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The Effectiveness of the PhET Assistant Argument-Driven Inquiry (ADI) Learning Model on Student's Argumentation Ability on Substance Pressure Materials

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Abstract.
This study aims to determine the effectiveness of the PhET- assisted argument-driven inquiry (ADI) learning model on students argumentation skills as an essential aspect of the skills needed by humans in the 21st century. The type of research used is quasi-experimental (quasi-research) with a posttest research design-only control group design. The research instrument uses test questions and information analysis techniques using an independent t-test. The results of the analysis show that there is effectiveness in the application of the argument-driven inquiry (ADI) learning model assisted by PhET on the argumentation ability of students on the material pressure of substances at SMPN 1 Koto Gasib as evidenced by the average score of the experimental class which is higher than the control class students, namely 59, 13 53. 15 and based on sig.(2- tailed) which is 0. 007< 0. 05, then there is a significant difference in the average value between the experimental and control classes. Based on the results of the information analysis, it was concluded that there was a substantial difference between the students argumentation skills in the experimental class and the control class. The results of this study indicate that the application of the PhET-assisted argument-driven inquiry (ADI) learning model is very effective in developing students argumentation skills.

Keywords: effectiveness, argument-driven, inquiry argumentation

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1. INTRODUCTION

21st- century skills are abilities that must be possessed by the global community in the face of 21st- century competition. The 21st- century world is known for technological advances so human resources(Human Resources) are starting to be replaced with technological sophistication, thus the competencies possessed by humans today can no longer follow the standard that existed in the past[1]. Learning in the 2013 curriculum, students are required to be active in learning[2].

The science argumentation ability of junior high school students is still relatively low[3, 4, 5]. Students experience some difficulties in scientific argumentation. Students

find it difficult to understand the purpose of argumentation, use evidence as support for claims, and perform reasoning and refutation[6]. The results of the 2018 PISA study on Indonesian students can also be an indication that students skills in providing scientific arguments are still unsatisfactory[7]. Students in Indonesia cannot still utilize scientific ideas and concepts related to everyday life and lack skill in formulating hypotheses and scientific investigations. The results of the PISA study indicate that students scientific argumentation skills and students cognitive abilities need to be developed.

Scientific argumentation is the skill to compile statements based on valid and relevant evidence and reasons, the aim is to give the truth about beliefs, attitudes, or values, defend them and influence others[8]. Scientific arguments can be used as a basis for students to think, act, and communicate scientifically based on evidence or information and science[9]. Scientific argumentation is different from argumentation in the everyday sense in general. The composition of scientific arguments that make the difference consists of statements or claims, evidence or information , and justification[10].

The results of observations made at SMPN Koto Gasib show that science learning activities have not been able to facilitate students argumentation skills where as many as 63. 6% admit limited knowledge about scientific argument- based learning, 72. 7% of teachers do not know about the ADI learning model and 54. 5% of teachers during the learning process often use conventional learning models and argumentative activities that are lacking in learning activities[11]. Teachers World Health Organization dominate learning so that student activities do not master the material and the teacher also gives more rote questions, resulting in argumentation skills not being encouraged[8].

Innovation is needed that can be done in overcoming problems in learning[12]. Scientific argumentation skills can be trained through laboratory- integrated inquiry learning models, one of which is the Argument- Driven Inquiry learning model[13]. The Argument- Driven Inquiry learning model is a learning model designed to provide opportunities for students to develop their own ideas through experimentation[14]. The steps for implementing the ADI learning model in science learning consist of 7 stages, namely (1) task identification, (2) information collection, (3) argument production, (4) argumentation session, (5) preparation of investigation reports, (6) peer review, and (7) Revision and report collection. The steps for implementing this ADI model were adopted from[15, 16]. The application of the ADI learning model can improve students ability to argue scientifically by prioritizing laboratory functions[17].

The laboratory used for experiments must of course have adequate quality and quantity based on the number of students. However, not all schools have adequate laboratories and the main obstacle is the lack of complete equipment and materials used

for experiments so that the science concepts learned cannot be conveyed optimally[18]. Overcoming the lack of complete experimental equipment, a virtual laboratory is known as PhET Simulation is an alternative to continue implementing learning that integrates experimental activities so that learning activities and various students thinking skills will continue to be developed[5]. PhET Simulation Interactive is one of the computational media that provides animations of physics, biology, and other sciences that become simulations of practical experiments such as in real laboratories[19]. By applying virtual experiments, students have the freedom to develop their own ideas, so that each student can become more active in thinking by synchronizing between real virtual laboratories[20].

The subject of substance pressure and its application in daily life is one of the materials studied in science. Substance pressure material is more meaningful and easily understood by students if it is done contextually through scientific investigation and argumentation[21]. Facts in the field show that cognitive ability on the subject of substance stress is still very low. The substance stress material is still relatively low, only 62% of students achieve Minimum Completeness Criteria(KKM) scores, the rest do not achieve KKM scores or scores below 70 on daily test scores. The application of the PhET- assisted Argument- Driven Inquiry model is expected to provide an understanding of the matter of substance stress and students can argue actively and get maximum learning results.

Based on the aforementioned phenomena that has been found above, one effort that can be done is to conduct research by applying the Argument- Driven Inquiry model to train PhET- assisted students argumentation abilities as an innovation in learning science. The purpose of this study was to determine the effectiveness of the PhET-assisted Argument- Driven Inquiry learning model on students argumentation abilities on substance stress material.

2. METHOD

This research is experimental research with the type of quasi-experimental research (quasi-experiment). The research design used was a posttest-only control group design[22]. In this study, there were two groups used, namely the experimental group and the control group. The variables in this study consisted of ability and argumentation as the dependent variable, and the PhET- assisted Argument-Driven Inquiry learning model as the independent variable. The population used is all class VIII students of Public Middle Schools in Koto Gasib District for the 2021/ 2022 academic year, a total of

180 students. The sampling technique in this study was random sampling. The sample in this study amounted to 102 students consisting of four class VIII SMPN 1 Koto Gasib.

The information analysis in the study began with testing the argumentation ability test instrument after carrying out the analysis of the questions which consisted of testing the validity and reliability tests. Validity is determined from the value of the r count compared to the r table, the item is declared valid if the value of the count table is with a significance of 5%. The reliability of the item is determined from the value of Cronbach's Alpha, the item is said to be reliable if Cronbach Alpha≥ r table. Criteria of validity and reliability [23]

No	Validity Value	Criteria Validity
1	$0,00 < r_{count} \leq 0,20$	Very low
2	$0,20 < r_{count} \leq 0,40$	Low
3	$0,40 < r_{count} \leq 0,60$	Currently
4	$0,60 < r_{count} \leq 0,80$	High
5	$0,80 < r_{count} \leq 1,0$	Very high

Figure 1: Criteria for item validity.

No	Reliability Value	Reliability Criteria
1	$0,00 < r \leq 0,20$	Very low
2	$0,20 < r \leq 0,40$	Low
3	$0,40 < r \leq 0,60$	Currently
4	$0,60 < r \leq 0,80$	High
5	$0,80 < r \leq 1,0$	Very high

Figure 2: Criteria for reliability value.

The procedure for carrying out the research was in the experimental class with treatment by applying the PhET- assisted Argument-Driven Inquiry learning model, while the control group applied to learn with a scientific approach. The instrument in this study was a description test consisting of 6 questions. The information obtained in this study is the student's argumentation abilities from the post-test results. Previously obtained information was tested for normality and homogeneity using IBM SPSS 23 For Windows. Analysis of the research information is independent sample T-test and effect size test. The effect size test uses Cohen's and the results are interpreted using the classification according to Cohen[24].

No	Effect Size Value	Criteria
1	ES < 0,3	Small
2	0,3 < ES ≤ 0,7	Currently
5	ES > 0,7	Big

Figure 3: Criteria for Effect SizeTable 3. Criteria for Effect Size.

3. RESULTS AND DISCUSSION

The collection process is based on the posttest results of argumentation abilities on the substance pressure material. Before the posttest questions were given to the experimental class and the control class, the test questions were first tested for the validity and reliability of the test. After testing the validity and reliability followed by giving a posttest to the experimental and control classes then carried out a descriptive statistical analysis. The results of the posttest were analyzed by testing the hypotheses prerequisites, namely the normality and homogeneity tests which were carried out by the t-test at a significance level of α = 0.005. The results of the validity and reliability of the test instruments that were tested on students who had studied the substance stress material, namely on 25 class VIII students at SMPN 3 Koto Gasib showed that 6 questions were declared valid and reliable in the high category.

Items	r_{count}	r_{tabel}	Test results
1	0,689	0,413	Valid
2	0,769	0,413	Valid
3	0,527	0,431	Valid
4	0,627	0,413	Valid
5	0,585	0,413	Valid
6	0,624	0,413	Valid

Figure 4: The results of the validity of the argumentation ability.

The reliability of the items is to find out that the argumentation test instrument has actually been able to measure the desired indicators precisely after several tests at different times. The result of the reliability test is 0.70 in a very high category. Based on the results of validity and reliability, the 6 questions can be used to determine students' argumentation abilities.

The results of the argumentation ability posttest were carried out with the aim of obtaining sample values after being given treatment. The form of the test used

in this posttest is an essay question of 6 essay questions. This argumentation ability test consists of three indicators consisting of six sub-indicators of argumentation ability, namely argumentation evidence, argumentation justification, counter-argument evidence, argumentation justification, refutation evidence, and refutation justification. The results of the posttest argumentation ability given to the experimental group and the control group.

Category	Posttest Score	
	Experimental Class	Control Class
The highest score	83	73
Lowest value	73	27
Total students	61	61
Average	59,13	53,15

Figure 5: Description of Posttest Data on Argumentation Ability Experiment class and control class.

The results of the analysis of argumentation abilities show that there is an average difference between the experimental class that has it and the control class. The average value of the posttest argumentation ability in the experimental class was 59.13 and the control class was 53.15. Students' argumentation abilities consist of students being able to provide evidence and justification of arguments, counter arguments and rebuttals. The test results obtained were then converted into percentages and categories. The average value of the argumentation ability of the experimental class and the control class.

Argumentation Ability Indicator	Experimental Class		Control Class	
	Posttest average score	Criteria	Posttest average score	Criteria
Argument Evidence	1,82	Very high	1,64	High
Evidence Against Argument	1,69	Very high	1,59	High
Proof of Disclaimer	1,30	High	1,15	Low
Argument Justification	1,50	Currently	1,33	Low
Justification Against Argument	1,36	Low	1,25	Low
Disclaimer Justification	1,22	Low	1,02	Low
Average	1,51	Currently	1,33	Low

Figure 6: Posttest Data Based on Argumentation Ability Indicators in Experiment Class and Control Class.

Based on Table 6, it shows that several indicators of argumentation ability in the experimental class are higher with an average of 1.5 in the good category while in the

control class the average is 1.3 in the low category. The results show that the Argument Driven Inquiry learning model is effective in training students' argumentation abilities. To answer the research hypothesis, a pre-requisite test was carried out which included the normality test and homogeneity test. The normality test using the Kolmogorov-Smirnov test aims to determine whether the posttest data of the argumentation abilities of the experimental class and the control class are normally distributed. The results of the posttest data normality test of students' argumentation abilities in the experimental class and control class.

Test	Class	Sig. (2-tailed)	Conclusion
Posttest	Experiment	0,187	Normal
	Control	0,093	Normal

Figure 7: Data Normality Test Results.

The results of the normality test for argumentation abilities in the experimental class obtained a significance value greater than 0.05, namely 0.187 in the experimental class and 0.093 in the control class. These results indicate that the data on the results of the argumentation abilities of both the experimental and control classes are normally distributed. The homogeneity test was carried out in both the experimental and control groups to find out the variance between the two classes compared in an identical comparative test or not, the homogeneity test used the Levene's Test. The results of the posttest data homogeneity test of the two research samples are presented.

Test	Class	*Levene Statistic*	Sig. (2-tailed)	Conclusion
Posttest	Experiment and Control	1,350	0,248	Homogen

Figure 8: Results of Data Homogeneity Test.

The results of the homogeneity test showed that the posttest argumentation ability data in the experimental class and the control class had a significance value of 0.248. It can be concluded that the argumentation ability posttest data in this study had the same variance which means homogeneous. After the assumption test is fulfilled, the hypothesis test is continued using the independent sample t-test. The results of the t-test on argumentation abilities are explained in Table 9.

No	Variable	Sig. (2-tailed)	Conclusion
1	Argumentation Ability	0,007	H_0 is rejected and H_1 is accepted

Figure 9: Results of independent t test.

The results of the t-test for argumentation ability obtained a significance value of 0.007 ≤ 0.05, so H0 was rejected and H1 was accepted, meaning that the argumentation ability of the experimental class was significantly different from the argumentation ability of the control class. This shows that there is an influence of the Argument Driven Inquiry model on argumentation skills in science lessons in junior high school. After obtaining the test results, an effect size test was carried out from the independent t test data. According to Olejnik and Algina [24] effect size is a measure of a variable against other variables, the size of the difference and the relationship that is independent of the influence of sample size. The effectiveness test in this study aims to answer the formulation in the study, namely how effective the application of the PhET-assisted Argument Driven Inquiry (ADI) learning model is on students' argumentation abilities on substance stress material. Posttest results of students' argumentation abilities in the experimental class and control class were 59.1311 and 53.1574. While the standard deviation of the experimental class is 11.27013 and the control class is 12.58949. The effect size formula used is as follows:

$$\Delta = \frac{\overline{Y}_E - \overline{Y}_c}{S_c}$$

Information:

Δ = *Effect size*

Y_E = The average change in experimental posttest scores

Y_C = Average change in control posttest scores

S_C = Standard deviation of posttest control class

Thus obtained:

$\Delta = \frac{59,1311-52,1574}{12,\ 58949} = 0,\ 47$

From the results of these calculations, an effect size value of 0.47 is obtained, based on the applicable criteria, the effect size value is in the moderate category so Argument Driven Inquiry learning model are more effective than students' argumentation abilities with scientific learning.

Science learning carried out in the experimental class applying the Argument-Driven Inquiry (ADI) learning model assisted by PhET with a scientific approach in this study

can make students play an active role in the learning process, besides that it can be made easier for students to understand the concept of the learning material presented. The implementation of learning by applying the Argument-Driven Inquiry (ADI) model lasted for three meetings on the material pressure of substances and their application in everyday life. The Argument-Driven Inquiry (ADI) learning model has seven learning syntaxes, namely, task identification, data collection, argument production, argument session, report preparation, peer-review, revision, and report collection [15].

In the learning process using the Argument-Driven Inquiry (ADI) model, the first step in this learning is task identification. Task identification is done by giving a problem to students related to the topic that has been determined at each meeting. In this activity, students were divided into several groups and then given LKPD assisted by PhET containing indicators of argumentation ability with the inquiry stage. Students collect data in groups by conducting experiments using a virtual laboratory or PhET Simulation which will generate data. The data generated in this activity is used as evidence to support the arguments that will be given. At this stage, it takes quite a long time from the predetermined time because some students cannot use computers. The next stage is argument production. Argument production is carried out by answering LKPD questions as the basis to be presented in the argumentation session. The next stage is the argument session. In the argumentation session, one student gave his argument, then several other students gave counterarguments and rebuttals accompanied by evidence and explanations. The next stage is compiling a report. The preparation of this report is done by students through LKPD. This report contains several components of argumentation ability. After finishing compiling the report, it was continued with peer-review activities. Peer review is carried out by students by exchanging investigation reports with students who are corrected, knowing the mistakes of other students, and giving reasons. This stage is led by a group that comes forward to submit the contents of its investigation report and proceed to the revision stage. The revised report is submitted to the teacher for assessment. Students are very enthusiastic about conducting experimental activities and asking each other questions with other groups. At the end of the lesson the teacher appoints one of the students to conclude the learning material. The teacher perfects and confirms in concluding the learning material in the lesson. Ginanjar in his research stated that the stages in the ADI model could train junior high school students' scientific argumentation abilities [25].

Learning using the PhET-assisted Argument-Driven Inquiry model can make students directly practice the substance-pressure material so that learning is more interactive and fun for students. This is in line with research conducted [26] which suggests that

learning using PhET simulations makes students interested and enthusiastic about doing practicals. Taufik suggests that learning with PhET simulation is effective and gives a positive, interesting impression, and helps in an in-depth explanation of a natural phenomenon [27]

In the post-test results of the experimental class's argumentative ability, the average score obtained is 59.13 with the highest score being 83 and the lowest score being 73. While the argumentation ability in the control class is an average of 53.15 with the highest score being 73 and the lowest score being 27. This result shows that the argumentation ability of students using the Argument-Driven Inquiry (ADI) model assisted by PhET (experimental) and the scientific approach (control) have differences.

The results of the argumentation ability t-test obtained a significance value or Sig (2-tailed) of 0.007 0.05, then H0 is rejected and H1 is accepted, meaning that the argumentation ability of the experimental class is significantly different. significant with the argumentation ability of the control class. This shows that there is an effect of the Argument-Driven Inquiry (ADI) model on argumentation ability in science lessons in junior high school. To see how much the effectiveness of argumentation skills in learning is carried out by calculating the effect size. The result of the calculation of the effect size is 0.47, so based on the applicable criteria, the value of the effect size is included in the medium category, which means that it is successful in applying the PhET-assisted Argument-Driven Inquiry (ADI) learning on the substance pressure material. Muslim in his research stated the influence of the dialogical argumentation learning model on the student's ability in scientific argumentation [28]. Amin in this study found that the use of the Argument-Driven Inquiry model was effective in students' argumentation skills [29]. The results of this study also show that the of the PhET-assisted Argument-Driven Inquiry (ADI) learning model is effective in students' argumentation skills. The results of this study are in line with research that states that the habit of arguing in learning makes students' argumentation skills increase significantly even though they have different academic abilities [30].

4. CONCLUSION

Based on the results of this study, it can be concluded that the application of the Scientific-based Argument-Driven Inquiry (ADI) learning model assisted by PhET has effects on students' argumentation skills on the substance pressure meter at SMPN 1 Koto Gasib. This is evidenced by the test results of the experimental class average which is higher than the control class which is 59.13 greater than 53.15 and based on

the sig value. (2-tailed) > 0.05, then there is a significant difference in the average value of students' argumentation skills between the experimental class and the control class. The result of the effect size test is 0.47 which is categorized as having moderate effectiveness.

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