



IMPLEMENTATION OF GUIDED INQUIRY INTERACTIVE REINFORCEMENT TO IMPROVE JUNIOR HIGH SCHOOL STUDENTS' SCIENTIFIC LITERACY

PENERAPAN PENGUATAN INTERAKTIF BERBASIS PENYELESAIAN MASALAH TERBIMBING UNTUK MENINGKATKAN LITERASI SAINS SISWA SEKOLAH MENENGAH PERTAMA

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Abstract

The low level of students' scientific literacy indicates the need for learning approaches that can train scientific thinking process through inquiry activities. This study aims to compare the effectiveness of Guided Inquiry Interactive Reinforcement learning with Guided Inquiry learning without Interactive Reinforcement on the topic of global warming in improving junior high school students' scientific literacy. This research employed a quantitative approach with a quasi-experimental design conducted at a public junior high school in Sidoarjo Regency. This research subjects were students of class IX F as the experimental class and class IX B as the control class. Data were collected through scientific literacy test instrument, learning implementation observation sheets, and student response questionnaires. The test data were analyzed using the Mann-Whitney U test, effect size calculation, and N-Gain, while the data from the observation of learning implementation and student response questionnaires were analyzed descriptively using quantitative methods. The results showed that there was a significant difference in scientific literacy between the experimental class and the control class with an Asymp. Sig. (2-tailed) value of $<0,001$. The effect size calculation obtained a value of $|r| = 0,869$, categorized as a large effect, indicating a very strong influence. The improvement in scientific literacy in the experimental class was higher with an average N-Gain of 0,927 (high category) compared to the control class with 0,783 (high category). The level of scientific literacy also increased from level 2 in the pretest to level 6 in the experimental class and level 5 in the control class in the posttest. These results were supported by the implementation of learning in both classes, which was categorized as very good, and student responses that showed very good criteria with a higher percentage in the experimental class. Based on these findings, the Guided Inquiry Interactive Reinforcement learning model is proven to be more effective in improving junior high school students' scientific literacy. This learning model is recommended to be applied to science topics that have contextual characteristics in order to enhance students' scientific literacy.

Keywords : Scientific Literacy, Guided Inquiry, Interactive Reinforcement, Global Warming.



Abstrak

Rendahnya tingkat literasi sains siswa menunjukkan perlunya pendekatan pembelajaran yang dapat melatih proses berpikir ilmiah melalui kegiatan penyelidikan. Penelitian ini bertujuan untuk membandingkan efektivitas pembelajaran Penyelidikan Terpandu dengan Penguatan Interaktif terhadap pembelajaran Penyelidikan Terpandu tanpa Penguatan Interaktif pada topik pemanasan global dalam meningkatkan literasi sains siswa sekolah menengah pertama. Penelitian ini menggunakan pendekatan kuantitatif dengan desain kuasi-eksperimental yang dilaksanakan di sebuah SMP negeri di Kabupaten Sidoarjo. Subjek penelitian ini adalah siswa kelas IX F sebagai kelas eksperimen dan kelas IX B sebagai kelas kontrol. Data dikumpulkan melalui instrumen tes literasi sains, lembar observasi pelaksanaan pembelajaran, dan kuesioner tanggapan siswa. Data tes dianalisis menggunakan uji Mann-Whitney U, perhitungan ukuran efek, dan N-Gain, sedangkan data dari pengamatan pelaksanaan pembelajaran dan kuesioner tanggapan siswa dianalisis secara deskriptif menggunakan metode kuantitatif. Hasil menunjukkan bahwa terdapat perbedaan yang signifikan dalam literasi sains antara kelas eksperimen dan kelas kontrol dengan nilai Asymp. Sig. (2-tailed) sebesar $<0,001$. Perhitungan ukuran efek memperoleh nilai $|r|=0,869$, dikategorikan sebagai efek besar, yang menunjukkan pengaruh yang sangat kuat. Peningkatan literasi sains pada kelas eksperimen lebih tinggi dengan rata-rata N-Gain sebesar 0,927 (kategori tinggi) dibandingkan dengan kelas kontrol sebesar 0,783 (kategori tinggi). Tingkat literasi sains juga meningkat dari level 2 pada pra-uji menjadi level 6 pada kelas eksperimen dan level 5 pada kelas kontrol pada pasca-uji. Hasil ini didukung oleh implementasi pembelajaran di kedua kelas yang dikategorikan sangat baik, serta tanggapan siswa yang menunjukkan kriteria sangat baik dengan persentase yang lebih tinggi pada kelas eksperimen. Berdasarkan temuan ini, model pembelajaran Guided Inquiry Interactive Reinforcement terbukti lebih efektif dalam meningkatkan literasi sains siswa SMP. Model pembelajaran ini direkomendasikan untuk diterapkan pada topik-topik sains yang memiliki karakteristik kontekstual guna meningkatkan literasi sains siswa.

Kata Kunci : Literasi Ilmiah, Penyelidikan Terpimpin, Penguatan Interaktif, Pemanasan Global.

1. INTRODUCTION

Science education plays a strategic role in developing students' critical, logical, and creative thinking while preparing them to compete globally through contextual learning that connects scientific concepts with everyday life (Irsan, 2021). Scientific literacy is an essential competency because it enables individuals to master, communicate, and use scientific knowledge to solve problems, make evidence-based decisions, and develop high environmental awareness (Anandari & Suama, 2023). Scientific literacy also shapes character and prepares individuals to face the rapid development of science and technology in an information-based society (Ala Purnawati & Nurul Yakin, 2025; Rokhmah & Fauziah, 2021).

The level of scientific literacy in Indonesia remains relatively low based on international assessments. The Programme for International Student Assessment (PISA) 2022 reported a science literacy score of 383, placing Indonesia 68th out of 81 participating countries and below the international average score of 500 (OECD, 2023). The Trends in International Mathematics and Science Study (TIMSS) 2015 also reported a score of 397, placing Indonesia 44th out of 49 countries and below the international average score of 500 (TIMSS, 2015). The Minimum Competency Assessment reported that one out of two students has not reached the expected competency level, indicating difficulties in reading information and understanding context as important prerequisites for scientific literacy development (Kemendikbud, 2021). These findings indicate that students' scientific literacy in Indonesia requires serious attention.

A preliminary study conducted at a public junior high school in Sidoarjo Regency involving nine ninth-grade classes shows that students' scientific literacy remains relatively low with an average achievement of 53%. Achievement in explain scientific phenomena reached 78% (high category), design and evaluate scientific investigations reached 33% (very low category), interpret data and



evidence critically reached 58% (moderate category), and investigate and use scientific information for decision-making and action reached 41% (low category). Referring to the scientific literacy achievement criteria proposed by Adriadi et al. (2025), these results indicate that students' abilities are still relatively low. Interviews with science teachers indicate that learning activities tend to emphasize conceptual explanation while scientific investigation and evidence-based reasoning have not developed optimally. These conditions indicate that students have not yet applied scientific knowledge and scientific processes comprehensively.

Several factors contribute to the low level of scientific literacy, including weak conceptual understanding, limited ability to interpret data, and students' low tendency to ask questions (Yusmar & Fadilah, 2023). Learning practices that emphasize memorization limit students' ability to connect scientific concepts with real-life contexts and hinder the development of scientific thinking skill (Juwita & Rosidin, 2022; Maulina et al., 2022). These conditions indicate the need for learning approaches that involve active investigation and analysis of real-world problems (Krishantari et al., 2025).

Guided inquiry learning has been widely reported to improve scientific literacy because it engages students in structured investigation processes that connect concepts with real-life problems and encourage independent concept discovery (Albina et al., 2022; Aprilia et al., 2021). Guided inquiry also strengthens scientific reasoning and improves scientific literacy in terms of content, context, and scientific processes (Jannah et al., 2024; Nasir et al., 2023; Warmadewi, 2022). Guided inquiry learning aligns with constructivist learning theory which emphasizes that students actively construct knowledge through interaction with experiences and their environment. Jean Piaget highlighted cognitive development through active exploration, while Lev Vygotsky emphasized the importance of social interaction and guidance in the Zone of Proximal Development. John Dewey also argued that effective learning occurs through direct experience and reflective thinking (Jalil, 2019).

Several studies report that weaknesses still occur during orientation, hypothesis formulation, data analysis, and conclusion stages, indicating that students require stronger support during the inquiry process. Reinforcement strategies strengthen students' responses and shape expected learning behaviors through feedback during the learning process based on behaviorist learning theory (Skinner, 2014). Interactive reinforcement can clarify students' responses, stimulate critical thinking, and strengthen the relationship between scientific evidence and concepts. Previous studies show that combining guided inquiry with reinforcement strategies can improve scientific literacy (Izzati & Handayanto, 2021). Research that systematically integrates Guided Inquiry Interactive Reinforcement at every stage of learning remains limited, particularly on the topic of global warming. The global warming topic provides a relevant context for developing scientific literacy because it requires students to analyze evidence, evaluate scientific information, and make decisions related to environmental issue (Sidik et al., 2025).

This study applies the Guided Inquiry Interactive Reinforcement model across all stages of the inquiry process to enhance junior high school students' scientific reasoning and literacy. It aims to examine the effectiveness of this approach in improving junior high school students' scientific literacy on the topic of global warming.

2. RESEARCH METHOD

This study employed a quantitative approach using a quasi-experimental design, specifically the nonequivalent control group design. The research was conducted at a public junior high school in Sidoarjo Regency during the second semester of the 2025/2026 academic year. The research involved two classes: class IX F as the experimental group, which received the Guided Inquiry Interactive Reinforcement learning model, and class IX B as the control group, which was taught using the Guided Inquiry model without Interactive Reinforcement. Each class consisted of 31 students. The sample was selected using purposive sampling based on students' cognitive average scores and the results of a preliminary scientific literacy assessment.



The research procedure began with the administration of a pretest to determine students' initial scientific literacy in both groups. The experimental group then received learning through the Guided Inquiry Interactive Reinforcement model, while the control group was taught using Guided Inquiry without Interactive Reinforcement. After the learning process was completed, a posttest was administered to both groups to measure the improvement in students' scientific literacy. The study was conducted in two meetings with a total of four instructional hours on the topic of global warming.

Data collection techniques consisted of test and non-test methods. The test consisted of scientific literacy questions, including eight multiple-choice items and four essay questions administered during the pretest and posttest. Non-test techniques included observation of learning implementation and student response questionnaires regarding the learning process. The collected data were analyzed using prerequisite tests, namely normality and homogeneity tests. Since the data were not normally distributed, the hypothesis testing was conducted using the Mann-Whitney U nonparametric test. Additionally, N-Gain analysis was used to determine the improvement in students' scientific literacy, and effect size analysis was conducted to determine the effectiveness level of the applied learning model.

3. RESULT AND DISCUSSION

a. Mann-Whitney U Test

Table 1. Mann-Whitney U Test Results

Test Statistics		
	Pretest	Posttest
Mann-Whitney U	399.000	2.500
Wilcoxon W	895.000	498.500
Z	-1.148	-6.842
Asymp. Sig. (2-tailed)	.251	<.001
Grouping Variable: Kelas		

The results of the Mann-Whitney U test in Table 1 show the Asymp. Sig. (2-tailed) value for the pretest was 0.251 (<0.05), indicating no significant difference in students' initial scientific literacy abilities between the experimental class and the control class. The posttest results shows an Asymp. Sig. (2-tailed) value of <0,001 (<0.05), indicating a significant difference in students' scientific literacy abilities between the experimental class that implemented Guided Inquiry Interactive Reinforcement learning and the control class that implemented Guided Inquiry learning without Interactive Reinforcement after treatment.

b. Effect Size

The prerequisite test showed that the parametric assumptions were not met, so the test was conducted using the Mann-Whitney U test. A non-parametric effect size calculation was conducted to determine the strength of the difference in the increase in scientific literacy between the experimental and control classes.

$$z = \frac{U - \frac{n_1 \times n_2}{2}}{\sqrt{n_1 \times n_2 \times \frac{n_1 + n_2 + 1}{12}}}$$

$$r = \frac{z}{\sqrt{N}}$$

(Cohen, 1992; Peres, 2026)

Based on the value of $z = -6.842$ in Figure 4.7 and $N = (n_1 + n_2) = 62$, the calculation is carried out as follows:

$$r = \frac{z}{\sqrt{N}}$$



$$r = \frac{-6,842}{\sqrt{62}}$$

$$r = \frac{-6,842}{7,874}$$

$$r = -0,869$$

$$|r| = 0,869$$

The effect size calculation results show a value of $|r|=0.869 \geq 0.050$, which is categorized as large. This findings indicates that the Guided Inquiry Interactive Reinforcement model has a very strong effect on improving students' scientific literacy compared to Guided Inquiry learning without Interactive Reinforcement.

c. N-Gain of Each Aspect Indicator in the Science Literacy Competency Aspect

The N-Gain analysis shows improvements in students' scientific literacy across all competency indicators, with differences between the experimental and control classes presented in Figure 1.

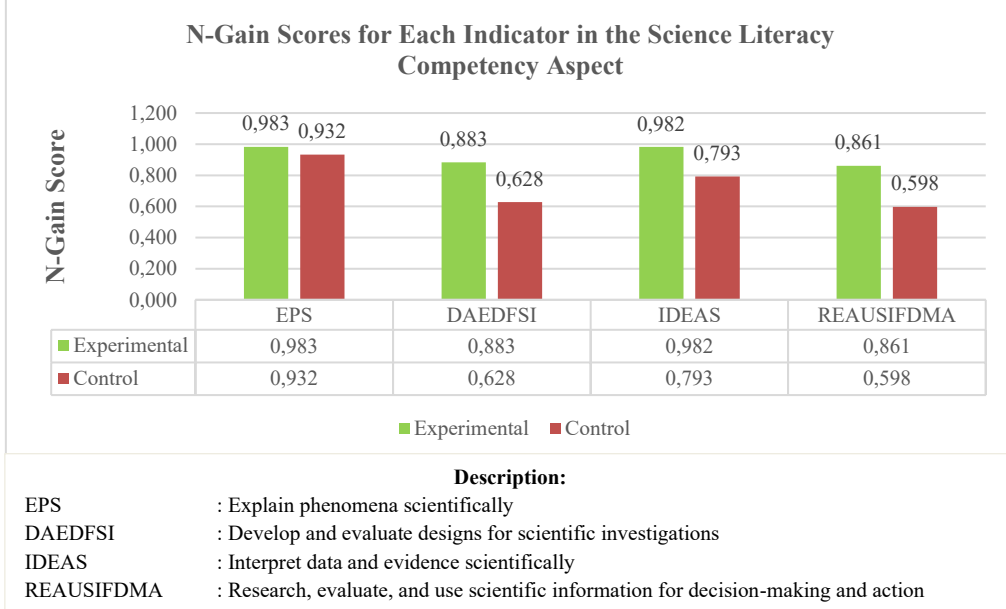


Figure 1. Graph of N-Gain Scores for Each Indicator in the Science Literacy Competency Aspect

The N-Gain scores of students' scientific literacy for each competency indicator on the global warming topic show differences between the experimental and control classes. The experimental class obtained N-Gain scores ranging from 0,861 to 0,983, all categorized as high (N-Gain $\geq 0,70$). In contrast, the control class had N-Gain scores ranging from 0,598 to 0,932 with more varied categories. In the control class, indicator 2 (designing and evaluating scientific investigations) achieved an N-Gain of 0,627, and indicator 4 (examining, evaluating, and using scientific information for decision-making) obtained 0,598 both categorized as moderate. Overall, the average N-Gain of the experimental class (0,927) was higher than that of the control class (0,738), indicating that the improvement in scientific literacy was greater and more consistent in the experimental class.

d. Increasing the Level of Scientific Literacy

This study analyzes the increase in students' scientific literacy levels to strengthen the answer to the difference in students' scientific literacy improvement between the Guided Inquiry Interactive Reinforcement class and the Guided Inquiry class without Interactive Reinforcement. The data recapitulation in the appendix serves as the basis for determining the percentage level based on the pretest and posttest scores in each class according to the interpretation of the scientific literacy level categories. Figure 2 presents the results of these percentages.



No.	Observed Aspects	Mode							
		Experimental Class				Control Class			
		P ₁	Cr	P ₂	Cr	P ₁	Cr	P ₂	Cr
10.	Closing	4	VG	4	VG	4	VG	4	VG
11.	Technical implementation	4	VG	4	VG	4	VG	4	VG
12.	Learning evaluation	4	VG	4	VG	4	VG	4	VG
Mode of Learning Implementation		4	VG	4	VG	VG	VG	VG	VG

Notes:P₁ : Meeting 1

Cr : Criteria

P₂ : Meeting 2

VG : Very Good

The results showed that all observed aspects of learning implementation in both the experimental and control classes obtained a mode score of 4 (Very Good) in both meetings, indicating consistent and comparable implementation of the learning process.

f. Student Responses**Table 3. Student Response Summary**

Statement Type	Statement Number	Experimental Class		Control Class	
		Percentage (%)	Criteria	Percentage (%)	Criteria
Positive	1	95	VG	85	VG
	2	96	VG	81	VG
	3	95	VG	82	VG
	4	94	VG	82	VG
	5	94	VG	85	VG
	6	91	VG	81	VG
	7	94	VG	83	VG
	8	90	VG	81	VG
Negative	9	91	VG	85	VG
	10	94	VG	85	VG
	11	94	VG	84	VG
	12	94	VG	85	VG
	13	94	VG	83	VG
	14	96	VG	85	VG
	15	93	VG	85	VG
	16	90	VG	84	VG

Notes:

VG : Very Good

The experimental class obtained percentages above 90% on all items, while the control class ranged from 81% to 85%, both categorized as Very Good. The higher scores in the experimental class indicate that Guided Inquiry Interactive Reinforcement increased students' engagement and supported the improvement of scientific literacy.

Discussion

This study compared the effectiveness of the Guided Inquiry Interactive Reinforcement learning model with Guided Inquiry without Interactive Reinforcement. The results of the Mann–Whitney U test showed an Asymp. Sig. (2-tailed) value $< 0,001$, indicating a significant difference in improvement between the experimental and control classes. The experimental class obtained a higher improvement with an effect size of $|r| = 0,869$, which falls into the large effect category, indicating that the learning model has a strong influence on improving students' scientific literacy. These results were supported



by classroom observations of the learning implementation in both classes, which obtained a mode of 4, indicating very good criteria. Responses to the seventh statement related to learning that improves scientific literacy, reaching 94% in the experimental class and 83% in the control class, both categorized as very good, although the experimental class showed a higher percentage. These findings are consistent with studies by Jannah et al. (2024) and Ningrum & Lestari (2025) which state that interactive reinforcement in guided inquiry learning is more effective in significantly improving students' scientific literacy.

Guided inquiry learning allows students to actively engage in scientific investigations. Students observe phenomena, ask questions, formulate hypotheses, design investigations, collect data, analyze results, draw conclusions, and reflect on scientific activities. These activities develop students' scientific, logical, critical, and analytical thinking skills (Wulandari et al., 2023). Inquiry-based investigations also help students connect concepts with everyday phenomena (Zidane et al., 2025). Optimal implementation requires each instructional stage to follow the learning model syntax (Narsan et al., 2025), providing opportunities for students to develop scientific literacy through direct engagement (Abdullah et al., 2025).

The indicator explaining phenomena scientifically showed an N-Gain of 0,983 in the experimental class and 0,932 in the control class, both in the high category. Improvement occurred because students were presented with contextual phenomena and required to formulate hypotheses systematically (Jannah et al., 2024), while scientific literacy assessment requires a deep conceptual understanding (Afidah & Sudiby, 2025; Arief & Utari, 2015). Interactive reinforcement in the experimental class provided immediate feedback, helping students correct misconceptions, apply concepts, construct evidence-based explanations, and make predictions (Nasution, 2017; Skinner, 2014). These results were supported by the observation of learning implementation in the orientation and problem presentation phases up to hypothesis formulation phases in both classes, which obtained a mode of 4 with a very good. In addition, students' responses to positive statements number 2, 5, 6, and 7 and negative statements number 14 and 15 indicated that students perceived that observing phenomena and formulating questions and hypotheses helped them understand concepts scientifically. The consistency between the increase in scores, optimal implementation of learning, and positive student responses confirms the effectiveness of both classes in developing the ability to explain phenomena scientifically.

The indicator designing and evaluating scientific investigation designs showed an N-Gain score of 0,883 in the experimental class (high category), while the control class obtained 0,628 (moderate category). The experimental class benefited from interactive reinforcement, while the control class needed more time to adapt to guided inquiry stages (Chen & Liu, 2018; Khalaf, 2018). Teacher guidance, group discussions, and worksheets strengthened procedural knowledge, enabling students to conduct experiments and evaluate designs systematically (Latip et al., 2022; Sahratullah & Rahmawati, 2020). Repeated interactive reinforcement during data collection improved accuracy and design evaluation (Febrianti, 2026; Sakina et al., 2024). These results were supported by the implementation of the data collection phase in both classes. In addition, students' responses to statements number 4, 5, and 7 as well as negative statements number 14 and 15, indicated that students perceived the experimental activities positively. The consistency between score improvement, optimal implementation, and positive student responses confirms the effectiveness of interactive reinforcement in the experimental class effectively enhanced students' ability to design and evaluate scientific investigations.

The indicator interpreting data and scientific evidence showed an N-Gain of 0,982 in the experimental class and 0,793 in the control class, both categorized as high. The experimental class improved more due to interactive reinforcement during data analysis and conclusion stages, which encouraged critical interpretation, linking evidence to concepts, and constructing conclusions (Aprizanti, 2023; Gisela et al., 2025; Hadiprayitno et al., 2020; Yunita et al., 2021). Guided worksheets, teacher guidance, and group discussions supported systematic and objective data interpretation



(Alfiyatin, 2023; Rukmi & Mutiah, 2023; Sulistiana et al., 2023). These results were supported by the implementation of the data analysis and conclusion phase in booth classes, which obtained a mode of 4 (very good). In addition, students' responses to positive statements number 3, 4, 5, and 7 as well as negative statements number 12 and 15 indicated that students responded positively to the data analysis activities conducted. The consistency between the increase in scores, optimal learning implementation, and positive student responses confirms the effectiveness of both the experimental and control classes in developing students' ability to interpret data and evidence scientifically.

The final indicator, investigating, evaluating, and using scientific information to make decisions and take actions, showed an N-Gain score of 0,861 in the experimental class (high category), while the control class obtained 0,598 (moderate category). The experimental class improved optimally due to interactive reinforcement, while the control class required longer adaptation to guided inquiry stages (Chen & Liu, 2018; Khalaf, 2018). Students collected data, evaluated its accuracy, interpreted findings, and determined actions based on evidence, enhancing critical thinking and decision-making skills (Afidah & Sudiby, 2025; Widiya & Radia, 2023). These results were supported by the reflection phase implementation in both classes, which reached a mode of 4 (very good). In addition students' responses to positive statements numbers 7 and 8 as well as negative statement number 16 indicated that students were able to use scientific information in the decision-making process. The consistency between the increase in scores, optimal learning implementation, and positive student responses confirms that interactive reinforcement in the experimental class effectively improved students' ability to investigate, evaluate, and use scientific information to make decisions and take actions.

Before the learning process, students' scientific literacy ranged from levels 1 to 5, with the most at level 2, indicating a relatively low level of literacy. Limited learning engagement, a tendency toward rote memorization, and a low reading culture (Hidayah et al., 2019), as well as external factors such as limited facilities, access to books, and less varied teaching methods (Jufri et al., 2019) contributed to this condition. Guided Inquiry Interactive Reinforcement in the experimental class and Guided Inquiry without Interactive Reinforcement in the control class significantly improved scientific literacy levels. The experimental class reached level 6, while the control class reached level 5, showing that interactive reinforcement enhances complex scientific literacy skills. Guided inquiry consistently improves literacy and indicator achievement (Hartono & Sari, 2023). Repeated reinforcement deepens conceptual understanding (Aprizanti, 2023; Febrianti, 2026), while scaffolding, structured feedback, and systematic reinforcement enhance cognitive engagement, critical evaluation, and scientific decision-making (Almuntasherri & Arabia, 2016; Irawan et al., 2025).

These findings align with Piaget's cognitive theory, which views learning as active assimilation, accommodation, and equilibration according to students' development (Magdalena et al., 2023), and the logical thinking skills of junior high students (Slavin, 2018). Guided inquiry engages students as active learners who construct knowledge and solve problems with teacher guidance (Sanrock et al., 2018; Woolfolk, 2016) and social scaffolding for meaningful collaboration (Arends, 2012; Swastika & Utami, 2024). Direct experience and contextual reflection support relevant knowledge construction (Sulistiawati, 2024), while interactive reinforcement strengthens responses, corrects errors, and enhances conceptual understanding (Nasution, 2017; Skinner, 2014), systematically improving scientific literacy.

4. CONCLUSION

It can be concluded that Guided Inquiry Interactive Reinforcement is more effective than Guided Inquiry without Interactive Reinforcement, as evidenced by a more significant improvement in scientific literacy, evenly distributed across all competency indicators, and a very strong effect on students' scientific literacy in the topic of global warming. The implementation of both learning models was very good and followed the guided inquiry syntax, indicating that differences in literacy improvement were due to the learning strategies applied rather than the quality of implementation. Students' responses to Guided Inquiry Interactive Reinforcement were higher, showing that interactive



reinforcement enhances engagement, conceptual understanding, and more meaningful learning experiences. These results confirm the effectiveness of Guided Inquiry Interactive Reinforcement in improving students' scientific literacy on the topic of global warming.

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