



## Enhancing critical thinking skills through SSI-based POGIL in environmental pollution education

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### ABSTRACT

Critical thinking is a core 21st-century competency; however, evidence shows that many Indonesian students struggle with higher-order cognitive tasks. In a Surakarta public high school, over 50% of the Grade 10 students answered C3–C6 biology items incorrectly. The average student score represents 62.86, which falls below the minimum passing grade of 75. This significant gap indicates that lecture-based instruction provides insufficient support for student learning. This study examined the effectiveness of integrating Socio-Scientific Issues (SSI) into Process-Oriented Guided Inquiry Learning (POGIL) to improve students' critical thinking on environmental pollution. A quantitative quasi-experimental pretest–posttest design was applied to two homogeneous classes (n=36 each) selected from a total of 324 students: an experimental class receiving SSI-based POGIL and a control class receiving conventional instruction. Critical thinking was measured using a validated 10-item essay test with five indicators, supported by observations, interviews, and document analysis. Analyses were conducted using SPSS and N-gain software. The experimental class achieved a higher mean critical thinking score than the control class (89.4 vs. 56.6), with significant pre–post improvement in the experimental group ( $p=0.00<0.05$ ) but not in the control group ( $p=0.20$ ). The SSI-based POGIL implementation strongly correlated with critical thinking gains ( $r=0.835$ ;  $p=0.000$ ) and yielded a high N-gain (0.76). Observations showed the strongest performance in concluding with evidence (2.67/3.00) and a weaker performance in interpreting problems using local pollution cases over three 80-minute meetings. These findings indicate that SSI-based POGIL can enhance critical thinking in environmental pollution learning, although generalizability is limited by the small sample size.

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## INTRODUCTION

In the 21st century, critical thinking has emerged as a fundamental competency for effective decision-making, civic participation, and global competitiveness (Chitwood et al., 2014; Facione & Facione, 1996). Consequently, education systems worldwide guided by frameworks like the OECD's principles of deeper learning are prioritizing the shift from rote memorization to inquiry-collaborative approaches (Alliance, 2011; Carlgren, 2013). However, a significant gap remains between these educational demands and reality. Empirical studies reveal that many Indonesian students still demonstrate low proficiency in critical thinking, particularly in analyzing biological phenomena (Hanson et al., 2006; Irwanto et al., 2018).

The lack of critical thinking skills among students can be influenced by several factors, including the learning model of the teacher (Richard and Elder, 2013; Syafitri et al., 2021). Many learning processes are still dominated by lecture-based learning (teacher-centered), where learning activities tend to be focused on the teacher. This hinders students' active learning. Teachers require students to read, identify, describe, state, and take notes, rather than analyze, conclude, correlate, evaluate, think, and reflect (Nasreen & Naz, 2013; Soltis & Soltis, 2009).

Observations conducted from September to November 2023 revealed that the learning process was predominantly teacher-centered. Teachers frequently assigned independent tasks without adequate scaffolding and relied heavily on lecture-based explanations during the subsequent meetings. This practice aligns with findings by Klankaew (2020), who emphasizes that conventional learning models often fail to stimulate students' critical thinking skills because they position students as passive recipients of information (Klankaew et al., 2020).

Furthermore, the assignments lacked indicators of critical thinking, requiring students merely to search for factual information rather than analyze problems. As noted by Duran (2016), learning that does not involve students in active inquiry and problem-solving leads to low motivation and underdeveloped higher-order thinking skills (Duran, 2016; Syafitri et al., 2021). During interviews, teachers reported difficulties fostering critical thinking during discussions, while students expressed a lack of engagement due to the monotonous nature of instruction. Consequently, there is an urgent need to shift from this passive approach to a more student-centered model.

Biology learning involves hands-on activities that require critical thinking through an inquiry-collaborative teaching approach, which means that teachers must equip students with hard and soft skills and help them integrate both in new situations. However, in Indonesia, the concept of science is often taught through lectures, resulting in limited information for students and reducing their ability to develop independence and learning interest. Therefore, students find it challenging to explain concepts and tend to be passive (Irwanto et al., 2018; Sukarni, 2018).

The current Merdeka Curriculum demands a student-centered learning process. Many innovative and constructive learning models have been discovered and applied. Biology learning should be carried out through scientific inquiry to foster the ability to think, work, and act scientifically and to communicate this as an essential life skill (Sadler & Zeidler, 2005a; Sukarni, 2018). It is necessary to implement a learning model that enhances students' problem-solving and critical thinking skills. One of the applied learning models is Process-Oriented Guided Inquiry Learning (POGIL), a collaborative, inquiry-based learning approach (Douglas & Chiu, 2013).

The inquiry collaborative learning model serves as a foundation for fostering independent problem solving skills by engaging students in researching and explaining scientific phenomena (Trna et al., 2012). A prominent implementation of this approach is Process Oriented Guided Inquiry Learning (POGIL), which enhances critical thinking through a structured learning cycle consisting of exploration, concept formation, and application (Hanson et al., 2006; Sukarni, 2018).

By working in collaborative groups to answer guided questions, students actively restructure information and negotiate ideas, thereby shifting the learning dynamic from passive reception to active construction of knowledge (Bailey et al., 2012b; Hanson et al., 2006). To maximize the effectiveness of POGIL, this study integrates it with Socio-Scientific Issues (SSI), creating a synergistic effect that connects abstract scientific concepts with controversial real-world problems. While POGIL provides the inquiry structure, SSI injects context by requiring students to employ moral reasoning and evidence-based evaluation (Sadler & Zeidler, 2005b; Simonneaux, 2013). This integration transforms the curriculum into an issue-based approach, ensuring that students do not merely memorize facts but are prepared as 21st-century citizens capable of navigating the intersection of science, technology, and

society (Nurtamara et al., 2019; Utomo et al., 2020).

Specifically, applying the SSI-based POGIL model to the topic of environmental pollution offers a pedagogical strategy that stimulates both intellectual and ethical development (Utomo et al., 2020). Environmental pollution serves as an ideal context for SSI because it presents complex, ill-structured problems that intertwine scientific facts with social, economic, and ethical dimensions (Douglas & Chiu, 2013; Simonneaux, 2013). Consequently, mastering this material requires high-level cognitive skills to evaluate conflicting evidence and formulate sustainable solutions, rather than simple rote learning (Sadler, 2011). This approach addresses the limitations of conventional teaching by encouraging students to analyze complex environmental crises through a multidimensional lens (Simonneaux, 2013). Consequently, this method aligns perfectly with the holistic demands of Kurikulum Merdeka, which emphasizes the development of students' ability to think, act, and reflect scientifically in facing everyday challenges (Bailey et al., 2012b; Hanson, 2015).

While previous studies have examined POGIL and SSI independently, such as Walker and Warfa (2017) those that focused on the effect of POGIL on achievement (Utomo et al., 2020), which explored SSI in problem-based learning, limited research has investigated the synergistic effect of integrating SSI explicitly into the POGIL syntax, particularly for environmental pollution topics in the Indonesian context (Irwanto et al., 2018; Nurtamara et al., 2019). This research is urgent because relying solely on conventional POGIL without the emotional and contextual hook of socio-SSIs often fails to fully engage students' moral reasoning. By infusing SSI, this study offers a novel pedagogical approach that aligns with the *Kurikulum Merdeka* demand for holistic competence, addressing the critical gap in students' ability to solve real-world environmental crises.

Based on the identified gap and proposed pedagogical innovation, this study aims to determine the effectiveness of the SSI-based POGIL model in enhancing students' critical thinking skills regarding environmental pollution material. Specifically, this research addresses the following question: "To what extent does the implementation of the SSI-based POGIL model significantly improve the critical thinking indicators of 10<sup>th</sup>-grade students compared to the conventional scientific approach?"

## METHODS

### Research Design

This quantitative study used a quasi-experimental design. The subjects were randomly selected, with each having an equal chance of being selected (Miller et al., 2020). The design used was a pretest-posttest-only non-equivalent control group, as it examined the results of the control and experimental classes before and after the treatment was administered (Shadish & Cook, 2002). One class served as the control group, where the SSI-based POGIL model was not applied, and the other class applied the SSI-based POGIL model. The control group was given a pretest to measure their initial abilities, and a posttest was administered to test their critical thinking skills. Details of the Pretest-Posttest Only Non-equivalent Control Group design are shown in Table 1

**Table 1**

Research Design

Group	Sample	Pretest	Treatment	Posttest
Experiment (E)	36	T	X	H
Control (C)	36	T	-	H
Total	72			

The description of the table consists of: K: Control class with 36 students (not given the SSI-based POGIL treatment), E: Experimental class with 36 students (given the SSI-based POGIL treatment), X: Class that received the SSI-based POGIL treatment, -: Class that did not receive the SSI-based POGIL treatment, T: Pretest for both classes, H: Posttest for both classes.

As shown in Table 1, in the teaching and learning process, the experimental class received treatment using the SSI-based POGIL model, while the control class received no treatment. Both classes were given a pretest, and at the final stage, a posttest was conducted to determine the differences in students' critical thinking skills between the two models.

### Population and Samples

The sampling technique used was cluster random sampling, because the sample selected refers to groups, not individuals. As explained (Taherdoost, 2018), cluster random sampling means that each case in the population has an equal probability of being included in the sample. The selected classes are

based on normality and homogeneity tests. Then, the experimental and control classes are randomly selected.

The population in this study consisted of all 10th-grade students at Surakarta State Senior High School who had not yet studied the environmental pollution chapter, totaling 324 students across nine classes. A sample is a group of elements that are directly studied (Khalid, 2024). Another statement also conveys that a sample is a group of elements selected from a larger group with the hope that studying the smaller group (sample) will reveal important information about the larger group (population) (Taherdoost, 2018). The sample consisted of two classes, namely class X MIPA 3 and X MIPA 4, which had previously undergone normality and homogeneity tests to determine two classes from all classes in Phase E, namely class X high school in Surakarta, as the control and experimental class samples.

### Instrument

The research instruments used to measure students' critical thinking skills include learning devices and teaching modules. These learning materials were designed to facilitate several ways to improve critical thinking skills, namely: (1) practicing reading critically, (2) engaging in discussions to analyze a problem to find the best solution, (3) optimizing the use of senses to make observations, and (4) being curious about something (Ariyati et al., 2021).

The instruments used included content validity and construct validity tests. The research instruments used to measure students' critical thinking skills include learning devices and teaching modules. Construct validity tests were conducted on the test instruments for critical thinking ability (Brown, 2010). The validity of the written test items was measured using Pearson's correlation with a significance level of 0.05. If the calculated  $r$  is greater than the table  $r$ , the test item is considered valid (Marselina & Siregar, 2017). Reliability testing was conducted using SPSS 29, with Cronbach's alpha at the 0.05 significance level. Test instruments are considered reliable if the calculated  $r$  is greater than the table  $r$  (Janna & Herianto, 2021).

### Validity Test

Research instruments underwent rigorous validity testing. Content validity for teaching modules was established through expert judgment by UNS Biology Education lecturers, resulting in an "excellent" rating and subsequent refinements based on feedback. Meanwhile, construct validity for the critical thinking test was assessed using Pearson's product-moment correlation (0.05). The analysis confirmed high validity ( $r_{\text{count}} > r_{\text{table}}$ ), rendering the instrument suitable for data collection (Marselina & Siregar, 2017).

### Reliability Test

Reliability is a measure of the stability of respondents' consistency in answering questions related to the construction of questions that are dimensions of a variable (Marselina & Siregar, 2017). Research instruments must be reliable, usable repeatedly, and exhibit good consistency (Nasution, M., 2016). The reliability test was conducted using SPSS 29, with Cronbach's alpha at a significance level of 0.05. The instrument is considered reliable if the calculated  $r$  is greater than the table  $r$  (Janna & Herianto, 2021). The test results showed that the research instrument had a high reliability coefficient (above the  $r$ -table threshold), indicating excellent consistency and suitability for measuring research data.

### Normality Test

The normality test was conducted using the Kolmogorov-Smirnov test with a significance level of 0.05; thus,  $H_0$  was accepted. This implies that the data are usually distributed. The results of the normality tests are shown in the [table 3](#).

**Table 3**

Normality Test

	Test	N	sd	Statistic	Sig
Experiment	Pretest	36	7.23	0.126	0.198
	Posttest	36	9.45	0.137	0.094
Control	Pretest	32	7.56	0.120	0.200
	Posttest	32	6.04	0.136	0.140

Based on [Table 3](#), the data on critical thinking ability, as measured by pretest and posttest scores in the experimental class, showed significance of 0.198 for the pretest and 0.094 for the posttest; thus, the data were normally distributed because both were  $>0.05$ . Meanwhile, the normality test results for

the control class yielded p-values of 0.20 for the pretest and 0.14 for the posttest, indicating that the data were normally distributed because both were  $>0.05$ . The normality test assesses the distribution of data within a dataset or variable, whether it is normally distributed. A data homogeneity test was conducted on the pre- and post-test scores for critical thinking ability questions. The homogeneity test used Levene's test formula in SPSS at a 5% significance level. The homogeneity test determines whether several population variances are equal.

### Homogeneity Test

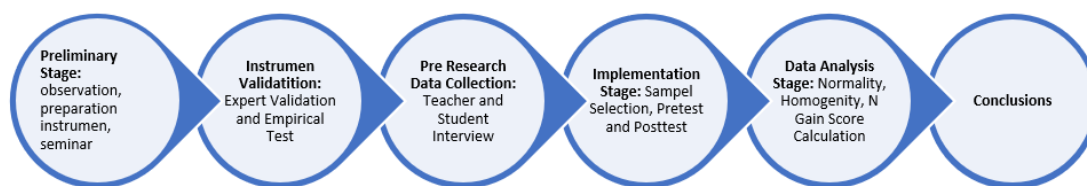
The homogeneity test was conducted using Levene's test, with a p-value  $> 0.05$ ; therefore,  $H_0$  was accepted, indicating that the research data were homogeneous. Hypothesis testing was performed using SPSS 25, as shown in Table 4.

**Table 4**  
Homogeneity Test

		Levene Statistic	df1	df2	Sig
Critical Thinking	Experiment	1.470	1	70	0.229
	Control	0.470	1	62	0.514

### Procedure

The research was conducted in a systematic series of stages to ensure the validity and reliability of the data. The procedure began with a preliminary study, followed by instrument validation, implementation of the SSI-based POGIL model, and concluded with the data analysis. The detailed flow of the research procedure is shown in Figure 1.



**Figure 1.** Flowchart of Research

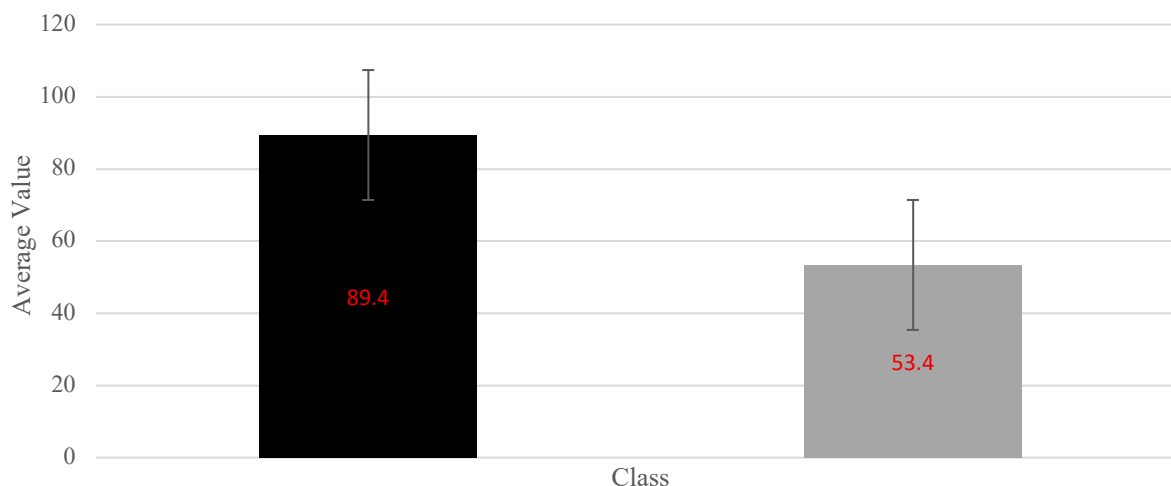
The research procedure encompassed preparation, implementation, and analysis stages. The preparation phase involved securing administrative permissions and expert validation of instruments. Data collection subsequently utilized unstructured interviews for preliminary needs analysis, a validated 10-item essay test to measure critical thinking indicators, and non-participatory observations using a 5-point Likert scale to monitor the learning syntax. Additionally, documentation of curricular and classroom activities was compiled to support the findings. The implementation stage was then conducted in two selected classes an experimental group using SSI-based POGIL and a control group followed by the statistical analysis of pre and post-test scores using SPSS.

### Data Analysis Techniques

The data analysis technique was conducted with prerequisite tests, namely, normality and homogeneity tests. An Independent-Samples T-Test was used to test the first hypothesis to determine the effect of the SSI-based POGIL model on critical thinking skills. The second hypothesis was tested using a correlation test to examine the relationship between the use of the SSI-based POGIL model and aspects of students' critical thinking skills. The third hypothesis test used N-Gain calculations to determine the effectiveness of the SSI-based POGIL model in improving critical thinking skills of the students.

## RESULTS AND DISCUSSION

Based on the research conducted, the results were the pretest and posttest scores from questions on critical thinking skills related to environmental pollution. The research results are explained in Figure 2.



**Figure 2.** Graph of Critical Thinking Ability Scores.

As shown in [Figure 2](#), the experimental class significantly outperformed the control class (mean score: 89.4 vs. 56.6), demonstrating the superior effectiveness of the SSI-based POGIL model. Further details on score distributions are provided in [Table 2](#).

**Table 2**  
Frequency Distribution of Pretest-Posttest Scores

Value	Categori	Pretest		Posttest	
		Experiment	Control	Experiment	Control
80-100	Very good	-	-	52.7%	-
66-79	Good	8.3%	-	38.8%	-
56-65	Enaugh	27.7%	23.5%	8.3%	37.5%
40-55	Poor	63.8%	76.5%	-	62.5%
0-39	Failed	-	-	-	-

As presented in [Table 2](#), there is a marked difference in post-intervention improvements. Despite a homogeneous baseline where over 50% of both groups began in the 'poor' category, the experimental class exhibited superior progression, with 52.7% achieving 'outstanding' scores. In contrast, the control class only reached the 'sufficient' level (37.5%). Prior to hypothesis testing, the normality of the data distribution was verified via the Kolmogorov-Smirnov test ( $\alpha = 0.05$ ).

Homogeneity testing ([Table 4](#)) confirmed equal variances for both the experimental ( $p=0.229$ ) and control classes ( $p=0.514$ ), as both values exceeded the significance level of 0.05. With the prerequisites of normality and homogeneity satisfied, a t-test was subsequently employed to analyze the differences in pre- and post-test critical thinking scores, as detailed in [Table 5](#).

**Table 5**  
Independent Simple T-Test

		Sig (2-tailed)	Mean Difference	Std. Error Difference
Experiment	assumed	0.00	-25.222	1.98466
	not assumed	0.00	-25.222	1.98466
Control	assumed	0.228	-2.2098	1.8139
	not assumed	0.223	-2.2098	1.7920

The Paired Sample T-test results ([Table 5](#)) reveal a significant difference in the experimental class ( $p = 0.00 < 0.05$ ), indicating a marked improvement in critical thinking skills after the SSI-based POGIL treatment. Conversely, the control class showed no significant change ( $p = 0.20 > 0.05$ ). This significant disparity confirms that while the conventional lecture method failed to generate cognitive growth, the SSI-based POGIL model effectively enhanced students' critical thinking capabilities (Kuhlthau, C., 2010; Sukarmin et al, 2020; Suwono et al., 2021).

The superiority of the experimental group is attributed to the synergistic effect of the SSI-based POGIL model, which anchors learning in real-world contexts. Aligning with Vygotsky's Social

Constructivism, the model fosters cognitive development through social interaction within the Zone of Proximal Development (ZPD). By debating controversial environmental issues (SSI) in small groups, students are compelled to externalize thoughts, challenge assumptions, and reconstruct their understanding (Sukarmin et al, 2020; Wertsch & Louis, 2010). This active inquiry process allows students to evaluate scientific information and participate in decision-making, which is significantly more effective than passive rote learning (Kuhlthau, C., 2010; Sukarmin et al, 2020).

Furthermore, the structured allocation of group roles (manager, spokesperson, recorder, and strategy analyst) played a pivotal role in this improvement. These roles necessitated active participation and accountability, preventing passivity (Howley, 2020; Ningsih & Bambang, 2012). This collaborative structure required students to exchange opinions, provide feedback, and clarify concepts to peers who struggled. Consequently, the dynamic exchange of ideas within these heterogenous groups served as a direct training ground for critical thinking and problem-solving skills (Campbell et al, 2019; Rodriguez et al., 2020).

**Table 6**  
Pearson Correlations

		Critical Thinking	POGIL-SSI
Critical Thinking	Pearson Correlation	1	0.835
	N	-	0.000
	Sig. (2-tailed)	72	72
POGIL-SSI	Pearson Correlation	0.835	1
	N	0.000	-
	Sig. (2-tailed)	72	72

Based on Table 6, the significance value ( $0.000 < 0.05$ ) and a correlation coefficient of 0.835 indicate a very strong, positive relationship between the SSI-based POGIL model and critical thinking skills. This implies that the rigorous implementation of POGIL stages directly correlates with improved cognitive abilities. This strong relationship is attributed to the model's syntax specifically the 'Exploration' and 'Concept Invention' phases which compels students to analyze data and formulate patterns rather than memorize facts (Campbell et al, 2019; Mamombe et al., 2022; Walker & Warfa, 2017). Furthermore, integrating Socio-Scientific Issues serves as a cognitive trigger, requiring students to evaluate conflicting evidence through collaborative inquiry. This active process, supported by teacher scaffolding, provides the concrete experience necessary for developing higher-order thinking skills (Bailey et al., 2012a; Chengere, 2025; Idul & Caro, 2022; Mahanani et al, 2019; Ningsih & Bambang, 2012)

To further validate this effectiveness, the third hypothesis was tested using N-Gain calculations to determine the specific improvement levels, as shown in Table 7.

**Table 7**  
Interpretation of N-Gain Score

N-Gain Score	Criteria
$g \geq 0.7$	High
$0.3 \leq g < 0.7$	Medium
$g < 0.3$	Low

(Hake, 2001)

The N-Gain score interpretation criteria used in this study are listed in Table 7. Based on this grouping, the effectiveness of improving learning outcomes is divided into three levels: high category if more than or equal to 0.7, medium category if less than or equal to 0.3 to less than 0.7, and low category if less than 0.3 (Hake, 2001).

**Table 8**  
N-Gain Score Calculation

	N	Mean	Sd
N-Gain	36	0.7691	0.20347
Valid N (listwise)	36	-	-

Based on [Table 8](#), the N-Gain score for critical thinking ability questions using the SSI-based POGIL learning model was 0.76. This result falls into the high category. These suggest that the SSI-based POGIL model can be effective in improving students' critical thinking skills (Ariza et al., 2021).

The findings of this study demonstrate that the SSI-based POGIL model significantly enhances students' critical thinking skills regarding environmental pollution material. This is evidenced by the N-Gain score of 0.76, categorized as highly effective. These results align with previous studies confirming that POGIL effectively shifts learning from rote memorization to active inquiry, thereby elevating cognitive abilities. Furthermore, the effectiveness of this model lies in the synergy between POGIL's structured syntax and SSI's contextual engagement. As noted by Amos and Levinson (2019), integrating SSI into POGIL exploration activities empowers students to actively interpret problems and synthesize solutions, a capability that is significantly superior to standard guided inquiry approaches (Amos & Levinson, 2019; Mufarohah & Dwiningsih, 2018)

A key factor in this success is the use of localized environmental pollution topics (e.g., Putri Cempo Landfill and Sekartaji WWTP). The concrete nature of these problems connects abstract concepts with students' daily lives. Environmental pollution presents complex, real-world issues that naturally demand critical thinking to critique and solve. By using data directly collected from the students' surroundings, the learning process becomes emotionally and socially relevant. This relevance motivates deeper engagement and higher retention of critical thinking skills compared to abstract scientific issues, fostering both cognitive improvement and scientific literacy (Ariza et al., 2021; Walker & Warfa, 2017)

Based on the observation of the implementation of the syntax, learning in the experimental class was in accordance with the POGIL syntax integrated with SSI. Activities in the inquiry-collaborative learning model integrated with SSI have an impact on students' critical thinking skills (Georgiou, 2023; Stegall et al., 2016). The POGIL model, when integrated with SSI, requires students to actively participate in group discussions and communicate their findings, thereby strengthening their communication and critical-thinking skills. The SSI-based POGIL model used can stimulate students' critical thinking skills regarding the problems presented (Artuz & B. Roble, 2021; Rauch & Radmann, 2020).

An in-depth analysis of the critical thinking indicators reveals a specific trend across the POGIL stages. The highest proficiency was observed in the "Closing" stage (Score: 2.67), specifically in the indicator of evaluating results and concluding (Hapsari, 2023; Vincent-ruz et al., 2020). This high score indicates that the controversial nature of SSI topics successfully motivated students to weigh evidence carefully before drawing conclusions. This supports Sadler and Zeidler (2005) and Walker and Warfa (2017), who argue that SSI contexts sharpen students' moral and evidence-based reasoning. The validation process at the closing stage proved crucial for solidifying these concepts (Qamariyah et al., 2021; Sadler & Zeidler, 2005a; Walker & Warfa, 2017).

Conversely, the lowest indicator was "interpreting problems" (Score: 2.44), primarily associated with the "Orientation" stage. While students excelled at evaluating outcomes, they faced challenges in the initial deconstruction of complex problems (Adzani et al., 2019; Soraya et al., 2024). This suggests that defining issues in open-ended SSI contexts imposes a higher cognitive load. As Guleker and Keci (2014) imply, the transition from passive listening to active interpretation requires significant adjustment. Therefore, future implementation necessitates stronger scaffolding during the Orientation phase to help students connect prior knowledge with new phenomena effectively (Dewi, 2013; Guleker & Keci, 2014).

In contrast, the control class demonstrated significantly lower critical thinking abilities due to the reliance on the lecture method (Sudartik et al., 2023). This approach resulted in passive learning, where information was retained only in short-term memory without deep cognitive processing (Falahudin et al., 2016; Supriyatno et al., 2020) This confirms Jayawardana's (2017) assertion that teacher-centered methods often lead to low engagement and are incompatible with constructivist paradigms. The lack of active participation in the control class where students merely listened and took notes aligns with Supiyati (2020; 2022), who states that such approaches fail to stimulate learning discipline, causing students to struggle in conveying concepts accurately (Jayawardana, 2017; Supiyati et al., 2019).

The strengths of this study lie in the novel integration of local environmental issues with the POGIL model, which is rarely explored in this specific context. However, limitations exist regarding the restricted sample size (Classes X MIPA 3 and 4) and facility constraints. Future research should expand the population and utilize more interactive blended learning materials to further enhance the learning infrastructure (Guleker & Keci, 2014; Wijaya & Handayani, 2021).

## CONCLUSION

The research results demonstrate that implementing the Socio Scientific Issues (SSI) based Process Oriented Guided Inquiry Learning (POGIL) model significantly affects students' critical thinking skills in the subject of environmental pollution with  $p < .05$ . Specifically, the model had the greatest impact on the indicator of evaluating results with relevant evidence, enabling students to draw valid conclusions and effectively communicate material concepts during discussions. Furthermore, the SSI-based POGIL model proves effective with an N-gain of 0.76 in enhancing critical thinking skills through its structured activities, which encompass orientation, exploration, concept discovery, application, and closing.

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