercion [12]. Interest in learning is one important factor that affects student learning outcomes. Interest in learning science is related to the self-efficacy of students [7]. Low self-efficacy will also affect learning achievement [13]. Self-efficacy means students' confidence in completing an activity. This belief must be owned by students because it can make students more enthusiastic and active in solving science problems. The self-efficacy of students must be increased in learning. High self-efficacy will increase the efficiency of other students' skills [14]. Students with high self-efficacy have high SPS too [15]. Self-efficacy of students in science can be improved by learning activities that encourage students' scientific inquiry skills [16].

ADI learning model can also be applied to foster student self-efficacy. The results of Eymur's research are that there is an increase in the self-efficacy of students in ADI learning model [7]. In addition, Erika, et al. states that low self-efficacy and argumentative skills can be overcome with ADI learning model [17]. Research from Tukiran, et al. states that ADI learning model can increase student's self-efficacy, motivation, and learning outcomes [18]. ADI learning model is expected to be used as an alternative and useful for teachers in science learning. ADI learning model trains students to argue because the ability to argue is an important thing that must be mastered in studying science. Studying science is not only limited to knowing, but also being able to explain scientific concepts [19].

The syntax of ADI learning model consists of 8 steps; (1) identifying experimental assignments and questions; (2) developing experimental methods; (3) collecting and analyzing data; (4) building tentative arguments; (5) arguing; (6) compiling experimental reports; (7) reviewing peer reports; (8) and revising experimental reports [6]. Science learning is based on the idea that people who learn must provide opinions and examine a science issue from time to time [20].

The purpose of this study was to determine the effectiveness of ADI learning model in enhancing SPS and self-efficacy of 8th grade junior high school students. This research was conducted to learn the nature of light and the process of image formation as the subject matter virtually appeared on student's daily life. The learning material is classified as difficult for students as only 16.22% who answered correctly of questions given about nature of light and the image formation process [11].

METHOD

The research method is quasi-experimental. The research design was a pretest-posttest control group design. There are two classes chosen, the first class is an experimental class that is applied to ADI learning model, while the second class is a control class that uses a direct instruction learning model. The direct instruction learning model is a learning model commonly used in SMP Negeri 8 Banda Aceh so that in this study, the control class is not given treatment. The population in this study were 7 classes of 8th grade students of Junior High School *(SMP)* 8, located in Banda Aceh of 2019/2020 academic year. They were selected by purposive sampling technique generating the chosen two classes are; VIII-3 and VIII-4 class. The sample selection was based on the similarity of students' ability characteristics based on the mean and standard deviation.

SPS is measured through observation and product assessment in the form of student experiment reports. The SPS instrument is prepared based on the SPS instrument from Subali [21]. The measured SPS is divided into three aspects, namely basic skills (in the form of sub-aspects of observing skills, recording data and information, following instructions, taking measurements, manipulating motion, implementing procedures, techniques, or using equipment), processing skills (in the form of sub-aspects of making predictions skills, inferencing, selecting procedures), and investigative skills (in the form of sub-aspects of experimental design skills, conducting experiments, reporting experimental results).

The self-efficacy of students was measured through a self-efficacy instrument which contains 28 statement items. The arrangement of instruments was based on instruments that have been compiled by Lin and Tsai which measure the level of self-efficacy of students in concept understanding, high-level cognitive skills, practical work, application of science in everyday life, and science communication [22]. Data collection was carried out before and after the implementation of treatment in the form of ADI learning model. Furthermore, the n-gain score from SPS and self-efficacy data of experimental class and control class were calculated with equation 1 as seen below.

$$(g) = \frac{\text{posttest score} - \text{pretest score}}{\text{maximum possible score} - \text{pretest score}} \quad (1)$$

The results of the n-gain calculation were interpreted accordance to the categories in Table 1 [23].

Tabel 1. N-Gain Score Category

Average N-Gain	Category
$(g) \geq 0{,}70$	High
$0{,}30 \leq (g) > 0{,}70$	Medium
$(g) < 0{,}30$	Low

Based on the results of the normality test, there are several research data that are not normally distributed. Research data that are not normally distributed are not assumed in parametric statistics. Therefore, the data analysis used non-parametric statistics. The assumptions of non-parametric statistics are that the sample used is small ($n \leq 25$), data is not normally distributed, and sample selection is not done randomly [24]. Furthermore, testing the research hypothesis using the Mann-Whitney U test. The Mann-Whitney U test is a non-parametric statistic used to test the difference between two independent samples.

RESULTS AND DISCUSSIONS

The Analysis Results from the SPS Data

SPS before treatment was measured through observation and students' products in the form of experimental reports about resonance in sound waves. The SPS of students after treatment was measured through observation and products in the form of experimental reports about the properties of light and optical instruments. The result of student's SPS average that has been measured through observation is depicted on Figure 1.

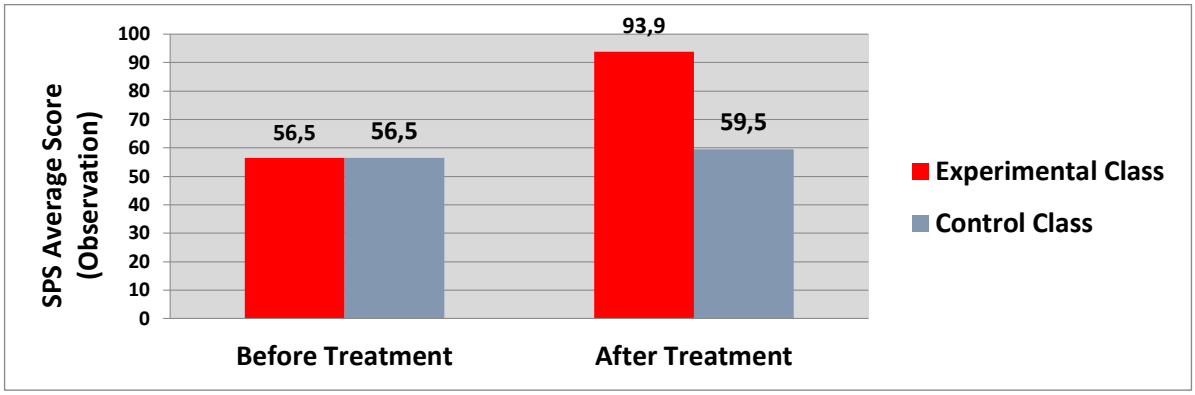

Fig 1. *The measured SPS average score through observation*

The results of the SPS average analysis measured through the product in the form of student experimental reports before and after treatment in both the experimental class and the control class can be seen in Figure 2 below.

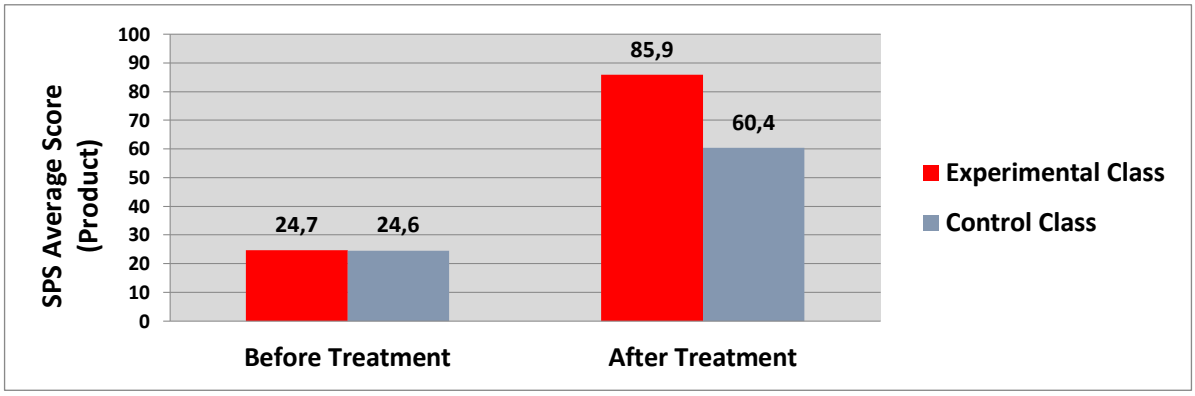

Fig 2. *The measured SPS average score through product was in the form of students' experimental report*

Furthermore, to find out the n-gain of SPS score in each class, it can be seen in Table 2 below.

Table 2 The N-Gain of SPS Scores in the Experimental Class and Control Class

No.	Class	SPS Assessment Method	
		Observation	Product
1	Experimental	0,86	0,81
2	Control	0,03	0,47

Based on Table 2, the results of the SPS n-gain analysis measured through observations in the experimental class are included in the high category, but the n-gain of the control class is included in the low category. Meanwhile, the results of the SPS n-gain analysis measured through the product in the form of an experimental report in the experimental class were included in the high category, while the n-gain of the control class was included in the medium category. This shows that ADI learning model is effective in improving students' SPS. As the research results from Nufus, et al. proves that ADI learning model is an effective model for increasing the academic achievement and SPS of students [25].

The difference in SPS n-gain scores between the two classes can be seen from the results of the Mann-Whitney U test as shown in Table 3 and Table 4.

Table 3. The Measured of Mann-Whitney U Test Results of SPS through Observation

Data	N	U	U*α*
Experimental Class	20	0,000	0,05
Control Class	20		

Table 4. The Measured of Mann-Whitney U Test Results of SPS through Product was in the form of Students' Experimental Report

Data	N	U	U*α*
Experimental Class	20	0,000	0,05
Control Class	20		

Tables 3 and 4 show that 0.000 < 0.05, it can be stated that there is a significant difference in SPS as measured through observation and the product is in the form of an experimental report between the experimental and control classes. The results of the SPS indicator analysis of students measured through observation after treatment showed that the highest percentage was in the sub-aspect of motion manipulation, selecting procedures, and reporting experimental results, while the percentage of students' SPS measured through products in the form of experimental reports after treatment was in the sub-aspect of recording data and information.

ADI learning model is suitable for developing competency domains in scientific literacy as measured in the PISA survey. As stated by Hunaidah, et al. namely ADI learning model can allow students to design research questions and make their conclusions, provide opportunities for students to engage in arguments by sharing ideas, supporting and discussing them, and facilitating students to understand science concepts well [26]. ADI learning model is also a learning model that is suitable for training students to develop their experimental methods such as how to obtain data, conduct experiments, use data to answer experimental questions, write and think more reflectively [27].

The Analysis Results from the Self-Efficacy Data

The application of ADI learning model also aims to increase the self-efficacy of students. Students with high self-efficacy will have ability to adapt better, influence situations, and their abilities was well-used so the feelings of threatened and insecure wisely under controlled. The results of the analysis of the average self-efficacy of students can be seen in Figure 3.

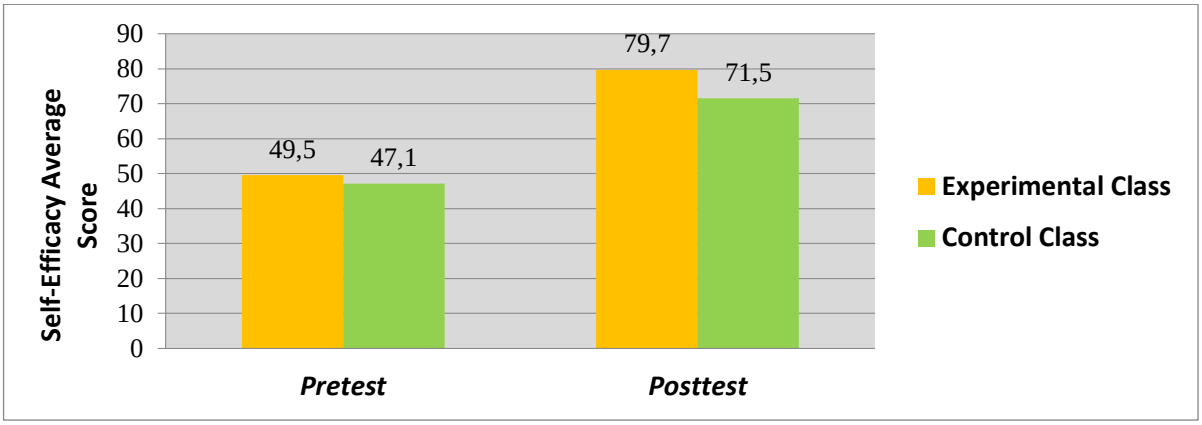

Fig 3. *Self efficacy average score of students*

The increase in self-efficacy of students in the experimental class and control class can be seen in Table 5.

Table 5 The N-Gain of Self Efficacy Scores in the Experimental Class and Control Class

No	Class	N-gain Score	Category
1	Experimental	0,59	Medium
2	Control	0,45	Medium

Based on Table 5, the results of the n-gain self-efficacy analysis for the experimental class and control class are included in the medium category. Research from Tukiran, et al. stated that the results of the n-gain calculation of the self-efficacy score before and after the implementation of ADI learning model also showed a medium category [18]. The n-gain score of the experimental class was higher in the control class so that it could be seen that ADI learning model was effective in increasing students' self-efficacy. The next step to determine the increase in self-efficacy between the experimental class and the control class, the Mann-Whitney U test can be carried out as shown in Table 6.

Table 6. The Mann-Whitney U test results of SPS as measured through observation

Data	N	U	Uα
Experimental Class	20	0,004	0,05
Control Class	20		

Table 6 shows that 0.004 < 0.05, it can be stated that there are differences in the self-efficacy of students before and after applying ADI learning model. This proves that ADI learning model has a significant effect on the self-efficacy of students. The syntax of ADI learning model that is suitable for increasing the self-efficacy of students is at the argumentation step.

Increased self-efficacy can make students more active in learning [18]. Self-efficacy affects scientific literacy and motivation for achievement. Students who have high achievement motivation will be more diligent, interested, and active in learning. In ADI learning model, students are more active in seeking information related to learning materials [26]. This can support the attainment of the domain of scientific literacy attitudes assessed in the PISA survey. The research from Wiarsana also revealed that self-efficacy has a significant effect on scientific literacy [28]. The results of the analysis of students' self-efficacy indicators after applying ADI learning model showed that the highest percentage was in the practical work aspect with a percentage reaching 82.8%.

Researchers also examined students' responses to the implementation of ADI learning model in the experimental class. The questionnaire measurement scale consisted of strongly agree (SS), agree (S), disagree (KS), disagree (TS), and strongly disagree (STS). The results of the analysis of the responses

of students in more detail can be seen in Figure 4.

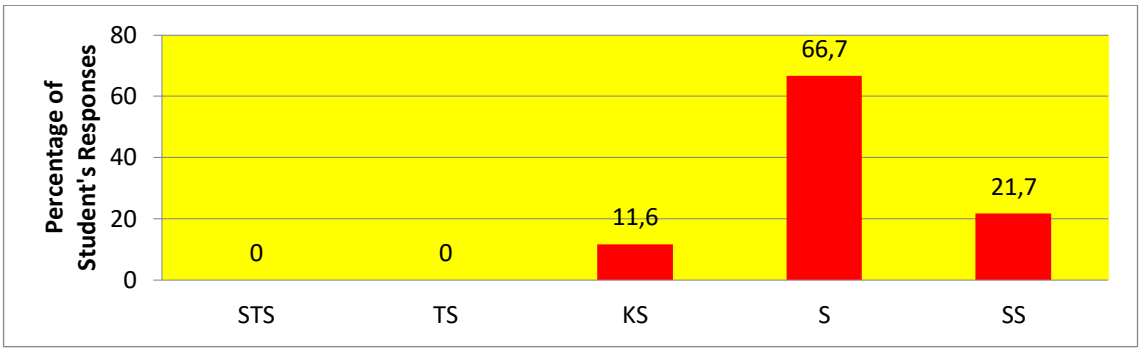

Fig 4. *Student's Response to ADI Learning Model*

Figure 4 shows that the percentage of students' responses to ADI learning model who answered strongly agreed reached 21.7% and agreed to reach 66.7%, so the overall results obtained reached 88.4%. Learning with ADI model on the material properties of light and optical instruments can increase the positive response of students. As research from Hadiwidodo states that most students are interested in ADI learning model [29].

CONCLUSION AND SUGGESTION

Based on the results of data analysis, it can be concluded that ADI learning model is effective in enhancing student's SPS and self-efficacy. Student's SPS assessed through observation and products in the form of experimental reports increased in the high category, while the student's self-efficacy increased in the medium category. The implementation of ADI learning model can increase the positive response of students. Therefore, it is hoped that further research can implement ADI learning model to measure other variables such as critical thinking skills, scientific reasoning, and argumentation of students and measure the relationship between several variables.

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