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The Role of Argument-Based Science Inquiry Learning Model to Improve Scientific Argumentation Ability

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Abstract: The Role of Argument-Based Science Inquiry Learning Model to Improve Scientific Argumentation Ability. **Objectives:** The purpose of this study was to determine the role of the argument-based science inquiry (ABSI) learning model in improving scientific argumentation skills**.** **Methods:** The quasi-experimental method used in this study was a one group pretest posttest design. The population in this study were high school students in the city of Bandung with a sample of two classes selected by cluster random sampling with a total of 100 students. **Findings:** The results of the study confirm that the ABSI learning model has a very significant effect on students' scientific argumentation skills. The improvement can be seen in the depth, organization, and accuracy scientific argumentation. **Conclusion:** Students' argumentation skills increase because they are trained to organize thoughts completely, scientifically, and systematically.

Keywords: argument-based science Inquiry learning model, scientific argumentation ability, critical thinking ability.

Abstrak: Peran Model Pembelajaran Science Inquiry Berbasis Argumen Untuk Meningkatkan Kemampuan Argumentasi Ilmiah. ***Tujuan:*** *Tujuan penelitian ini adalah untuk mengetahui peran model pembelajaran inkuiri sains berbasis argumen (ABSI) dalam meningkatkan keterampilan argumentasi ilmiah.* ***Metode:*** *Metode eksperimen semu yang digunakan dalam penelitian ini adalah one group pretest posttest design. Populasi dalam penelitian ini adalah siswa SMA di kota Bandung dengan sampel dua kelas yang dipilih secara cluster random sampling dengan jumlah 100 siswa.* ***Temuan:*** *Hasil penelitian menegaskan bahwa model pembelajaran ABSI berpengaruh sangat signifikan terhadap keterampilan argumentasi ilmiah siswa. Peningkatan kemampuan argumentasi ilmiah siswa dapat dilihat pada kedalaman, pengorganisasian, dan ketepatan penggunaan komponen argumentasi ilmiah berupa klaim, data, justifikasi, dan pendukung.* ***Kesimpulan:*** *Kemampuan argumentasi siswa meningkat karena dilatih untuk mengorganisasikan pikiran secara utuh, ilmiah, dan sistematis.*

Kata kunci: *model pembelajaran inkuiri sains berbasis argumen, kemampuan argumentasi ilmiah, kemampuan berpikir kritis.*

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INTRODUCTION

Learning science is basically learning an understanding of concepts, theories or natural laws. In studying science it is not enough just to remember it. But the most important thing is how to understand these concepts, theories or laws. The National Research Council (1996) revealed that science learning is a n active process in which students must do something, not something that is done to students. Therefore, the physics learning process in schools must emphasize the provision of direct experience by inquiry so that students can be actively involved in constructing their own knowledge and understanding (D. Hadianto et al., 2021; Jönsson, 2016). The process of scientific discovery carried out by scientists involves various scientific skills. This method can be imitated and carried out by students in learning physics through practical activities in the laboratory. Inquiry learning with experimental activities will involve students directly in various activities such as proposing hypotheses, planning an experiment, predicting, interpreting data, processing information and making conclusions (Ford, 2012; Gibson, 2008).

ABSI learning model is learning model that focuses on students' argumentation skills, because ABSI learning prioritizes discussion activities between students as an effort to train these argumentation skills, both in the form of group discussions and class discussions. In addition, what is more important is that the argument is based on a scientific inquiry activity, so that in making an argument, students base their argument based on the results of the inquiry activity. ABSI learning adopts a science writing heuristic approach. Science writing heuristics have been widely used as an argument-based science inquiry (ABSI) approach in many countries including the United States, Korea and Turkey (Daris Hadianto et al., 2022; Noroozi et al., 2020). Science inquiry is an approach to science education developed by students. Students learn science using methods, adopt attitudes, and apply scientific skills when conducting scientific research. Students can find their own problems and generate their own questions, formulate their own hypotheses, design and implement their own methods to test their hypotheses, and use their own data to answer the original questions.

In general, the ABSI model adopts the arguments put forward by Toulmin. Toulmin's argumentation is in line with everyday arguments which facilitates the task of analysis connecting its main parts in facilitating the conceptualization of the meaning of the argument. Some of the benefits of Toulmin's argumentation model are: (1) simple rules for discussion procedures through type and grammar; (2) a clear overall structure of what has been said or written; (3) complex contributions become clearer when they are broken down into argumentative elements. The main components of TAP include claims, data, justification, and support/warrants (Kuhn et al., 2016; Marble, 1986) . Several studies that have tested scientific argumentation-based learning models, including Lugli, (2015) have also developed a Dialogical Argumentation learning model by adopting the ABSI model to train students' scientific argumentation skills. In this model, students have an argumentative dialogue based on the Toulmin Argumentation Pattern (TAP). This Learning Model provides great opportunities for students to debate, such as making claims or counter claims that are supported by evidence to defend their claims or even raise objections to cancel these claims. The development of procedures or stages of this argumentation learning model is based on the flipped classroom learning model.

These studies are proven to improve students' scientific argumentation skills. In addition, Villarroel et al., (2019) has used the Two

Stay Two Stray (TSTS) and Think Pair Share (TPS) learning models which are integrated with ABSI to develop students' argumentation skills. The TSTS and TPS models are cooperative learning models that provide opportunities for groups to share results and information with other groups. This cooperative learning model has the aim of inviting students to work together in finding a concept. Then, Campbell & Filimon, (2018) have applied the Argument Driven Inquiry (ADI) learning model in learning Natural Sciences (IPA). This learning model focuses on student participation by emphasizing the construction and validation of knowledge through inquiry activities. This model is designed to help students make a scientific explanation so that in the end they can reflect on the work they have done. These studies piloted learning models that strongly emphasized the aspect of scientific argumentation ability in the process, as well as the ABSI model. The difference between this research and previous research is to look at the role of the ABSI Model on the ability of scientific argumentation (argument organization, depth, and accuracy) and the quality of the learning process.

From the explanation above, it can be seen that argumentation has an important role in learning sains in the classroom. With the argumentation ability possessed by students, the learning process in class will be more interesting because students will actively participate in class, either in the form of submitting opinions, rebuttals, questions and answering teacher questions. For this reason, there is a need for learning that is able to provide inquiry experiences as well as train students' arguments. The learning method is argument-based science inquiry (ABSI), which is an argumentation learning model that integrates scientific inquiry into learning (Shemwell & Furtak, 2010; Stark et al., 2009). ABSI learning provides opportunities for students to carry out practical inquiry activities, providing opportunities for small group discussions and class discussions so that students are trained to argue whose arguments are based on the results of scientific inquiry activities. In other words, ABSI learning can facilitate investigation activities and build students' arguments. Jones, (2014) and Lin & Tsai, (2017) reported that ABSI learning was able to improve student learning outcomes, argumentation skills and writing skills. Furthermore, the use of inquiry-based arguments was more effective in improving the quality of students' argumentation compared to the use of conventional methode (Muis, 2007; Noroozi & Hatami, 2019).

METHODS

Participant

The subjects of this study were students of class XI science at SMAN 3 Bandung as many as 2 classes with a total of 100 students (one experimental class and one control class) from eight existing classes. The population in this study were students of SMA 3 Bandung, while the sample in this study were students of class XI IPA at SMAN 3 Bandung as many as 2 classes with a total of 100 students. The sampling technique used in determining the sample in this study was a class random sample, namely random sampling without regard to the existing strata in the population because the eight classes of XI IPA at SMAN 3 Bandung City were considered homogeneous (Mao et al., 2018; Mercan, 2012). The argumentation ability of students was measured by using the argumentation ability test on the elasticity material of O1 X O2. The sampling technique used in determining the sample in this study was a class random sample, namely random sampling without regard to the existing strata in the population because the eight classes of XI IPA at SMAN 3

Bandung City were considered homogeneous (González-Howard et al., 2017). Test used This method is used to find out the results of the treatment which is more accurate, because it can be compared with the conditions before and after being given treatment.

Research Design and Procedure

In this study, a pre-experimental research method was used with the design of The One-Group Pretest-Posttest Design (Sugiyono, 2012). The design uses 2 measurements, namely before the experiment (pretest) and after the experiment (posttest) with the same questions. This design only uses one experimental class and does not use a control class.

$$O_1 \quad X \quad O_2$$

Figure 1. The one-group pretest- posttest design
Information :
O1 : Students' argumentation ability pretest
O2 : posttest of students' ability to argue
X : Treatment in the form of elasticity material using the ABSI learning model

In accordance with the research design chosen by the researcher, namely the One-Group Pretest-Posttest Design, the first researcher conducted a pretest on the students to determine the ability of scientific argumentation about the elasticity of the material. After getting the profile of students' initial scientific argumentation abilities, the researchers analyzed what aspects were lacking. Then an intervention was carried out using the ABSI model. At the time of the intervention, the teacher explained in advance the importance of argumentation in solving problems or questions, and explained the components of an ideal scientific argument, and organized the arguments initiated by Toulmin. The intervention was carried out in groups. After giving an explanation, the teacher gives some problems to be studied in groups. The questions given require students' scientific argumentation skills. Students are given time to discuss and try to solve problems according to the instructions given. The intervention process ends with an evaluation at the end of the learning process. After a few weeks, a posttest was conducted to determine the students' scientific argumentation skills after the intervention using the ABSI model. The time interval between the pretest to the intervention was one week, the intervention was carried out 1 time on the elasticity material which took 1 week. From the intervention to the posttest the distance was 3 weeks to avoid remembering the answers at the time of the intervention, so this study took less than 5 weeks.

Instrument

The instruments used include evaluation questions to measure scientific argumentation skills at the pretest and posttest, as well as explanatory material about elasticity material. The instrument to measure students' argumentation ability is to use an argumentative ability test, which is a description of the elasticity material. The test given is in the form of a description test that requires scientific argumentation skills. The test questions train and require students to be able to make claims in accordance with the problems given in the questions, present and analyze existing data, provide justification for data results and claims and provide support or rebuttal to the results of these claims. These four indicators are indicators developed by Toulmin in Robertshaw and Campbell. The rubric for the assessment of the argumentation ability test can be explained in table 1.

Table 1. Assessment rubric for argumentation ability test

No	Ability to argue		Score and criteria		
	Element	Aspect	**1**	**2**	**3**
1	Claim	Claim accuracy	Completely inaccurate claims	Claims partially accurate	Claims are completely accurate
2	Data	Sufficient data	Include data but not relevant to support claims	Include data, but not enough to support claims	Include sufficient data to support the claim
		Data quality	Data exists but is not analyzed to support claims	Partial data analyzed to support claims	Data is fully analyzed to support claims
3	Justification	Quality of justification	The justification for explaining the relationship between the data and the claim does not support the claim	Justification for explaining the relationship between data and claims partially supports claims	The justification for explaining the relationship between the data and the claim fully supports the claim
4	Support	Support Quality	Support for underlying justification does not support claims	Support for substantiating justification partially supporting claims	Support for underlying justification fully supports claims

To determine the effect of the ABSI learning model on students' ability to argue on elasticity material, calculations using effect size are used. Effect size calculation is a measure of the strength of the relationship between an independent variable and the dependent variable (Afshar et

al., 2017). What is meant by the relationship in this study is the strength or weakness of improving students' understanding and argumentation skills. The strength and weakness of improving the ability to understand and the ability to argue illustrates the size of the contribution of the application of the ABSI model in improving the ability to understand and the ability to argue. The effect size (d) value obtained is then interpreted using the following some of criteria.

The effect size criteria are if the value of d < 0.2 is included in the very small category, if 0.2 d < 0.5 is in the small category, if 0.5 d < 0.8 is in the medium category, if 0.8 d <1.0 is in the large category, and d 1.0 is in the very large category. The analysis of the data used to determine the improvement of students' argumentative abilities on the elasticity material used <g> average score data which was processed using the equation developed by Hake (1999), which is as follows. While the <g> category is presented as follows. If the value <g> > 0.70 is in the high category, if 0.30 <g> 0.70 is in the medium category, and if <g> < 0.30 is in the low category.

Data Analysis

Data analysis in this study using SPSS. This study aims to see the effect of the ABSI model in improving scientific argumentation skills. Therefore, the researchers looked at the effect size of the intervention using SPSS with the criteria if the value of d < 0.2 is included in the very small category, if 0.2 d < 0.5 is in the small category, if 0.5 d < 0.8 is in the medium category, if 0.8 d <1.0 is in the large category, and d 1.0 is in the very large category. Meanwhile, the analysis of the data was used to determine the improvement of students' argumentative abilities on the elasticity material used <g> average score data which was processed using the equation developed by Hake (1999), which is as follows. While the <g> category is presented as follows. If the value <g> > 0.70 is in the high category, if 0.30 <g> 0.70 is in the medium category, and if <g> < 0.30 is in the low category. Explanations are presented in the form of inferential statistics and diagrams assisted by narrative explanations so that the data presentation can be understood clearly.

RESULTS AND DISCUSSION

The argumentation ability data was obtained through the argumentation ability test which was conducted at the beginning (pretest) and at the end (posttest). This argumentative ability test consists of 6 sections of description questions that refer to the indicators of the ability to argue for elasticity material consisting of the concept of elastic modulus, Hooke's law, and Hooke's law in series and parallel circuits. The argumentation ability indicators used in the test are; claims, data, justification and support contained in each part of the question. The effect of the application of the ABSI model on students' argumentation ability is generally used to calculate the effect size (d). Based on the calculation results, the data obtained in Table 4.

Table 4. Size of effect size ability to argue

Aspect	Initial Test (%)	Final Test (%)
Average	63,35	93,45
Standard Deviation	3,24	6,67
Effect Size (d)	5,75 (Very large)	

Based on the results of the effect-size calculation, it can be concluded that the learning power of the ABSI model in improving the ability to argue is very large with an Effect Size (d) of 5.80. From these data, it can be seen that the application of the ABSI model has a very big influence on students' argumentation abilities. This means that it implicitly indicates that the application of the ABSI model has an important meaning and cannot be ignored for its influence on students' argumentation abilities. This is because each learning stage of the ABSI model contains activities oriented to the growth of the ability to argue. Further recapitulation of the results of the pretest, posttest and <g> ability to argue is presented in table 5.

Table 5. Recapitulation of arguing ability

Arguing Ability	Experiment Class		<g>
	Pretest	*Posttest*	
Max Score	**62**	**88**	
Minimum Score	**54**	**57**	
Average Score	**58, 35**	**86,25**	**0,83**
Average Score (%)	**63,35**	**93,45**	**87**

Based on Table 5, it can be seen that the average pretest score of the experimental class students is 58.35 (63.35% of the ideal score of 90). The posttest average score of the experimental group was 86.25 (93.45% of the ideal score of 90), and the <g> average score of argumentative ability was 0.83 (87% of the ideal score 1), which was in the high category. This shows that learning using the ABSI model is effective in improving students' argumentation skills. This is also in line with research conducted by Casas-Quiroga & Crujeiras-Pérez, (2020), who reported that the ABSI model can improve students' argumentation skills. Meanwhile, the comparison of the student's <g> average score on each indicator of the ability to argue is shown in the following diagram.

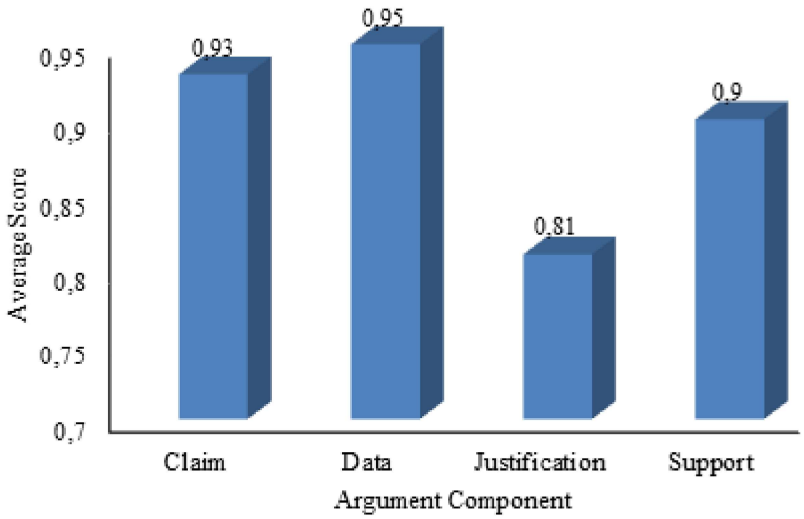

Figure 2. Comparison of mean scores <g> each indicator of argumentation kemampuan

Based on the diagram above, it can be seen that the four indicators of argumentation ability have different <g> values. The ability to provide claims is 0.93, the ability to present and analyze data is 0.95, the ability to justify is 0.81, while the ability to provide support is 0.90. Of the four indicators of ability to argue, the lowest <g> is on the ability to justify and for <g> the highest is on the ability to give claims. The claims indicator, <g> average is 0.95. Students are facilitated at the stage of understanding exploration before learning. Students submit and answer a claim from the demonstration event presented by the teacher regarding the material to be discussed. Furthermore, the claims indicator was also facilitated at the stage of brainstorming and comparing data interpretations in small groups. Each student in the group submits a claim to be discussed in his group. This provides an opportunity for students to explore the knowledge that was known during the practicum at the previous stage. Furthermore, it is also facilitated at the stage of understanding exploration after learning. Students give a final claim based on the results of class discussions so that it becomes the final conclusion (Villarroel et al., 2019; Voss & Van Dyke, 2001).

In the data indicator, the average <g> is 0.96. Students are facilitated at the stage of active participation in practicum activities. Students collect data from practicum activities which are then interpreted into tables and the data is analyzed as a reinforcement of the claims submitted. The ability to provide data and be able to analyze it is what causes <g> to be the highest compared to other indicators. As for the justification indicator, the average <g> is 0.81. In this justification indicator, students are facilitated at the stage of writing individual understanding for practical activities. Students relate the results of the data obtained in practical activities with the claims submitted (Malpique & Veiga-Simão, 2016) . In addition, this justification indicator is also facilitated at the stage of comparing scientific ideas with textbooks or other sources through class discussions. While the support indicator, the average <g> is 0.90. Students are facilitated at the stage of exchanging ideas and comparing interpretations of data in small groups. Students try to provide support based on theories, laws and equations related to the material discussed in small groups. In addition, this support indicator is also facilitated at the stage of comparing scientific ideas with textbooks or other sources through class discussions (Kuhn et al., 2016; Marble, 1986) . In this class discussion, student representatives provide support for the claims put forward based on theories, laws and equations that have been supported by the results of group discussions. While other students recorded the results of class discussions as final support. The ABSI learning model and the argumentation-oriented model have a good impact on students' argumentation skills. Argumentation-based learning can have a good impact on students' argumentation skills.

■ CONCLUSIONS

Based on the data and analysis of the results of research that has been carried out on the effect of the application of the argument-based science inquiry (ABSI) learning model on students' argumentation abilities, it can be concluded that the argument-based inquiry science (ABSI) model has a very large influence on the ability to argue students with an effect size (d) of 5.75. The improvement of students' scientific argumentation skills can be seen in the depth, organization, and accuracy of the use of scientific argumentation components in the form of claims, data, justifications, and supports. Students' critical thinking and argumentation skills will be optimal if the learning process always provides

instructions or questions that require scientific argumentation.

The implication of this research is that every learning process must encourage students' scientific argumentation skills so that critical thinking skills, scientific reasoning, and language skills are trained and go hand in hand in supporting students' academic abilities. The limitations of this study are that participants are taken from one group of science majors, only involve one school in the upper cluster, and focus on studies on science problems. The recommendation for further research is that research will be better if the sample is more diverse by involving students from various majors such as science, social studies, and language with the topics taken being expanded to include issues of social life.

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