The Development of Learner Activity Sheets Based on Argument Driven Inquiry Model With Socioscientific Issues Context to Improve Students Argumentation Skills

Agustina Dua Kuki[*], Kristiana Nathalia Wea, Petronela Ivoni Susanty

Department of Chemistry Education, Faculty of Teacher Training Education, Universitas Nusa Nipa, Sikka, Indonesia
[*]e-mail: agustinakuki03@gmail.com

Abstract: Learning by integrating argumentation skills has not been fully implemented in learning. The purpose of this study was to develop a student activity sheet based on the Argument-Driven inquiry model with a socioscientific issue context. This research integrates the context of socioscientific issues as a stimulus for students in building scientific argumentation. This research method is the 4D model, which includes the define, design, develop, and disseminate stages. However, the stages of this research are limited to the development stage. The results showed that the student activity sheet was developed based on the learning stages of the Argument-Driven inquiry model, which is limited to the scientific argumentation phase. The study of socioscientific issues is adjusted to the learning subtopic of factors that affect the reaction rate. The data from the validation study of the Learner Activity Sheet is classified as a very valid category with a content validity score of 89%; the validity of the layout presentation aspect is 92% and the language aspect is 96%. Meanwhile, the students' response result shows that the level of satisfaction with the activity sheets is 96%, including the category of very satisfied. The improvement of students' argumentation skills was at a moderate level with an N-gain score of 0.64. Statistical test results show there is a significant difference between pretest and posttest scores with a P-value <0.05. Based on these results, it can be concluded that the LAS based on the Argument Driven Inquiry model with a socioscientific Issue context is valid, practical and effective for improving students' argumentation skills.

Keywords: Argument-Driven Inquiry; Argumentation Skill; Learner Activity Sheets; Socioscientific Issues.

Introduction

Argumentation skills are one of the competencies that students need to have in science learning. This skill helps students form their knowledge. [1] stated that knowledge is formed through the process of reasoning, evaluating evidence, and supporting rational statements, where this process leads to the stages of building a scientific argument. Argumentation skills are a person's ability to provide logical statements based on facts and based on theories that aim to justify the truth of a claim [2].

The process of justifying the truth of an idea is an important skill. Students must have amid the current development of information and technology. This skill also needs to be applied in science learning so that students are critically able to provide scientific explanations related to scientific phenomena in everyday life [3]-[8]. The argumentation process encourages learners to provide views and reflections both verbally and in writing so that teachers can identify learners' conceptual deficiencies and errors [9]. These findings emphasize the importance of integrating argumentation skills in learning that is relevant to 21st-century needs.

The learning model that can accommodate students' argumentation skills in the learning process is the Argument Driven Inquiry (ADI) model. [9] stated that the ADI model is designed to provide opportunities for students to engage in scientific practices such as developing data collection methods, conducting investigations, answering questions,

sharing information, expressing opinions, and writing scientific arguments. As a stimulus to train students' argumentation skills, it can be done by presenting various controversial issues in society so that learning becomes more meaningful. Science-related issues that are controversial and involve dimensions of science, technology, social, moral, health, economics, politics, and ethics are referred to as socioscientific issues [10]-[11]. Controversial issues that are close to the lives of learners become a medium to provoke debate and share opinions. Thus, learners need to be equipped with thinking skills that can criticize the credibility of information obtained through scientific argumentation activities.

Considering the essentiality of argumentation skills for students, it is fitting that these skills are explicitly trained in the learning process. However, facts in the field show that students' argumentation skills are still relatively low. The low level of argumentation skills in science learning is shown by the results of previous research studies. [12]-[14], stated that the low quality of student argumentation had an impact on low concept understanding. Learning by practising argumentation skills has not been fully implemented in the classroom [15]. Teachers have tried to build argumentation by presenting contextual phenomena so that students are involved in discussions, but the readiness factor of students in digesting the information obtained is also a challenge. This condition is also caused by the limitations of learning media that integrate argumentation skills.

One of the learning media that can be used to integrate argumentation skills in learning is the Learner Worksheet. Learner Activity Sheets (LAS) help teachers in the learning process by presenting structured tasks according to learning outcomes [15]. LAS is the fulcrum of teacher innovation in equipping students with various skills that are integrated into learning. The argumentation component integrated in the LAS refers to the Toulmin Argumentation Pattern. According to Toulmin, an argument consists of 6 indicators, namely, claim, data, warrant, backing, rebuttal, and qualifier [16]. However, in this study, it is limited to the rebuttal indicator. The novelty of this research is the integration of SSI topics on reaction rate material in a modified Argument Driven Inquiry model limited to the stage of developing tentative argumentation.

Research Methods

This research is a research and development method with the output produced being LAS based on the Argument Driven Inquiry (ADI) model with Socioscientific Issue (SSI) context as part of learning tools in the independent curriculum. The development of LAS refers to the Four-D (4D) development model, including the stages of define, design, develop, and disseminate [17]. In this study, the focus is only on three stages of development, while the dissemination stage is carried out in a separate study.

The draft product developed was then validated by 3 experts including 1 media expert lecturer and 2 material expert lecturers. The draft product was tested on a small scale to obtain data on the effect of LAS application on improving students' argumentation skills and student responses.

1) Place and time of research
   Draft Student activity sheets were tested at SMA Negeri 4 Surabaya Implementation of Merdeka Curriculum.
2) Research subjects and targets
   The research targets were class XII IPA 5 SMA Negeri 4 Surabaya students. Selection of research samples using the purposive sampling technique with certain considerations. According to Piaget's theory, children aged 16-18 years have entered the formal operation stage, so that they can think abstractly, provide scientific explanations and solve problems through the experimental stage.
3) Research instruments and data analysis
   The instruments used in this research are validation sheets, argumentation skills tests and student satisfaction questionnaires.
4) Validation test
   Data analysis techniques on product validation and student response questionnaires refer to Likert scale ratings in Table 1.

Table 1. Student Worksheet Grading Scale [18].

Scale	Criteria
1	Invalid
2	Less Valid
3	Valid
4	Very Valid

The results of the assessment by the validator were then analyzed in a quantitative descriptive manner. The

analysis was carried out on each aspect of the validation sheet. Based on the score given by the validator, the acquisition score is then compared with the criterion score. The assessment of the validation results was converted into percentages using the percentage formula.

$$P = \frac{\text{data collection result scores}}{\text{Criteria score}}$$

The data from the validation results in the form of percentages are then interpreted in the validity criteria shown in Table 2.

Table 2. Validation Criteria

Validity Criteria (%)	Validity Level
85.01 – 100	Very valid and can be used
70.01 – 85.00	Valid with minor revisions and can be used
50.01 – 70.00	Less valid, recommended not to be used
01.00 – 50.00	Invalid

A student's worksheet is said to be valid if the validator's assessment meets the assessment results ≥ 70.01% with valid and very valid categories.

5) Practicality test
   The practicality of using development products refers to the criteria for interpreting respondents' scores in Table 3. While the practicality of using development products refers to the criteria for interpreting respondents' scores in Table 3.

Table 3. Practicality Criteria

Validity Criteria (%)	Validity Level
80.01 – 100	Highly Practical
60.01 – 80.00	Practical
40.01 – 60.00	Moderate practical
20.01 – 40.00	Less practical
0 – 20.00	Not practical

6) Effectiveness test
   The effectiveness of the student activity sheet was measured based on data from students' pre-test and post-test scores. The improvement of students' scientific argumentation skills was analyzed with the N-Gain equation [19].

$$N - Gain = \frac{\text{posttest score} - \text{pretest score}}{\text{maximum score} - \text{pretest score}}$$

Furthermore, the acquisition of Normalized Gain is classified into three categories in Table 4.

Table 4. Classification of N-Gain Values

Score Range	Criteria Mean Score
g > 0.70	High
0.30 ≥ g < 0.70	Medium
g < 0.30	Low

Learner Activity Sheets are categorized as improved if students' argumentation skills are in the medium category. The difference test of argumentation skills is measured by

looking at the difference in the average pre-test and post-test scores, analyzed using the paired T-test using the SPSS 23 application. The test hypothesis is presented as follows.

$$H_0 = \mu_1 = \mu_2$$
$$Ha = \mu_1 < \mu_2$$

H_0: The means of pretest and posttest of argumentation skills are the same

H_a: The mean pretest and posttest of argumentation skills are different

μ_1 = mean pretest score of argumentation skills
μ_2 = mean posttest score of argumentation skills

LAS is effective if there is a significant difference in the mean pretest and posttest scores of students' argumentation skills.

Results and Discussion

Validity

The results of this study are the validity and practicality of learner activity sheets (LAS) based on the Argument-Driven Inquiry (ADI) model with Socioscientific Issue (SSI) context on the material of factors affecting the reaction rate. This research product aims to train the argumentation skills of Class XI high school students. LAS is developed based on the learning stages of the ADI model integrated with the SSI context. The learning stages in the LAS refer to the syntax of the ADI model, which is limited to 4 learning stages. It included 1) the task identification phase, 2) the method design and data collection phase, 3) the tentative argumentation phase, and 4) the argumentation phase. The developed LKPD is divided into three learning subtopics: concentration factor, temperature factor, and surface area factor. The appearance of the developed LKPD is as follows.
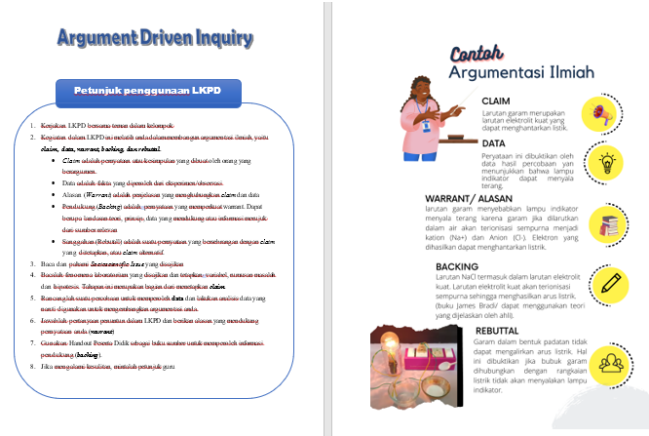

Figure 1. Front Cover

Figure 2. Instructions for Use and Argumentation Components

The features developed in the SSI-contextualised ADI model LKPD and the relationship with Toulmin's argumentation components are presented in Table 5.

Table 5. Features of the ADI model LAS with SSI context

Syntax of ADI Model Learning	Features Developed	Description
Identification Tasks	Socioscientific Issue Topics	Contains controversial discourse from various articles and current news relevant to the subtopics studied
Design a method and collect data.	Laboratory phenomena	Contains discourse on laboratory phenomena designed for students to conduct simple experiments and collect data to develop scientific arguments.
Analyze data and develop a tentative argument	Claim	Guiding questions are used to help students establish statements that they believe to be true.
	Data	Guiding questions for students to present data supporting the claim set
	Warrant	Guiding questions for students to provide scientific reasons or explanations.
	Backing	Guiding questions are used for students to find supporting references in the form of supporting theories.
Argumentation Session	Rebuttal	Contains a column of counterarguments for other groups.

In the SSI topic feature, the discourse presented is tailored to the learning subtopics as presented in Table 6. The Learner Activity Sheet (LAS) that has been designed is then validated by two material expert lecturers and one media expert lecturer. The results of the validation of the three validators obtained the results that the ADI model LAS with SSI context is very valid for use in training students'

argumentation skills. The validation result data is presented in Table 7.

Table 6. Study of socioscientific discourse

Subtopics	Socioscientific Issues
Concentration	Indonesia's food waste emergency vs Mukbang culture
Temperature	"Ciki Ngebul" phenomenon: Is using Liquid Nitrogen in food safe?
Surface area	Fireworks and air pollution

Table 7. Validation Results

No.	Aspect Assessment	Validation Percentage	Category
I	Content	89	Very Valid
II	Layout Presentation	92	Very Valid
III	Language	96	Very Valid

The role of content validity is to measure the suitability of the LAS developed with the concept of learning material. This validity contains an assessment of the indicators of the suitability of learning objectives with the design of LAS, the suitability of the SSI phenomenon with the subtopic of the material studied, the suitability of the laboratory phenomena presented, and the suitability of the argumentation component trained in learning. The results of content validity are presented in Figure 3 below.
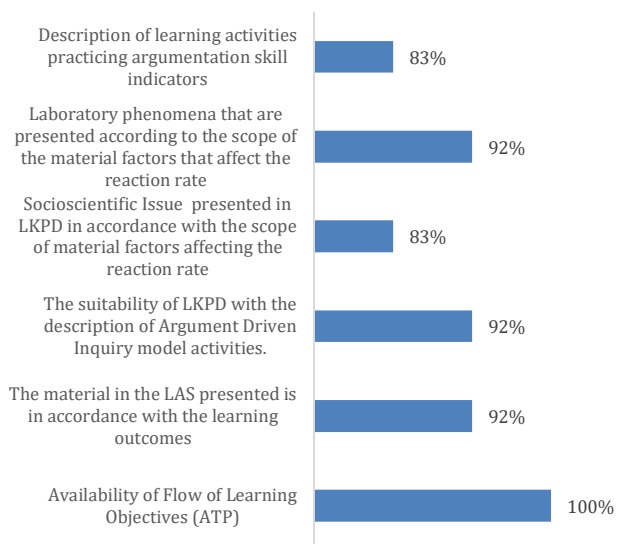

Figure 3. Content Validity Result

Data on Figure 3 shows that all indicators in the LAS content aspect are declared valid with a percentage of > 80%. According to Prastowo in [20], the validation of the content of the media developed must be by the learning objectives to be achieved, the relevance of the material, and the clarity of the instructions for using the media.

The presentation aspects in the LAS include the clarity of the systematic presentation of material in the LAS, the organization of the material presented, the layout of the images, the colors presented, and the font size used. The presentation in this LAS presents an attractive color display, and the suitability of the font size for attracting students' attention. In addition, the language aspect in this LAS pays attention to the use of the Indonesian language that is easy to

understand, clarity of sentence structure, so as not to cause ambiguity. According to [18], the procedure for developing teaching materials must pay attention to aspects of writing rules and reading ability. Writing rules include spelling, terms, and sentence structure. In contrast, readability aspects include sentence length and structure that make it easy for readers to understand the concept of the material presented.

Practicality

The activity sheet in the limited test was distributed on a small scale to 15 students. The results of the student satisfaction questionnaire on the use of LAS showed that the level of satisfaction of students learning to use student activity sheets was 96%, including the very satisfied category. The results of the analysis of student responses are presented in Figure 4.
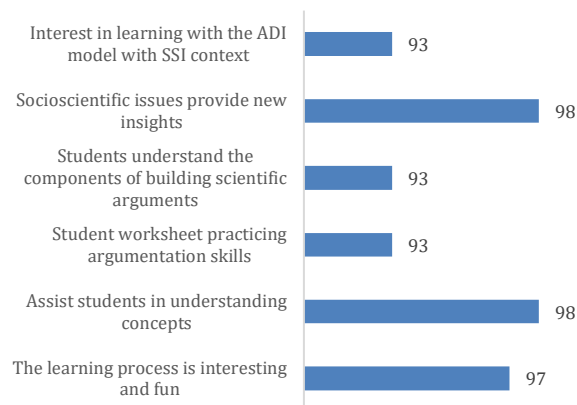

Figure 4. Students responses result

Students stated that the student activity sheet helped them recognize the components of scientific argumentation. This statement aligns with research conducted [21] related to the self-argumentation process that argumentation-building activities deepen concept understanding, critical thinking skills, and create meaningful learning. In addition, students stated that the socioscientific study of the issue provides a new view of chemical concepts in everyday life. The study of SSI in learning increases students' science literacy, and provides an overview of students in maintaining health, the environment, and social welfare [22].

Effectiveness of Learner Activity Sheet

Improvement of Argumentation Skills

The results of improving students' argumentation skills in class XII MIPA 5 are shown in Table 8. The data shows an increase in students' argumentation skills, as seen from the N-gain average of 0.64, including in the moderate category. Data on students' pre-test and post-test scores were then analyzed specifically to see the improvement of argumentation skills on each indicator presented in Figure 4.

The data shows that the average pretest score on three indicators is still relatively low, <61, including warrant, backing and rebuttal indicators. The application of LAS provides a difference in post-test scores on each argumentation skill indicator. Based on the data, the claim indicator obtained the highest scores in the pretest and

posttest. Claim is a basic argumentation component and a simple statement of a phenomenon. The claim is a general idea and the basis of argumentation [23]. The claim component obtained the highest score compared to other indicators in the pretest and posttest [24]-[27]. Other findings state that claim is an aspect that often appears in students' answers because claim is a simple statement, a basic idea that does not have to be explained [28]-[29]. The warrant and backing indicators in the pretest showed the lowest score because students did not understand the concept or recognize the components of an argumentation.

Table 8. Argumentation Skills Test Results XII MIPA 5

Students	Pre-test	Post-test	N-gain
PD 1	47.5	75	0.52
PD 2	58.75	77.5	0.45
PD 3	65	93.75	0.82
PD 4	68.75	82.5	0.43
PD 5	65	83.75	0.53
PD 6	58.75	86.25	0.66
PD 7	67.5	88.75	0.65
PD 8	58.75	90	0.76
PD 9	57.5	87.5	0.70
PD 10	63.75	81.25	0.48
PD 11	60	87.5	0.68
PD 12	62.5	95	0.86
PD 13	65	81.25	0.46
PD 14	55	86.25	0.69
PD 15	60	93.75	0.53
Average	60.88	86	0.64

Figure 4. Indicators of students' argumentation skills

Paired sample t-test

The requirement for determining statistical tests is the normality test of data using pre-test and post-test data on students' argumentation skills. The results of the data normality test are presented in Table 9.

Table 9. Normality Test Result

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pre_test	.144	15	.200*	.934	15	.316
Post_test	.117	15	.200*	.968	15	.823

The normality test results are in Table 5. show that the pre-test and post-test data of class XII MIPA 5 are normally distributed. This refers to the significance value in the Shapiro-Wilk and Kolmogorov-Smirnov columns with a P-value> 0.05. Therefore, the different test of argumentation skills uses a paired sample t-test to determine the impact of using LAS on students' argumentation skills. The paired sample t-test results are presented in Table 10.

Table 10. Paired sample T-Test result

Aspek	Paired Differences			t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean			
Pre-Post	-25.08333	6.65587	1.71854	-14.596	14	.000

Based on the data in Table 10, it can be seen that the P-value obtained is 0.000 <0.05; therefore, H_0 is rejected and H_a is accepted. This states that a significant difference exists between the pre-test and post-test results of students' argumentation skills. This means that there is an increase in students' argumentation skills after participating in learning using LAS. Thus, it can be concluded that learning using the ADI model LAS with SSI context effectively improves students' argumentation skills.

Conclusion

Based on the description of the results and discussion, it can be concluded that the Learner Activity Sheet (LAS) based on the Argument Driven Inquiry model with a socioscientific Issue context is valid, practical and effective for improving students' argumentation skills. This research is limited to a small-scale test so that the effectiveness of LAS can be measured on a larger sample. In addition, the integration of the ADI model with the SSI context can be studied on other science topics.

Author's Contribution
Agustina Kuki: Contributed to the research concept, drafting original paper; Kristiana Natalia: contributed to the analysis results and writing the original draft; Petronela Ivoni Susanti: contributed to the methodology and analysis results.
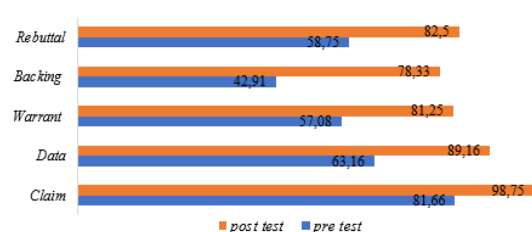
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