IMPLEMENTATION OF A REBUTTAL LEARNING STRATEGY IN A SOCIO-SCIENTIFIC ISSUES CONTEXT WITH ENVIRONMENTAL THEMES TO IMPROVE STUDENTS' SCIENTIFIC ARGUMENTATION

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Abstract

This study aims to determine the effectiveness of the Socio-Scientific Issues (SSI) learning model through the Rebuttal Learning strategy in improving students' individual argumentation skills and to describe the improvement of group argumentation. This research employed a quantitative approach using a quasi-experimental design with a one group pretest-posttest model. The sample consisted of 25 ninth-grade students. The instrument used was a test based on Toulmin Argumentation Pattern (TAP), including claim, data, warrant, and rebuttal. The results showed a significant improvement in students' argumentation skills. The average pretest score was 66.84 and increased to 90.16 in the posttest. The Paired Samples T-Test showed a significant difference ($t = -11.93$, $df = 24$, $p < 0.001$). The N-Gain score of 0.71 indicates a high category. Group argumentation results also showed improvement in argument structure components. It can be concluded that the implementation of Rebuttal Learning based on SSI is effective in improving students' argumentation skills.

Keywords: Rebuttal Learning, Socio-Scientific Issues, argumentation, environmental issues

1. INTRODUCTION

Environmental issues such as flooding represent complex problems involving interactions between natural processes and human activities, making them appropriate contexts for science learning because they require students to integrate scientific knowledge with social considerations and decision-making processes (Zeidler & Nichols, 2009; Sadler et al., 2017). The occurrence of flash floods in Sumatra and Tegal illustrates that environmental issues are closely related to scientific concepts, social considerations, and policy decisions, making them relevant contexts for science learning.

In science education, students' scientific argumentation abilities remain relatively limited. Students often express opinions without sufficient evidence and experience difficulties in constructing logical counterarguments. This condition is influenced by learning practices that are still predominantly teacher-centered and provide limited opportunities for students to engage in argumentative discussions and evaluate different perspectives.

The *Socio-Scientific Issues (SSI)* approach offers a potential solution by connecting scientific concepts with real-world contextual issues. SSI-based learning encourages students to analyze complex problems, utilize scientific evidence, and develop reasoned arguments. However, SSI implementation requires integration with specific learning strategies that can explicitly facilitate the development of rebuttal skills.

The *Rebuttal Learning* strategy emphasizes the ability to construct evidence-based counterarguments through scientific reasoning. Students are encouraged to identify weaknesses in existing arguments

and provide logical responses supported by relevant evidence. Therefore, the integration of SSI and *Rebuttal Learning* provides a learning environment that is not only contextual but also promotes scientific argumentation and critical evaluation of different viewpoints.

Based on this background, this study aims to address the following research questions:

1. How does the implementation of the *Socio-Scientific Issues* approach through the *Rebuttal Learning* strategy influence students' individual scientific argumentation abilities?
2. How does students' group scientific argumentation ability improve after participating in SSI-based *Rebuttal Learning*?

2. METHODOLOGY

This study employed a quantitative approach using a quasi-experimental design with a one-group pretest-posttest model. The research participants consisted of 25 ninth-grade students from a junior high school.

The research instrument was analyzed using the Toulmin Argumentation Pattern (TAP), which evaluates argument structures through components of claim, data, warrant, and rebuttal (Toulmin, 1958; Erduran et al., 2004). The argumentation components assessed included *claim*, *data*, *warrant*, and *rebuttal* to evaluate students' ability to construct evidence-based scientific arguments.

Data analysis was conducted through the Shapiro-Wilk normality test, paired samples t-test, and normalized gain (N-Gain) calculation. The normality test was used to determine whether the data met the assumptions for parametric analysis, the paired samples t-test was applied to identify differences between pretest and posttest scores, and the N-Gain analysis was used to determine the effectiveness of the learning intervention in improving students' scientific argumentation abilities.

3. RESULTS

3.1 RESPONDEN CHARACTERISTICS

The participants in this study consisted of 25 ninth-grade students from a junior high school in Tegal City, Indonesia. The sample was selected using a purposive sampling technique by considering the characteristics of the class and its suitability with the objectives of the study. All participants were involved in a learning intervention using the *Socio-Scientific Issues (SSI)* model through the *Rebuttal Learning* strategy conducted over two instructional sessions.

The learning activities consisted of a pretest, SSI-based learning activities involving environmental issues, argumentative discussions, and a posttest. Throughout the learning process, students were engaged in analyzing socio-scientific problems, constructing arguments based on evidence, and responding to opposing viewpoints through the rebuttal process.

3.1.1 Instrumen Testing

Instrument testing was conducted to ensure that the research instruments met the criteria of validity and reliability before being administered to the research participants. The instrument evaluation consisted of content validity and empirical validation, including item validity, reliability testing, difficulty level analysis, and discrimination power analysis.

Content validity was conducted to determine the extent to which the instruments corresponded to the measured indicators and constructs, ensuring that they appropriately represented the research variables. The validation process was carried out through expert judgment by science education

experts, considering the aspects of content relevance, language clarity, and the alignment of each item with the learning indicators. Content validity was analyzed using Aiken's V coefficient to determine the level of agreement among experts regarding item relevance (Aiken, 1985). The results of the content validity analysis are presented in Table 1.

Table 1
Content Validity Results Based on Expert Judgment Using Aiken's V

Indikator	V	Ket
Validasi Instrumen Stimulus dan Masalah Pembelajaran	0,90	Sangat Valid
Validasi Instrumen Lembar Observasi	0,94	Sangat Valid
Validasi Instrumen RPP	0,95	Sangat Valid
Validasi Instrumen LKPD	0,97	Sangat Valid
Validasi Instrumen Tes	0,94	Sangat Valid
Validasi Instrumen Lembar Panduan Kelompok	0,91	Sangat Valid
Rata-Rata	0,94	Sangat Valid

Based on the Aiken's V analysis presented in Table 1, the average content validity coefficient was 0.94, which was categorized as very valid. This finding indicates that all research instruments fulfilled the criteria for content validity and were appropriate for measuring students' scientific argumentation abilities and learning outcomes.

Empirical validation was conducted based on the results of instrument trials to evaluate the quality of test items before their implementation in the research. The empirical validation analysis included item validity, reliability testing, difficulty level analysis, and discrimination power analysis. Item validity was examined to determine the accuracy of each item in measuring the intended construct through the correlation between item scores and total scores at a significance level of 5% ($\alpha = 0.05$). An item was considered valid when the significance value was less than 0.05.

The item validity analysis showed that out of 60 tested items, 47 items met the validity criteria, while 13 items did not meet the required criteria. Valid items were selected and used as research instruments, whereas invalid items were excluded because they did not adequately represent students' abilities.

Furthermore, reliability testing was conducted using Cronbach's Alpha coefficient to determine the internal consistency of the instrument in measuring students' scientific argumentation abilities. The results of the instrument reliability analysis are presented in Table 2.

Table 2
Instrument Reliability Analysis Based on Cronbach's Alpha Coefficient

Instrumen	Jumlah Butir	Cronbach's Alpha	Kriteria	Keterangan
Paket Soal 1	15	0,6236	≥ 0,70	Cukup Reliabel
Paket Soal 2	15	0,5458	≥ 0,70	Cukup Reliabel
Paket Soal 3	15	0,6108	≥ 0,70	Cukup Reliabel
Paket Soal 4	15	0,7303	≥ 0,70	Reliabel

Based on Table 2, the Cronbach's Alpha coefficients ranged from 0.5458 to 0.7303. The fourth test package obtained the highest reliability coefficient and was categorized as reliable, while the first, second, and third test packages were categorized as moderately reliable. These results indicate that the instrument had an acceptable level of internal consistency and was suitable for use in the research.

The difficulty level analysis was conducted to identify the characteristics of each test item based on its level of difficulty. The results showed that, out of 60 test items, 41 items were categorized as easy, 19 items were categorized as moderate, and no items were categorized as difficult. These findings indicate

that most items could be understood by students while still providing sufficient variation to assess their scientific argumentation abilities.

Furthermore, discrimination power analysis was conducted to determine the ability of each item to differentiate between students with high and low abilities. The results showed that 7 items were categorized as having good discrimination power, 49 items as having adequate discrimination power, and 4 items as having poor discrimination power. Items with good and adequate discrimination power were considered appropriate for use, whereas items with poor discrimination power required revision or exclusion from the research instrument.

Based on the results of content validity and empirical validation, the research instruments were considered appropriate for measuring students' scientific argumentation abilities. The argumentation instrument was developed based on the Toulmin Argumentation Pattern (TAP), which consists of four components: *claim*, *data*, *warrant*, and *rebuttal*. These components were used to assess students' ability to construct evidence-based scientific arguments.

3.2 INDIVIDUAL ARGUMENTATION RESULTS

Students' individual scientific argumentation abilities were assessed through pretest and posttest measurements. The descriptive analysis of students' scores before and after the implementation of the learning intervention is presented in the following table.

Table 3
Students' individual scientific argumentation abilities were assessed through pretest and posttest measurements.

	pretest	**posttest**
Mean	66.84	90.16
Median	67.00	90.00
Modus	70.16	95.05
Maksimal	90.00	100.0
Minimal	47.00	77.00

Based on Table 3.2.1, the mean pretest score increased from 66.84 to 90.16 in the posttest. The minimum score also increased from 47 to 77, while the maximum score improved from 90 to 100. These results indicate an improvement in students' individual scientific argumentation abilities after participating in the learning intervention. The analysis of these argumentation components was based on the Toulmin Argumentation Pattern (TAP), which describes argument structures through claims, evidence, reasoning, and rebuttal components (Toulmin, 1958; Erduran et al., 2004).

Furthermore, this improvement suggests that students became more capable of constructing scientific arguments involving the components of claim, data, warrant, and rebuttal. The more consistent distribution of posttest scores also indicates that the improvement occurred across students' abilities rather than being limited to certain individuals.

3.3 GROUP ARGUMENTATION IMPROVEMENT

In addition to individual scientific argumentation abilities, this study also analyzed the improvement of students' group argumentation abilities based on the Toulmin Argumentation Pattern (TAP) components, namely *claim* (C), *data* (D), *warrant* (W), and *rebuttal* (R). The analysis of group argumentation was conducted based on students' discussion outcomes in addressing the given socio-scientific issues, including the flooding issue in Sumatra and the environmental issue in Guci. The results of the group argumentation improvement analysis during the pretest and posttest are presented in Table 4.

Table 4
Group Argumentation Improvement Based on Toulmin Argumentation Pattern (TAP)

Isu Lingkungan	Pre-Test					Post-Test				
	C	D	W	R	Total	C	D	W	R	Total
Sumatera (kontra)	15	20	20	10	65	21	20	15	15	71
Sumatera (pro)	15	17	21	18	71	23	25	24	25	97
Guci (kontra)	12	15	10	24	61	22	20	18	18	78
Guci (pro)	15	24	22	12	73	10	14	12	5	41

Based on Table 4, an overall improvement in students' group scientific argumentation abilities was observed after the implementation of the Socio-Scientific Issues (SSI) model through the Rebuttal Learning strategy. The improvement was identified in most groups, particularly in the ability to present claims, provide supporting evidence (data), establish relationships between evidence and scientific reasoning (warrant), and construct responses to opposing viewpoints (rebuttal).

The Sumatra (contra) group showed an increase in the total score from 65 in the pretest to 71 in the posttest. The improvement was mainly observed in the claim and rebuttal components, indicating that students began to develop clearer argumentative positions and provide responses to different perspectives. The Sumatra (pro) group demonstrated the highest improvement, with the total score increasing from 71 to 97. This improvement occurred across all argumentation components, particularly in data and rebuttal, suggesting that students' ability to utilize evidence and challenge opposing arguments became more developed after the learning intervention.

For the Guci (contra) group, the total score increased from 61 to 78. The improvement occurred in the claim, data, and warrant components, indicating that students were better able to connect environmental phenomena with relevant scientific concepts. However, the Guci (pro) group experienced a decrease in the total score from 73 to 41. The decline was observed across all argumentation components, particularly in the rebuttal aspect. This condition may have been influenced by students' limited ability to maintain their arguments during the rebuttal process and the less optimal use of supporting evidence during discussions.

Although one group experienced a decrease in score, the overall findings indicate that students' group argumentation abilities developed after the implementation of the Rebuttal Learning strategy. Discussion activities, exchange of perspectives, and the process of constructing rebuttals in SSI-based learning provided opportunities for students to evaluate information, consider multiple viewpoints, and develop more evidence-based scientific arguments.

3.4 NORMALITY TEST and HYPOTHESIS TESTING

Before conducting the hypothesis test, a normality test was performed to determine whether the data met the assumptions for parametric statistical analysis. The normality test was conducted using the Shapiro-Wilk test because the number of participants in this study was less than 50. The results of the normality test are presented in Table 5.

Table 5
Normality Test Results

	PRETEST	POSTTEST
Valid	25	25
Missing	0	0
Mean (arithmetic)	66.84	90.16
Std. Deviation	12.01	7.192

	PRETEST	POSTTEST
Shapiro-Wilk	0.9670	0.9321
P-value of Shapiro-Wilk	.569	.097

Based on Table 5, the pretest data obtained a *Shapiro-Wilk* value of 0.967 with a significance value of 0.569, while the *posttest* data obtained a *Shapiro-Wilk* value of 0.932 with a significance value of 0.097. Both significance values were greater than 0.05, indicating that the *pretest* and *posttest* data were normally distributed. Therefore, the data fulfilled the assumption for conducting parametric statistical analysis using the paired sample t-test.

The paired sample t-test was used to determine differences between pretest and posttest scores (Sugiyono, 2019). The paired sample t-test was conducted to determine whether there was a significant difference between students' scientific argumentation ability before and after the implementation of the *Socio-Scientific Issues (SSI)* model through the *Rebuttal Learning* strategy. The results of the paired sample t-test analysis are presented in Table 6.

Table 6
Paired Samples t-Test Results of Students' Scientific Argumentation Ability

Measure 1		Measure 2	t	df	p
PRETEST	-	POSTTEST	-11.93	24	< .001

Based on the results presented in Table 6, the results of the paired sample t-test showed that the obtained t-value was -11.93 with a significance value of $p < 0.001$. Since the significance value was lower than 0.05, there was a statistically significant difference between students' pretest and posttest scores. These results indicate that the implementation of the *Socio-Scientific Issues (SSI)* model through the *Rebuttal Learning* strategy was effective in improving students' scientific argumentation ability.

3.5 N-GAIN ANALYSIS

The N-Gain analysis was conducted to determine the improvement of students' individual scientific argumentation abilities after the implementation of the *Rebuttal Learning* strategy in a *Socio-Scientific Issues* (SSI) context with environmental issues as the learning theme. The N-Gain calculation was performed by comparing students' pretest and posttest scores to identify the level of improvement achieved after the learning process.

The descriptive analysis showed that the mean pretest score of students' scientific argumentation ability was 66.84, while the mean posttest score increased to 90.16. The results indicate an improvement in students' argumentation abilities after participating in the SSI-contextualized *Rebuttal Learning* activities. The results of the N-Gain analysis are presented in Table 7.

Table 7
N-Gain Analysis of Students' Individual Scientific Argumentation Ability

	NGAIN SCORE	NGAIN PERSEN

Valid	4	10
Missing	21	15
Mean (arithmetic)	157.0	71.00
Std. Deviation	312.0	26.33
Shapiro-Wilk	0.6298	0.9140
P-value of Shapiro-Wilk	.001	.309
Minimum	1.000	20.00
Maximum	625.0	100.0

Based on Table 7, the obtained N-Gain score was 0.71, corresponding to an improvement percentage of 71.00%, which was categorized as high. These findings indicate that the implementation of the *Rebuttal Learning* strategy in an SSI context with environmental issues contributed to improving students' individual scientific argumentation abilities.

The improvement reflects students' increased ability to construct scientific arguments through the components of the Toulmin Argumentation Pattern (TAP), including *claim*, *data*, *warrant*, and *rebuttal*. The learning activities involving issue analysis, evidence evaluation, argument construction, and rebuttal processes provided opportunities for students to develop more structured and evidence-based arguments.

4. CONCLUSIONS

This study demonstrates that the implementation of the *Rebuttal Learning* strategy in a *Socio-Scientific Issues* (SSI) context with environmental issues as the learning theme improved students' scientific argumentation abilities. The improvement in students' individual argumentation abilities was indicated by a significant difference between pretest and posttest scores based on the paired sample t-test results ($p < 0.001$). Furthermore, the N-Gain analysis showed a value of 0.71, categorized as high, indicating a substantial improvement in students' scientific argumentation abilities after the learning intervention.

The implementation of the *Rebuttal Learning* strategy also contributed to the development of students' group argumentation abilities based on the Toulmin Argumentation Pattern (TAP) components, including *claim*, *data*, *warrant*, and *rebuttal*. Students demonstrated improvements in constructing claims, utilizing scientific evidence, providing supporting reasoning, and responding to different viewpoints through the rebuttal process. Although variations were observed among groups, the overall argumentative discussion activities within SSI-based learning provided opportunities for students to evaluate environmental issues from multiple perspectives.

Based on these findings, the *Rebuttal Learning* strategy in an SSI context with environmental issues can be considered an alternative approach in science education to foster students' scientific argumentation abilities. This strategy facilitates learning experiences that connect scientific concepts with real-world problems while encouraging students to use evidence, engage in critical thinking, and construct logical scientific arguments.

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