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Mangrove Forests As A Learning Resource: Improving Students' Science Literacy In Esd-Oriented Science Learning

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Abstract

This study examines the improvement of students' science literacy through science learning oriented towards Education for Sustainable Development (ESD), using mangrove forests as a learning resource. The method used is an experiment with a “Pretest-Posttest Control Group Design”, which allows for a comparison of students' science literacy abilities before and after treatment. The experimental class followed ESD-based learning using mangrove forests, while the control class continued to use conventional methods. A significant difference in science literacy improvement was found between the experimental and control groups (Mann-Whitney test, Asymp.sig. = 0.00), with the experimental class showing a larger increase. Their average post-learning score was 75.29, which was higher than the control group's average of 66.4. A challenge of this learning approach is the potential danger to students from flooded forest conditions. Therefore, student health and safety must be taken into consideration, for example, by using Personal Protective Equipment (PPE) during visits. With this measure, ESD-based science learning in the field remains safe while effectively improving students' science literacy.

Keywords: *Mangrove Forest, ESD, Science Literacy.*

Introduction

Good science learning is one that can create students' curiosity, increase scientific thinking skills, and make students apply knowledge in everyday life (Kelana et.al, 2019). Natural Science (IPA) learning is closely related to science literacy and environmental literacy. Both support each other in shaping students' understanding of science and their surroundings. Teachers can boost students' science literacy by turning the surrounding environment into a learning tool, allowing students to directly observe the natural world and the creatures within it. This activity not only strengthens the understanding of scientific concepts but also increases student engagement in the learning process (Kristyowati, R., & Purwanto, A., 2019). Science education rooted in science literacy can foster a more engaging and contextual learning experience. Good science instruction goes beyond just scientific facts and should also highlight the significance of being environmentally conscious. Students who have good science literacy tend to be more concerned about environmental issues (Adjie et.al, 2023).

Science literacy is part of the 21st century skills that must be mastered by students in order to be able to keep up with the flow of global progress, while current conditions show that the science literacy skills of Indonesian students are still low (Yusmar et.al, 2023). Referring to the score Programme for International Student Assessment (PISA) 2022, Indonesia still ranks low in the aspect of science literacy (Marwah et.al, 2024).

One of the main goals of science education is to create the next generation who have adequate scientific literacy skills (Narut et.al, 2019; Ariani et.al, 2024). Science literacy can be defined as scientific knowledge and skills to be able to identify questions, acquire new knowledge, explain scientific phenomena, draw conclusions based on facts, understand the characteristics of science, awareness of how science and technology shape the natural, intellectual, and cultural environment; and the willingness to engage and care about issues related to science (Narut et.al, 2019).

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The first of four characteristics of science literacy is an awareness of how science and technology are involved in various life situations. This is the context for assessment units and items; 2) understanding the natural world, including technology, based on scientific knowledge that includes knowledge of nature and knowledge of science itself; 3) competencies include identifying scientific questions, explaining scientific phenomena, and using scientific evidence as the basis for arguments to draw conclusions and decisions (Ibrahim et.al, 2021)

ESD or Education for Sustainable Development is an educational approach that aims to equip individuals with the knowledge, skills, and values necessary to contribute to sustainable development (Vioreza et.al, 2023; Alissa, 2022). ESD integrates the concept of sustainability into formal and non-formal education curricula, and promotes an understanding of the relationship between the environment, society, and the economy (Tristananda, 2018; Yasin, 2024). The main goal of ESD is to raise awareness of global issues such as climate change, natural resource management, and social justice, so that students can take appropriate and responsible actions in their daily lives (Sutanto, 2017; Rahmayanti, 2022). Through ESD, it is hoped that future generations will be able to make sustainable decisions and contribute to environmental conservation efforts and improve the quality of life of the community (Ghany, 2018; Widoresmi et.al, 2024).

The implementation of ESD in Indonesia from elementary school to tertiary education level is attempted through the integration of ESD in the school curriculum, both intracurricularly through integration into subjects and extracurricular activities (Prabawani et.al, 2017). Education for Sustainable Development (ESD), or in Indonesian, sustainable education, is a new global education framework that has been approved at the conference United Nations Educational, Scientific, and Cultural Organization (UNESCO) and recognized by the UN in 2019 (UNESCO, 2023). ESD is designed to increase knowledge, awareness, and action towards achieving sustainable development goals (UNESCO, 2020). Science learning in Indonesia currently focuses on cognitive aspects and information delivery, without linking it to sustainable values or Education for Sustainable Development (ESD) (Kusumaningrum et.al, 2022; Teddy, 2023). The teaching and learning process tends to prioritize mastery of scientific concepts and facts rather than applying concepts in everyday life contexts related to environmental, social, and economic issues (Kusumawati, 2022; Indrawati et.al, 2019). Therefore, there is an urgent need to integrate the ESD approach into the science curriculum so that students not only understand science but also contribute to solutions to complex global problems (Ningrum et.al, 2021; Lestari et.al, 2022).

Natural Science (IPA) learning oriented towards Education for Sustainable Development (ESD) aims to equip students with a deep understanding of environmental and sustainability issues, as well as the ability to contribute to creating solutions (Latifah et.al, 2023; Vioreza et.al, 2023). In this context, science learning does not only focus on scientific concepts, but also integrates sustainability values, such as ecological awareness, social responsibility, and critical thinking skills (Vioreza et.al, 2023; Sawitri et.al, 2024).

Forests can be a resource for science learning, as research conducted by Jufrida and Rahmat (2018) shows. Forests possess scientific values, including half-life, radioactivity, and energy, in geological diversity. Biodiversity encompasses the scientific value of classifying living things and the environment, and cultural diversity encompasses the concepts of sound and body movement. One suitable environment that can serve as a learning resource for students in coastal areas is the mangrove ecosystem (Santoso et al., 2022). The forms of mangrove ecosystem service values that can be used as teaching material include: (a) spatial and temporal changes in mangroves, (b) the richness, diversity and distribution of mangrove species and fauna (c) the structure and function of the mangrove ecosystem (Salahuddin et.al., 2021). Consequently, the mangrove ecosystem can be used to create effective biology lessons on the topic of ecosystems (Santoso et.al., 2022).

Utilizing the environment as a learning resource in education provides opportunities for students to learn directly from the world around them (Choiri, 2017; Irwandi et.al, 2020). Integrating the local environment into the learning process will result in students being able to observe, explore, and analyze various natural phenomena, which will not only increase their understanding of scientific concepts but also foster a sense of love and responsibility for the environment (Saputra et.al, 2024; Solihin et.al, 2024). Activities that integrate the local environment into learning, such as observing local ecosystems, visiting parks, or researching biodiversity around the school, can enrich students' learning experiences and connect the theories learned in class with the realities of everyday life (Abidin et.al, 2023; Muliana, 2024).

Mangrove forests have great potential as a rich and diverse learning resource, especially in the context of environmental education and natural sciences (Ilhami et.al,2021; Wicaksono et.al, 2023; Priesthood et.al, 2024). Mangrove forests not only function as important ecosystems that support biodiversity, but also provide many practical lessons regarding the interaction between humans and nature (Ganda, 2023; Meliyana, 2023). Through mangrove forest exploration, students can learn various aspects, such as ecosystem structure, the role of mangroves in maintaining environmental quality, and the importance of conservation for climate change mitigation and coastline protection (Rosyid, 2020; Flassy et.al, 2022; Harefa et.al, 2023). Learning activities in mangrove forests, such as direct observation, data collection on flora and fauna, and studies on the impact of human activities, enable students to develop research and critical thinking skills (Arsya, 2023; Shobirin, 2024).

The design of learning implementation with mangrove forests as a learning resource can be carried out through an interdisciplinary approach that combines theory and practice (Cahyaningtyas et. al, 2022). Given its close proximity only 2 km away the mangrove ecosystem can be used as a science learning resource for 7th graders at SMP N 12 Pekalongan to teach them about the interactions between living things and their environment. Combining mangrove forest exploration with an ESD approach to improve students' science literacy through interactive learning experiences and project-based learning is a novelty in this research.

Method

This study aims to see how ESD-based science learning in mangrove forests affects students' science literacy. It uses a Pretest-Posttest Control Group Design to compare student abilities before and after the intervention. Two seventh-grade classes at SMP Negeri 12 Pekalongan served as the research sample. To evaluate the effectiveness of using mangrove forests as a learning resource, students' science literacy was measured with a PISA-based questionnaire. This questionnaire, which included 16 essay questions, focused on three key indicators: context, knowledge, and competence. A pretest and posttest were administered to assess the students' progress. The test results were analyzed using SPSS through a t-test to compare the scores between the experimental and control classes. By using PISA-based instruments, this study ensured that the questions were relevant to international standards and measured students' ability to understand context, master knowledge, and solve scientific problems. Statistical data analysis helped prove whether the use of mangrove forests as an ESD-based learning resource significantly improved students' science literacy. The aspects assessed in the PISA science literacy measurement are listed in Table 1.

Table 1. PISA 2018 Science Literacy Aspects

Aspect	Understanding
Context	Students need to grasp how science and technology relate to present and future challenges, whether they're personal, local, or global.
Knowledge	A foundational scientific understanding requires knowing key facts and ideas about the natural world and technology, along with the process of creating new knowledge and the reasoning behind scientific practices.
Competence	The ability to explain scientific events, critically assess and design experiments, and analyze scientific data and evidence.

Research Variables

The factor being manipulated in this study is the independent variable, the use of mangrove forests for ESD-based learning. The outcome being measured, the dependent variable, is the students' science literacy, defined by their conceptual understanding, knowledge, and problem-solving skills.

Data analysis

Initial Data Analysis

Normality Test

To see if data has a normal distribution, you can use a normality test. For sample sizes smaller than 100, the Shapiro-Wilk test is a good choice in SPSS. A significance value above 0.05 suggests the data is normally distributed.

Homogeneity Test

The homogeneity test determines if research groups share the same variance. Homogeneity is assumed when the significance value is greater than 0.05.

T-test

The T-test was used to find if there's a significant difference between the experimental and control groups' averages, specifically comparing pre- and post-test scores. According to Ghozali (2016), using SPSS with a 95% confidence level (α=0.05), if the sig value > 0.05, the learning method did not improve science literacy. If sig < 0.05, it did have an effect.

Result

Based on the research results, the average value of students' science literacy was obtained as listed in Table 2.

Table 2 Average Student Science Literacy Scores

Activity	Class	N	Rate-rate
Pretest	Experiment	24	66.33
	Control	25	59.64
Posttest	Experiment	24	75.29
	Control	25	66.4

The data is also presented in the form of a bar chart as we can see in Figure 1.

Average Science Literacy Score

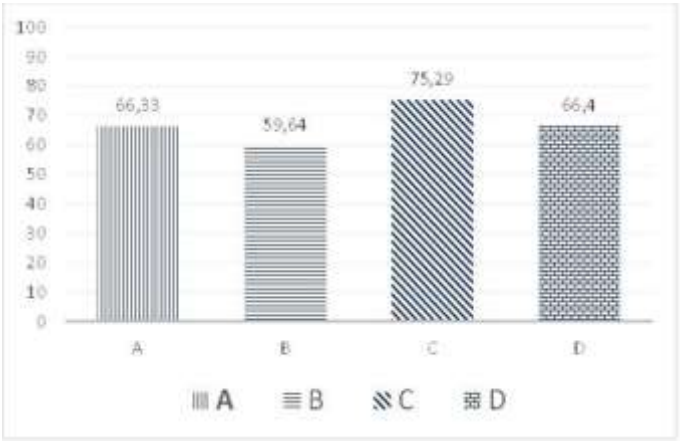

Figure 1 Average Science Literacy Score

Information:

A : Experiment Pretest

B : Pretest Control

C : Posttest Experiment

D : Posttest Control

The data shows that the experimental group's average science literacy improved from 66.33 to 75.29. The control group also saw an increase, with averages of 59.64 and 66.4 for the pretest and posttest.

The pretest and posttest averages for the experimental class's science literacy are shown in Table 3.

Table 3. Frequency data of average pretest and posttest scores experimental class science literacy

Criteria	Interval shoes	Frequency		Percentage (%)	
		Pretest	Positions	Pretest	Positions
Very well	81-100	-	7	-	29.17
Good	61-80	15	17	62.5	70.83
Enough	41-60	9		37.5	-
Not enough	21-40	-	-	-	-
Less than once	0-20	-	-	-	-

Using data from Table 3, a bar graph (Figure 2) was created to show the frequency of the average pretest and posttest scores for science literacy in the experimental class.

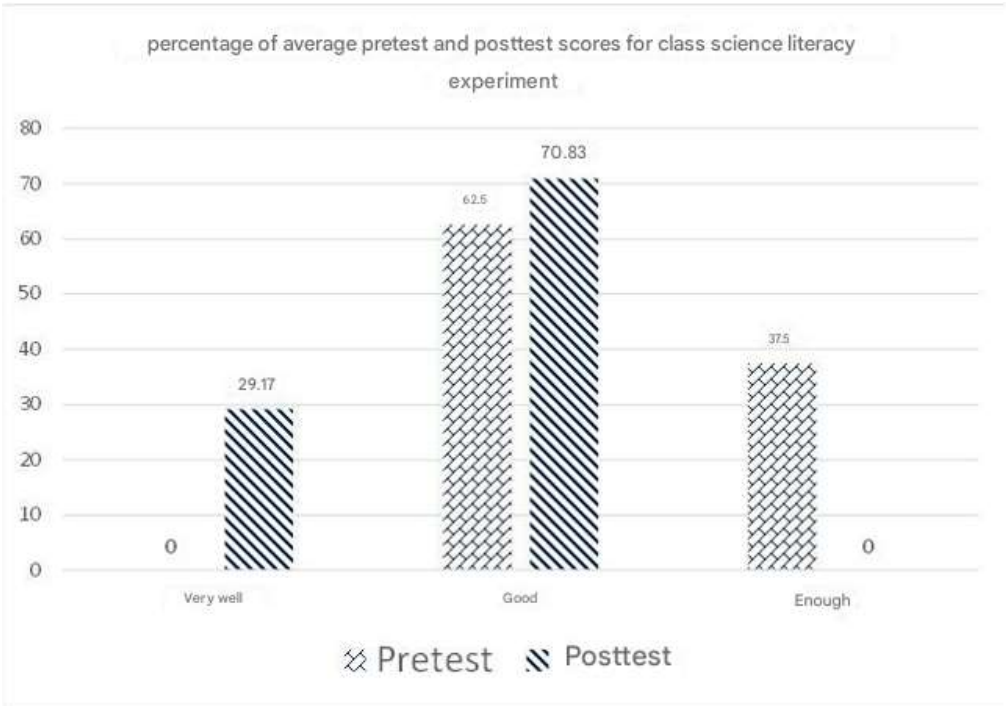

Figure 2. Chart Illustrating the Percentage of Average Pretest and Posttest Scores in Science Literacy for the Experimental Class

Based on Table 3 and Figure 2, science literacy scores in the experimental class jumped considerably, with the average pretest score of 62.5% (good) rising to an average posttest score of 29.17% (very well).

The science literacy pretest and posttest averages for the control class are shown in Table 4.

Table 4. Frequency Data of Average Pretest and Posttest Scores of Science Literacy in the Control Class

Criteria	Interval shoes	Frequency		Percentage (%)	
		Pretest	Positions	Pretest	Positions
Very well	81-100	-	-	-	-
Good	61-80	11	22	44.0	88.0
Enough	41-60	14	3	56.0	12.0
Not enough	21-40	-	-	-	-
Less than once	0-20	-	-	-	-

Using data from Table 4, a bar graph (Figure 3) was created to show the frequency of the average pretest and posttest scores for science literacy in the control class.

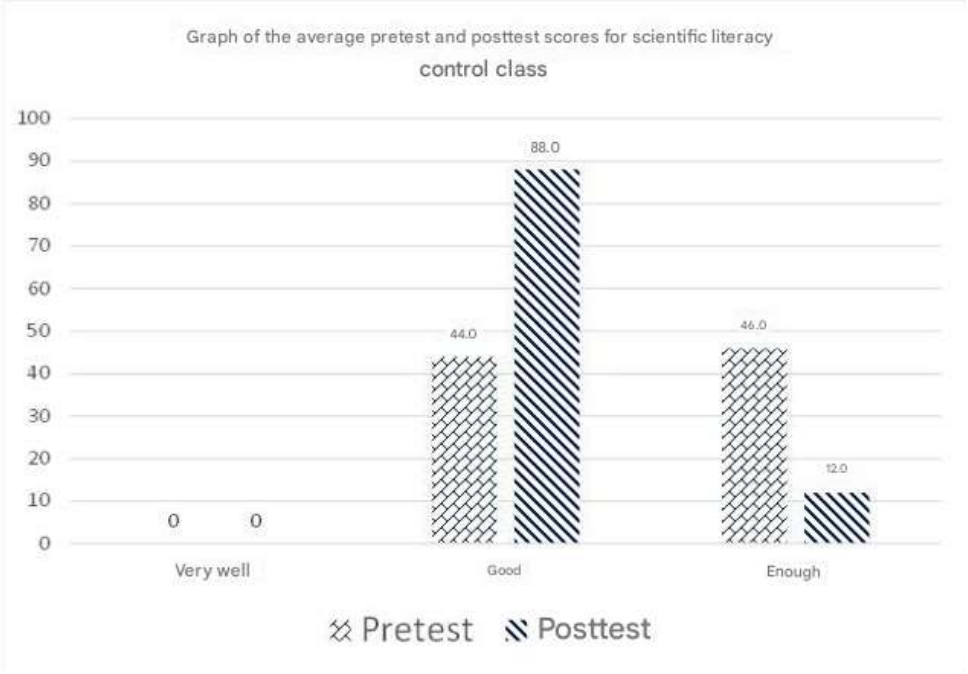

Figure 3. Diagram Displaying the Mean Pretest and Posttest Scores of the Control Class's Science Literacy

The data from Table 4 and Figure 3 shows that the control class's science literacy scores remained largely unchanged from the pretest to the posttest. This can be seen from the pretest scores, which initially fell within the good criteria of 44% and the sufficient criteria of 56%. After the posttest, the average scores remained the same, with the good criteria at 88% and the sufficient criteria at 12%. Although the percentage of the good criteria tended to increase from 44% to 88%, the criteria did not change to excellent.

Figure 4 provides a breakdown of the value descriptions for each indicator of science literacy in the control group's posttest.

Percentage of Science Literacy Score

Each Control Class Indicator

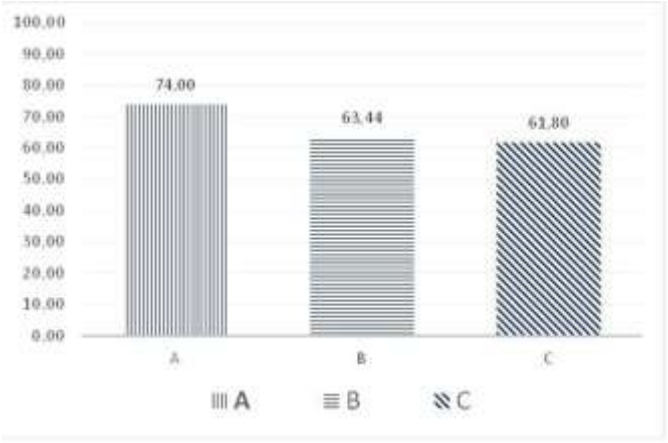

Figure 4. Chart of Science Literacy Percentages by Indicator for the Control Class
Information:

A : Knowledge

B : Competence

C : Context

In Figure 4 it can be seen that the value *posttest* the science literacy scores for each indicator in the control class were 74.00% for knowledge, 63.44% for competence, and 61.80% for context. Meanwhile, the science literacy scores for each indicator in the experimental class can be seen in Figure 5.

Percentage of Science Literacy Score

Each Experimental Class Indicator

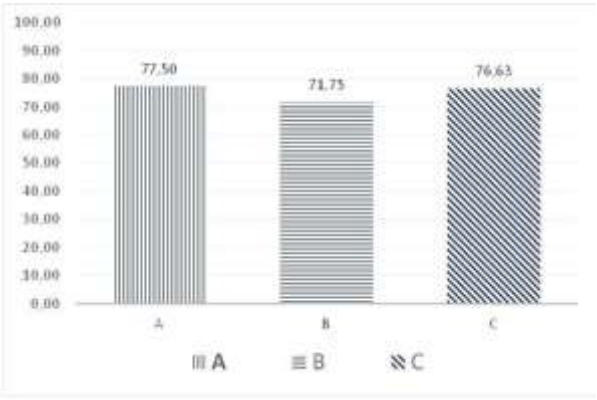

Figure 5. Percentage of Science Literacy Values for Each Indicator Experimental Class

Information:

A : Knowledge

B : Competence

C : Context

Figure 5 shows the experimental group's posttest scores for science literacy were: knowledge (77.50%), competence (71.75%), and context (76.63%). Table 5, on the other hand, presents the control group's pretest and posttest knowledge scores.

Table 5. Frequency Data of Pretest and Posttest Scores of Science Literacy in the Control Class on the Knowledge Indicator

Criteria	Interval shoes	Frequency		Percentage (%)	
		Pretest	Positions	Pretest	Positions
Very well	81-100	-	4	-	16
Good	61-80	8	17	32	68
Enough	41-60	17	4	68	16
Not enough	21-40		-	-	-
Less than once	0-20	-	-	-	-

The frequency data from Table 5, which covers the pretest and posttest scores of the control class's science literacy on the knowledge indicator, is presented in a bar graph:

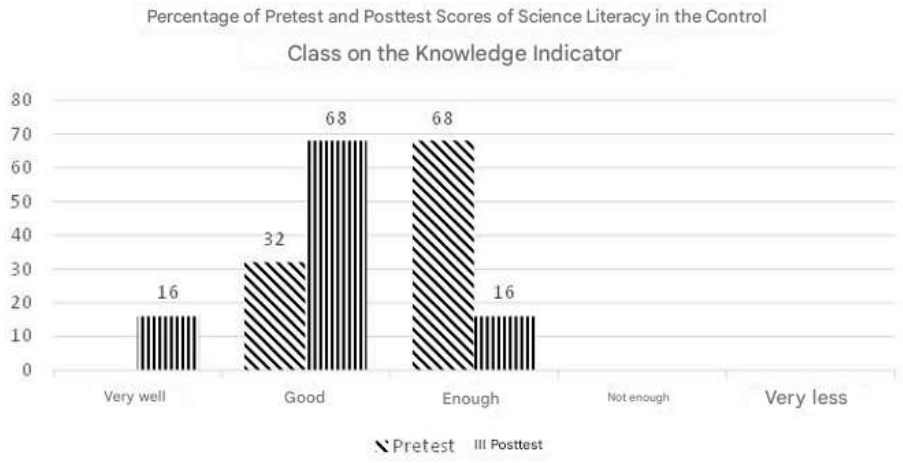

Figure 6. Percentage of Pretest and Posttest Scores for Science Literacy in the Control Class on the Knowledge Indicator

Based on Table 5 and Figure 6, the average pretest score of the science literacy of the control class on the knowledge indicator obtained the highest percentage with a value of 68.0% including sufficient criteria and the lowest percentage with a value of 32.0% including good criteria. Meanwhile, the average posttest score of the science literacy of the control class on the knowledge indicator obtained the highest percentage with a value of 68.0% including good criteria and the lowest percentage with a value of 16.0% with sufficient criteria.

Table 6 details the scores of the control group's science literacy, focusing on the competency indicators, for both the pretest and posttest.

Table 6. Frequency Data of Pretest and Posttest Scores of Science Literacy in the Control Class on Competency Indicators

Criteria	Interval shoes	Frequency		Percentage (%)	
		Pretest	Positions	Pretest	Positions
Very well	81-100	-	-	-	-
Good	61-80	13	19	52	76
Enough	41-60	12	6	48	24
Not enough	21-40		-	-	-
Less than once	0-20	-	-	-	-

The bar graph shows the frequency data for the control group's science literacy scores on the competency indicators, with the data coming directly from Table 6:

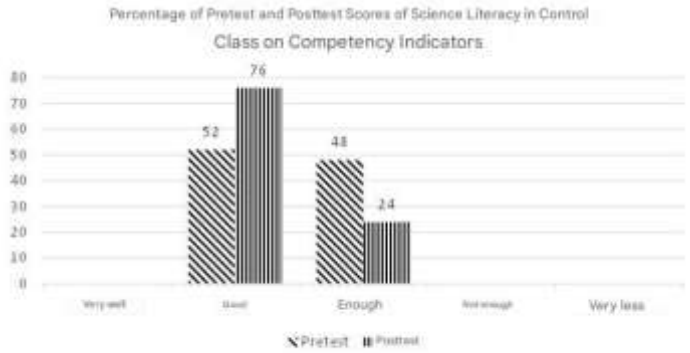

Figure 7. Percentage of Pretest and Posttest Scores of Science Literacy in the Control Class on Competency Indicators

As shown in Table 6 and Figure 7, the control class's pretest competency scores had a high of 52.0% (good) and a low of 48.0% (sufficient). Posttest scores for competency were 76.0% (good) at the high end and 24.0% (sufficient) at the low end.

Table 7 Frequency Data of Pretest and Posttest Scores of Science Literacy in the Control Class on the Context Indicator

Criteria	Interval shoes	Frequency		Percentage(%)	
		Pretest	Positions	Pretest	Positions
Very well	81-100	-	-	-	-
Good	61-80	16	19	64	76
Enough	41-60	9	6	36	24
Not enough	21-40		-	-	-
Less than once	0-20	-	-	-	-

Based on Table 7, the frequency data for the pretest and posttest scores for science literacy in the control class on the context indicator can be presented in the following bar graph:

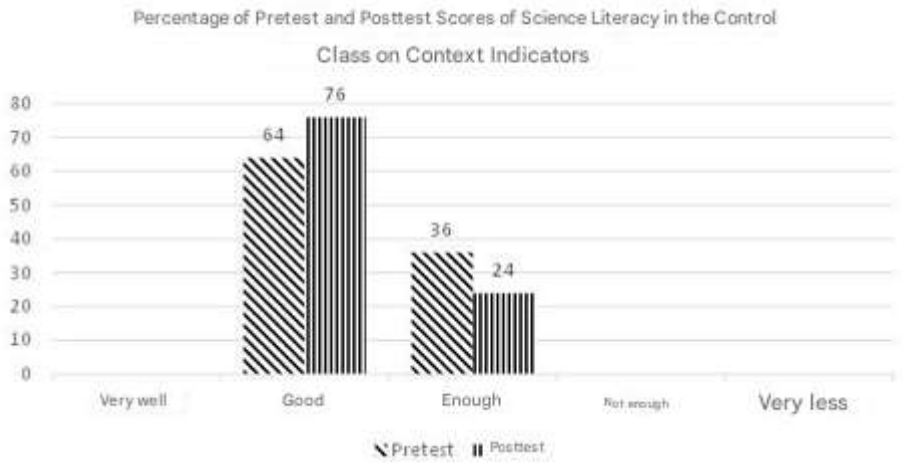

Figure 8 Percentage of Pretest and Posttest Scores of Science Literacy in the Control Class on the Context Indicator

Based on Table 7 and Figure 8, the control class's pretest context scores were highest at 64.0% (good) and lowest at 36.0% (sufficient). The posttest scores saw an increase, with the highest at 76.0% (good) and the lowest at 24.0% (sufficient).

Table 8 Frequency Data of Pretest and Posttest Scores of Science Literacy of Experimental Class on Knowledge Indicator

Criteria	Interval shoes	Frequency		Percentage (%)	
		Pretest	Positions	Pretest	Positions
Very well	81-100	-	5	-	20.83
Good	61-80	6	15	25	62.5
Enough	41-60	17	4	70.83	16.67
Not enough	21-40	1	-	4.17	-
Less than once	0-20	-	-	-	-

The bar graph shows the frequency data for the experimental group's science literacy scores on the knowledge indicator, with the data coming directly from Table 8:

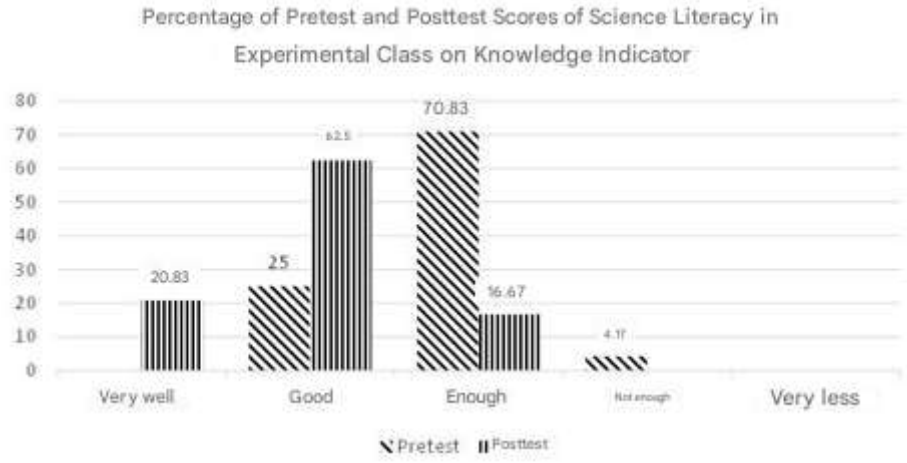

Figure 9 Percentage of Pretest and Posttest Scores for Science Literacy in the Experimental Class on the Knowledge Indicator

According to Table 8 and Figure 9, the experimental group's pretest scores for the knowledge indicator ranged from a high of 70.83% ("sufficient") to a low of 4.17% ("less"). The posttest scores reflected an improvement, with the lowest score increasing to 16.67% ("sufficient") and the highest score being 62.5% ("good").

Table 9 Frequency Data of Pretest and Posttest Scores of Science Literacy in Experimental Class on Competency Indicators

Criteria	Interval shoes	Frequency		Percentage(%)	
		Pretest	Positions	Pretest	Positions
Very well	81-100	-	4	-	16.67
Good	61-80	14	18	58.33	75
Enough	41-60	10	2	41.67	8.33
Not enough	21-40	-	-	-	-
Less than once	0-20	-	-	-	-

Based on Table 9, the frequency data for the pretest and posttest scores for the experimental class' science literacy on the competency indicators can be presented in the following bar graph.

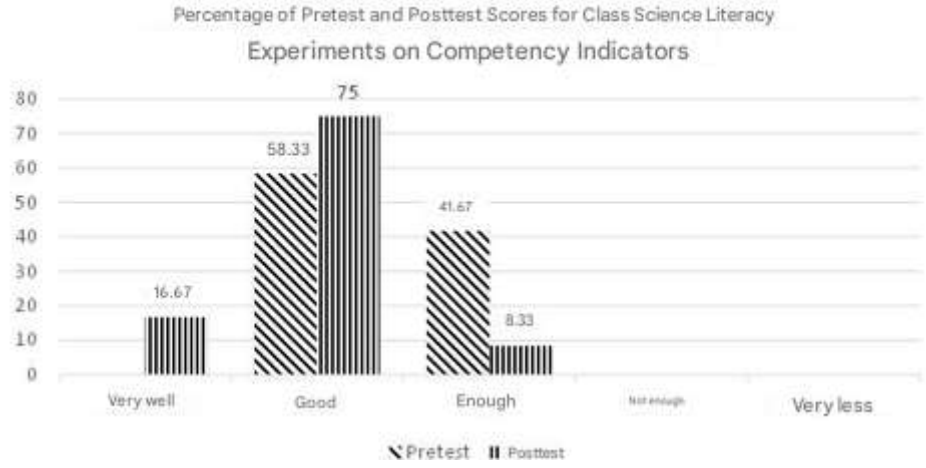

Figure 10 Percentage of Pretest and Posttest Scores of Experimental Class Science Literacy on Competency Indicators

Based on Table 9 and Figure 10, the average pretest value of the experimental class's science literacy on the competency indicator obtained the highest percentage with a value of 58.33%, including good criteria, and the lowest percentage with a value of 41.67%, including sufficient criteria. Meanwhile, the average posttest value of the experimental class's science literacy on the competency indicator obtained the highest percentage with a value of 75%, including good criteria, and the lowest percentage with a value of 8.33%, including sufficient criteria.

Table 10 Frequency Data of Pretest and Posttest Scores of Science Literacy of Experimental Class on Context Indicator

Criteria	Interval shoes	Frequency		Percentage (%)	
		Pretest	Positions	Pretest	Positions
Very well	81-100	-	3	-	12.5
Good	61-80	22	21	91.67	87.5
Enough	41-60	2	-	8.33	-
Not enough	21-40	-	-	-	-
Less than once	0-20	-	-	-	-

Based on Table 10, the frequency data for the pretest and posttest scores for the experimental class' science literacy on the context indicator can be presented in the following bar graph.

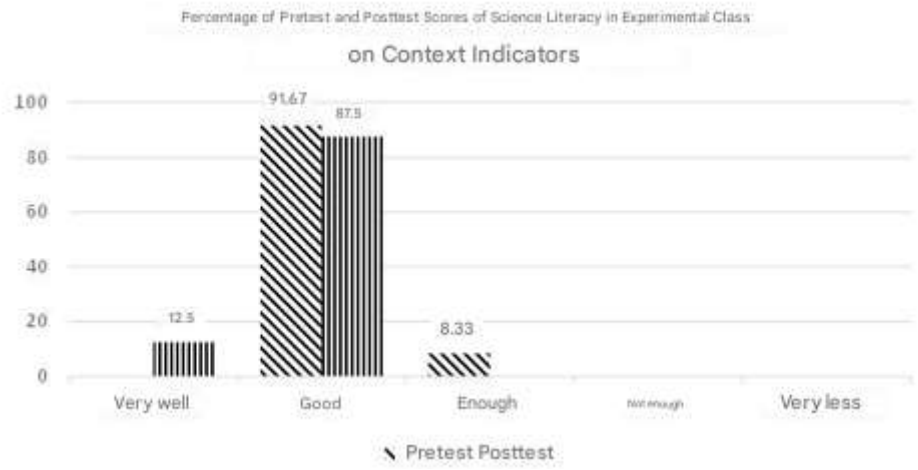

Figure 11 Percentage of Pretest and Posttest Scores of Experimental Class Science Literacy on Context Indicators

The experimental class's science literacy in the context indicator had a pretest high of 91.67% (good) and a low of 8.33% (sufficient). Posttest scores ranged from a high of 87.5% (good) to a low of 12.5% (very good). The influence of using mangrove forests for learning was tested after confirming the normality and homogeneity of both the experimental and control groups.

The normality test values for science literacy can be seen in Table 11

Table 11 Results of Normality Test on Science Literacy Scores

Tests of Normality

Class	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Say.	Statistic	df	Say.
Results Pretest A (Control)	.189	25	.021	.924	25	.065
Posttest A (Control)	.182	25	.033	.905	25	.023

Pretest (Experiment)	B	.158	24	.123	.918	24	.052
Posttest (Experiment)	B	.305	24	.000	.777	24	.000

a. Lilliefors Significance Correction

The Shapiro-Wilk test revealed that both pretest datasets (experimental class: 0.052; control class: 0.065) are normal. However, the posttest datasets for both groups are not normal (experimental: 0.00; control: 0.023). Therefore, because the independent samples T-test requires normal and homogeneous data, the non-normal posttest data will be analyzed using the Mann-Whitney test.

The results of the Mann-Whitney test can be seen in Table 12

Table 12 Mann-Whitney Test of Science Literacy

Mann-Whitney Test

Ranks

Class	N	Mean Rank	Sum of Ranks
Science Literacy Learning Outcomes Experimental Class	24	34.02	816.50
Control Class	25	16.34	408.50
Total	49		

Test Statistics[a]

	Science Literacy Learning Outcomes
Mann-Whitney U	83.500
Wilcoxon W	408.500
WITH	-4.426
Asymp. Sig. (2-tailed)	.000

a. Grouping Variable: Kelas

Based on the Mann-Whitney test, there's a statistically significant difference between the two groups (Asymp. Sig. (2-tailed) = 0.00, $p < 0.05$). This is further supported by the experimental group having a higher mean rank (34.02) than the control group (16.34), showing a clear distinction in their performance.

The study's results demonstrate that students' science literacy improves when they learn about mangrove forests. The data reveals a more significant increase in science literacy among students in the experimental group, who saw their average score rise from 63.33 to 75.29. In contrast, the control group's average score only improved from 59.64 to 66.4. These results indicate that direct, hands-on learning experiences in a natural setting like a mangrove forest are more effective for improving students' scientific understanding.

The improvement in science literacy in the experimental class was also evident in each of the science literacy indicators, namely knowledge, competence, and context. The posttest scores in the experimental class for the knowledge indicator reached 77.5%, competence 71.75%, and context 76.63%. In contrast, the control class's indicator scores were relatively lower, with knowledge at 74%, competency at 63.44%, and context at 61.8%. This difference shows that ESD-based learning through mangrove forests not only improves theoretical understanding but also students' ability to apply scientific concepts and understand the real environmental context.

The findings are strengthened by the Mann-Whitney test, which revealed a significant difference between the two groups (Asymp. Sig. = 0.00). The experimental group's higher mean rank (34.02) compared to the control group (16.34) confirms that using mangrove forests as a source of learning is effective. This supports the conclusion that **c**onnecting science education with real-world environments

can significantly improve students' scientific understanding and their awareness of environmental sustainability.

Teachers can improve students' science literacy by using their surroundings, such as mangrove forests, as a learning resource. This not only enhances students' comprehension of scientific concepts but also builds their awareness of environmental preservation. Schools must provide adequate safety measures, including PPE, to make these field trips effective and secure.

The recommendation from this study is for teachers to design more interactive and contextual science learning activities by utilizing natural learning resources. Future researchers can explore various other types of environments as learning resources, or examine the effects of similar methods on other aspects, such as students' attitudes or motivation to learn, to obtain a more comprehensive picture of ESD-based learning.

Conclusion

Based on the research results, it can be concluded that:

The use of mangrove forests as a learning resource in science learning improves science literacy with significant differences in results between the control and experimental classes.

Implications

The use of mangrove forests as a learning resource in ESD-oriented science learning is expected to be able to shape students' attitudes to play a role and contribute to sustainable development. Students can act as volunteers for mangrove conservation and rehabilitation, conducting education and campaigns, to spread the message of nature conservation and build public awareness about the mangrove ecosystem.

References

1. Abidin, N., Maturahmah, E., & Hasan, H. (2023, July). Pemanfaatan Keanekaragaman Hayati Untuk Meningkatkan Pembelajaran Sains Di Kabupaten Manokwari. In Seminar Nasional Pendidikan (Vol. 1, No. 1).
2. Adjie, D. A. S., Pramadi, R. A., & Maspupah, M. (2023, October). Korelasi Kemampuan Literasi Sains Dengan Perilaku Peduli Lingkungan Peserta Didik Pada Materi Ekosistem. In Gunung Djati Conference Series (Vol. 30, pp. 258-268).
3. Agustina, R., Huda, I., & Nurmaliah, C. (2020). Implementasi Pembelajaran STEM pada Materi Sistem Reproduksi Tumbuhan dan Hewan Terhadap Kemampuan Berpikir Ilmiah Peserta Didik SMP. Jurnal Pendidikan Sains Indonesia, 8(2), Article 2. https://doi.org/10.24815/jpsi.v8i2.16913
4. Alissa, V. (2022). Kesadaran Peserta Didik Dalam Penerapan Green School Untuk Mendukung ESD (Education for Sustainable Development). EduTeach: Jurnal Edukasi dan Teknologi Pembelajaran, 3(2), 51-60.
5. Anjela, D. (2023). Penggunaan Alat Peraga Pada Mata Pelajaran IPA Sebagai Upaya Meningkatkan Hasil Belajar Siswa Kelas IV di SDN 05 Seluma (Doctoral dissertation, UIN Fatmawati Sukarno Bengkulu).
6. Apdillah, D., Ritha, N., Zulfikar, A., & Nanda, T. (2024). Penerapan Aplikasi Cerdas Berbasis AI untuk Pengenalan Jenis Mangrove Pendukung Ekowisata Berkelanjutan di Desa Pengudang, Kabupaten Bintan. Jurnal Abdi Masyarakat Indonesia, 4(6), 1753-1762.
7. Aprianti, A., & Maulia, S. T. (2023). Kebijakan Pendidikan: Dampak Kebijakan Perubahan Kurikulum Pendidikan Bagi Guru Dan Peserta Didik. Jurnal Pendidikan Dan Sastra Inggris, 3(1), 181-190.
8. Aprilia, I., & Suryadarma, I. G. P. (2020). E-module of mangrove ecosystem (emme): development, validation and effectiveness in improving students' self-regulated. Biosfer, 13(1), 114–129. https://doi.org/10.21009/biosferjpb.v13n1. 114-129
9. Ariani, D., & Khalil, M. (2024). Literasi Sains Bagi Siswa Sekolah Dasar Dalam Proses Belajar Mengajar Di Aceh. Jurnal Pembelajaran dan Sains (JPS), 3(1).
10. Ario, R., P. Subardjo dan g. Handoyo. 2015. Analisis Kerusakan Mangrove di Pusat Restorasi dan Pembelajaran Mangrove (PRPM), KotaPekalongan. Jurnal Kelautan Tropis., 18(2) : 64-69.
11. Arnyana, I. B. P. (2019). Pembelajaran untuk meningkatkan kompetensi 4c (communication, collaboration, critical thinking dancreative thinking) untukmenyongsong era abad 21. Prosiding: Konferensi Nasional Matematika dan IPA Universitas PGRI Banyuwangi, 1(1), i-xiii.
12. Arsya, G. T. (2023). Pengaruh Model Pembelajaran Double Loop Problem Solving Terhadap Kemampuan Pemecahan Masalah Dan Keterampilan Berpikir Kritis Peserta Didik Pada Materi Keanekaragaman Hayati (Studi eksperimen di kelas X MIPA SMAN 4 Tasikmalaya Tahun Ajaran 2022/2023) (Doctoral dissertation, Universitas Siliwangi).
13. Aswita, D., Nurmawati, M. P., Salamia, M. S., Sarah, S., Si, S. P., Saputra, S., ... & Ismail, N. M. (2022). Pendidikan Literasi: Memenuhi Kecakapan Abad 21. Penerbit K-Media.

14. Azizi, A. (2022). Ilmu Pengetahuan Alam (IPA) dan Filsafat dalam pengembangan potensi lokal untuk pembelajaran masa depan. LAMBDA: Jurnal Ilmiah Pendidikan MIPA dan Aplikasinya, 2(3), 102-110.
15. Cahyaningtyas, T. I., Kusumawati, N., & Laksana, I. M. S. D. (2022). Pendidikan lingkungan hidup SD berbasis PJBL. Cv. Ae Media Grafika.
16. Choiri, M. M. (2017). Upaya pemanfaatan lingkungan sekitar sebagai sumber belajar anak. Refleksi Edukatika: Jurnal Ilmiah Kependidikan, 8(1).
17. Creswell, J. W., Hanson, W. E., Clark Plano, V. L., & Morales, A. (2007). Qualitative research designs: Selection and implementation. The counseling psychologist, 35(2), 236-264.
18. Creswell, J.W., & Creswell, J.D. (2018). Research design: Qualitative, quantitative, and mixed methods approaches (5th ed.). LA: SAGE.
19. Daniyarti, W. D. (2022). Pendidikan Literasi Lingkungan Sebagai Penunjang Pendidikan Akhlak Lingkungan. Tamaddun Journal of Islamic Studies, 1(2), 89-101.
20. Darling-Hammond, L., Flook, L., Cook-Harvey, C., Barron, B., & Osher, D. (2020). Implications for educational practice of the science of learning and development. Applied Developmental Science, 24(2), 97–140. https://doi.org/10.1080/10888691.2018.1537791
21. Dini, J. P. A. U. (2021). Manajemen pembelajaran untuk menciptakan suasana belajar menyenangkan di masa new normal. Jurnal Obsesi: Jurnal Pendidikan Anak Usia Dini, 5(2), 1566-1576.
22. Dini, J. P. A. U. (2022). Kepedulian Lingkungan melalui Literasi Lingkungan pada Anak Usia Dini. Jurnal Obsesi: Jurnal Pendidikan Anak Usia Dini, 6(6), 6690-6700.
23. Farid, A. (2023). Literasi Digital Sebagai Jalan Penguatan Pendidikan Karakter Di Era Society 5.0. Cetta: Jurnal Ilmu Pendidikan, 6(3), 580-597.
24. Fathi, M., & Hidayat, W. (2023). Analisis Risiko Curah Hujan Tinggi Terhadap Kelangsungan Kegiatan Belajar dan Mengajar di MTs Hudatul Falah. AKSI: Jurnal Manajemen Pendidikan Islam, 1(3), 223-235.
25. Fatimah, S. (2024). Pembelajaran IPA SD/MI Inovatif & Kontekstual Berorientasi Education For Sustainable Development. CV Pajang Putra Wijaya.
26. Febriasari, L. K., & Supriatna, N. (2017). Enhance Environmental Literacy through Problem Based Learning Enhance Environmental Literacy through Problem Based Learning. International Conference on Mathematics and Science Education (ICMScE).
27. Flassy, M., Frank, S. A. K., Idris, U., Muttaqin, M. Z., & Darmawaan, H. (2022). Hutan Perempuan: Kearifan Lokal Orang Tobati-Enggros dalam Merawat Ekosistem Hutan Mangrove. wawasan Ilmu.
28. Ganda, R. A. (2023). Pengembangan Lembar Kerja Peserta Didik Berbasis Kearifan Lokal Di Kawasan Hutan Mangrove Pulau Baai Pada Materi Ekologi Dan Keanekaragaman Hayati Untuk Meningkatkan Kepedulian Lingkungan Sebagai Bahan Ajar IPA Di SMP Kota Bengkulu (Doctoral dissertation, UIN Fatmawati Sukarno Bengkulu).
29. Ghany, H. (2018). Penyelenggaraan Pendidikan Untuk Pembangunan Berkelanjutan Di Sekolah Dasar. Madaniyah, 8(2), 186-198.
30. Gunawan, H., & Zuhriana, D. (2019). Mempromosikan konservasi mangrove melalui Pendidikan lingkungan hidup tematik, di Kabupaten Indramayu.
31. Handayani, S., Kusumawati, I., & Rosdianto, H. (2018). Penerapan Model Learning Cycle 7E Berbantuan Media Visual Untuk Meningkatkan Hasil Belajar Siswa Pada Materi Cahaya Kelas VIII. JIPF (Jurnal Ilmu Pendidikan Fisika), 3(2), 35-37.
32. Harefa, M. S., Delita, F., Restu, M. S., Berutu, N., Yenny, N., Hidayat, S., ... & Tuhono, E. (2023). Pembelajaran Ekosistem Mangrove Tingkat SMA. Selat Media.
33. Hasibuan, A. N., Rebista, N., Manurung, R. S. J., & Arwita, W. (2024). Analisis Penerapan Model Pembelajaran Problem Based Learning Pada Materi Sistem Gerak Manusia Kelas XI SMA Swasta Imelda Medan:(Analysis of the Application of the Problem Based Learning Learning Model in Class XI Human Movement Systems Material at Imelda Private High School Medan). BIODIK, 10(2), 145-155.
34. Ilhami, A., Diniya, D., Susilawati, S., Sugianto, R., & Ramadhan, C. F. (2021). Analisis kearifan lokal manongkah kerang di kabupaten indragiri hilir, riau sebagai sumber belajar IPA Berbasis etnosains. Sosial Budaya, 18(1), 20-27.
35. Imamah, T. A., Kurniawan, A., Kamiliyah, N., Asyura, R. R., & Hidayatillah, Y. (2024). Analisis Pemanfaatan Ekowisata Hutan Mangrove Sebagai Sumber Belajar Pada Siswa Sekolah Dasar. Jurnal Multidisiplin Ilmu Akademik, 1(6), 363-374.
36. Indrawati, F. A., & Wardono, W. (2019, February). Pengaruh self efficacy terhadap kemampuan literasi matematika dan pembentukan kemampuan 4C. In PRISMA, Prosiding Seminar Nasional Matematika (Vol. 2, pp. 247-267).
37. Irwandi, & Fajeriadi, H. (2019). Pemanfaatan Lingkungan sebagai Sumber Belajar untuk Meningkatkan Minat dan Hasil Belajar Siswa SMA di Kawasan. Jurnal Biologi-Inovasi Pendidikan, 1(2), 66–73.
38. Irwandi, I., & Fajeriadi, H. (2020). Pemanfaatan lingkungan sebagai sumber belajar untuk meningkatkan minat dan hasil belajar siswa SMA di kawasan pesisir, Kalimantan Selatan. BIO-INOVED: Jurnal Biologi-Inovasi Pendidikan, 1(2), 66-73.
39. Jeramat, E., Jehadus, E., & Hildegardis, M. (2019). Penanaman Sikap Peduli Lingkungan Dan Tanggung Jawab Melalui Pembelajaran Ipa Pada Siswa Smp. Journal of Komodo Science Education, 01(02), 10. https://i-mes.org/jurnal/9295
40. Jufrida, and Rahmat. 2018. “Potensi Kearifan Lokal Geopark Merangin Sebagai Sumber Belajar Sains Di SMP.” Jurnal Pendidikan Fisika 3:1–16.

41. KBBI, 2016. Kamus Besar Bahasa Indonesia (KBBI). [Online] Available at: https://kbbi.kemdikbud.go.id/
42. Kelana, J. B., & Pratama, D. F. (2019). Bahan Ajar IPA Berbasis Literasi Sains. Bandung: Lekkas.
43. Khusna, A. (2024). Persepsi dan SIkap Siswa SMAN 1 Pasir Sakti terhadap Konservasi Mangrove (Doctoral dissertation, IAIN Metro).
44. Kristyowati, R., & Purwanto, A. (2019). Pembelajaran Literasi Sains Melalui Pemanfaatan Lingkungan. Scholaria: Jurnal Pendidikan Dan Kebudayaan, 9(2), 183-191.
45. Kurniawati dan Pangaribowo, N. D. Dan E. H. Pangaribowo. 2016. Valuasi Ekonomi Ekosistem Mangrove di Desa Karangsong Indramayu. Jurnal Bumi Indonesia., 6(2) : 1-12
46. Kusumaningrum, D. (2018). Literasi lingkungan dalam kurikulum 2013 dan pembelajaran IPA di SD. Indonesian Journal of Natural Science Education, 1(2), 57-64.
47. Kusumaningrum, M. E., Roshayanti, F., & Dewi, E. R. S. (2022). Pengembangan Modul Pembelajaran Biologi Berbasis Education For Sustainable Development (ESD) Berpotensi Meningkatkan Kemampuan Kognitif Siswa Kelas X. BIOPENDIX: Jurnal Biologi, Pendidikan Dan Terapan, 8(2), 48-70.
48. Kusumawati, N. (2022). Pembelajaran IPA di Sekolah Dasar. CV. AE MEDIA GRAFIKA.
49. Kuswendi, U., Arga, H. S. P., & Altaftazani, D. H. (2020). Environmental literacy sekolah dasar. Tre Alea Jacta Pedagogie.
50. Labobar, J., & Kapojos, S. (2023). Literasi Ekologis Literasi Ekologis: Implementasi Pendidikan Lingkungan Hidup bagi Siswa SMP Negeri Se-Distrik Sentani. Civics Education and Social Science Journal (CESSJ), 5(2), 94-109.
51. Lasaiba, I. (2023). Menggugah Kesadaran Ekologis: Pendekatan Biologi untuk Pendidikan Berkelanjutan. Jendela Pengetahuan, 16(2), 143-163.
52. Latifah, N., Hayat, M. S., & Khoiri, N. (2023). Potensi Implementasi Pembelajaran Berdiferensiasi Berorientasi ESD dalam Projek IPAS Aspek Zat dan Perubahannya. Jurnal Penelitian Pembelajaran Fisika, 14(2), 261-268.
53. Laurie, R., & Nonoyama-Tarumi, Y. (2016). Contributions of Education for Sustainable Development (ESD) to Quality Education: A Synthesis of Research. Journal of Education for Sustainable Development, 10(2), 226–242. https://doi.org/10.1177/0973408216661442
54. Lestari, H., & Rahmawati, I. (2022). Pendidikan Pembangunan Berkelanjutan Dimensi Pelestarian Lingkungan Melalui Model Pembelajaran RADEC Pada Pembelajaran IPA Di Sekolah Dasar. Jurnal Kajian Islam Modern, 8(1), 1-13.
55. Lestari, S. (2021). Pengembangan orientasi keterampilan abad 21 pada pembelajaran fisika melalui pembelajaran PjBL-STEAM berbantuan Spectra-Plus. Ideguru: Jurnal Karya Ilmiah Guru, 6(3), 272-279.
56. Limiansih, K., Sulistyani, N., & Melissa, M. M. (2024). Persepsi guru SMP terhadap literasi sains dan implikasinya pada pembelajaran sains di sekolah. Jurnal Pendidikan MIPA, 14(3), 786-796.
57. López-Alcarria, A., Poza-Vilches, M. F., Pozo-Llorente, M. T., & Gutiérrez-Pérez, J. (2021). Water, waste material, and energy as key dimensions of sustainable management of early childhood eco-schools: An environmental literacy model based on teachers action-competencies (ELTAC). Water (Switzerland), 13(2). https://doi.org/10.3390/w13020145
58. Mahrus, M. (2024). Transformasi Pendidikan Agama Islam Berbasis Kesadaran Ekologis Pada Siswa. Dirosat: Journal of Islamic Studies, 9(1), 109-122.
59. Mahrus, M., Anggraeni, M. N., & Silmi, I. M. (2022). Pengaruh Authentic Learning Berbasis Lingkungan terhadap Kemampuan Berpikir Kritis dan Pemecahan Masalah IPA. Terampil: Jurnal Pendidikan dan Pembelajaran Dasar, 9(1), 39-50.
60. Mardhiyah, R. H., Aldriani, S. N. F., Chitta, F., & Zulfikar, M. R. (2021). Pentingnya keterampilan belajar di abad 21 sebagai tuntutan dalam pengembangan sumber daya manusia. Lectura: Jurnal Pendidikan, 12(1), 29-40.
61. Mardiani, N. D., Husamah, H., Fatmawati, D., Miharja, F. J., & Fauzi, A. (2021). Environmental Literacy of Students in AlRifa'ie Modern Islamic Boarding School, Malang Regency-Indonesia Based on Gender Differences and Parents' Occupation. Jurnal Pendidikan Sains Indonesia, 9(2), 317–328.
62. Marfiana, T., Roshayanti, F., Indiati, I., & Hayat, M. S. (2024). Profile Of Students' Creative Thinking Skills And Science Literacy In Science Learning At SMP N 12 Pekalongan. Journal of Sustainable and Science Education (JSSE), 1(1), 41-46.
63. Marwah, A. S., & Pertiwi, F. N. (2024). Literasi Sains Siswa dalam Berinovasi pada Pembelajaran IPA Berbasis Produk. Jurnal Tadris IPA Indonesia, 4(1), 114-126.
64. Masruroh, M. (2016). Pemanfaatan Hutan Mangrove Sebagai Sumber Belajar Untuk Meningkatkan Pemahaman Konsep Dan Kepedulian Lingkungan (Doctoral dissertation, Universitas Pendidikan Indonesia).
65. McBeth, W., & Volk, T. L. (2009). The National Environmental Literacy Project: A Baseline Study Of Middle Grade Students In The United States. The Journal Of Environmental Education, 41(1), 55-67.
66. Meliyana,T. (2023). Studi Literatur Konservasi Hutan Mangrove Petengoran Di Desa Gebang Kabupaten Pesawaran (Doctoral dissertation, UIN RADEN INTAN LAMPUNG).
67. Miterianifa, M., & Mawarni, M. F. (2024). Penerapan Model Pembelajaran Literasi Lingkungan dalam Meningkatkan Pengetahuan dan Kesadaran Lingkungan. Jurnal Sains dan Edukasi Sains, 7(1), 68-73.
68. Muliana, G. H. (2024). Pemanfaatan Lingkungan Sekolah sebagai Sumber Belajar IPA-Biologi. Jurnal Ilmiah Wahana Pendidikan, 10(8), 1062-1071.

69. NAAEE, by the North American Association for Environmental Education (2011). Washington, USA http://www.naaee.net/. Diaksespada 28 Desember 2015
70. Nabil, W., & Rossidy, I. (2024). Penerapan Metode Field Trip Observation untuk Meningkatkan Wawasan Siswa di MTs Muhammadiyah 10 Gresik. ISLAMIKA, 6(4), 1484-1496.
71. Nabila Alifia, I. (2023). Pengaruh Model Project Based Learning (Pjbl) Dengan Pendekatan Bio-Entrepreneurship (Bep) Terhadap Kemampuan Literasi Sains Dan Life Skill Peserta Didik.
72. Narut, Y. F., & Supardi, K. (2019). Literasi sains peserta didik dalam pembelajaran ipa di indonesia. JIPD (Jurnal Inovasi Pendidikan Dasar), 3(1), 61-69.

Nasution, R. (2016). Analisis kemampuan literasi lingkungan siswa SMA Kelas X di Samboja dalam pembelajaran biologi. In Proceeding Biology Education Conference (Vol. 13, No. 1, pp. 352-358).

Nihayati, F. (2024, August). Upaya Meningkatkan Kemampuan Berpikir Kreatif Peserta Didik Menggunakan Model Project Based Learning (PjBL) Bermuatan ESD. In Proceeding Seminar Nasional IPA (pp. 273-280).

Ningrum, M., & Hasanah, E. (2021). Manajemen kurikulum dan implementasi education for sustainable development pada perguruan tinggi. Didaktis: Jurnal Pendidikan dan Ilmu Pengetahuan, 21(2).

Norlena, I. (2015). Sekolah Sebagai Organisasi Formal (Hubungan Antar Struktur). Tarbiyah Islamiyah: Jurnal Ilmiah Pendidikan Agama Islam, 5(2). Syaadah, R., Ary, M.

Nugraha, F., Permanasari, A., & Pursitasari, I. D. (2021). Disparitas literasi lingkungan siswa sekolah dasar di Kota Bogor. JIPI (Jurnal IPA dan Pembelajaran IPA), 5(1), 15-35.

Nurhayati, M. E., Indrawati, I., & Wicaksono, I. (2022). Pengaruh Penggunaan Edmodo pada Materi Perubahan Iklim terhadap Kemampuan Literasi Sains dan Hasil Belajar Siswa SMP. PSEJ (Pancasakti Science Education Journal), 7(2), 76-88.

Nurjannah, S. (2024). Strategi Pembelajaran PAI Kontekstual. Analysis, 2(1), 204-213.

OECD, PISA 2018 Assesment

Pauw, J. B. de, & Gericke, N. (2015). The effectiveness of education for sustainable development. Sustainability (Switzerland), 7(11), 15693–15717. https://doi.org/10.3390/su71115693

Prabawani, B., & Hanika, I. M. (2017). Primary schools eco-friendly education in the frame of education for sustainable development. International Journal of Environmental and Science Education, 12(4), 607–616. https://doi.org/ijese.2017.040

Prasrihamni, M., Marini, A., Nafiah, M., & Surmilasari, N. (2022). Inovasi pendidikan jenjang Sekolah Dasar dalam pelaksanaan pembelajaran di era digital. JRPD (Jurnal Riset Pendidikan Dasar), 5(1), 82-88.,

Pratiwi, S. N., Cari, C., & Aminah, N. S. (2019). Pembelajaran IPA abad 21 dengan literasi sains siswa. Jurnal Materi dan Pembelajaran Fisika, 9(1), 34-42.

Purnama, Margareta, Juwita Boru, and Nanik Hariyana. (2022). "Peran Program Kampus Mengajar dalam Meningkatkan Komptensi SDN Sepatan III Kabupaten Tangerang." 1(4):316–24.

Rahayu, R., Iskandar, S., & Abidin, Y. (2022). Inovasi pembelajaran abad 21 dan penerapannya di Indonesia. Jurnal Basicedu, 6(2), 2099-2104.

Rahayu, S. (2023). "Rain in A Bottle", Inovasi Pembelajaran IPA di Sekolah Dasar. PRIMARY, 2(2), 92-101.

Rahmayanti, H., & Feryl Ilyasa, S. K. M. (2022). Pendidikan Lingkungan dan Perubahan Iklim. Selat Media.

Ramli, M. (2015). Rancangan Media Pembelajaran Pendidikan Agama Islam. Tarbiyah Islamiyah: Jurnal Ilmiah Pendidikan Agama Islam, 5(2).

Ratnasari, D., Koosbandiah, R. H., & Supriatno, B. (2017). Pengaruh field trip mangrove cagar alam pulau dua terhadap sikap ilmiah siswa SMA. Jurnal Eksakta Pendidikan (JEP), 1(2), 1-8.

Restu, R., Berutu, N., Ridha Syafii Damanik, M., & Suriani Harefa, M. (2017). Model of Mangrove Ecosystem Utilization as Media and Learning Resources of Environmental Education at Senior High School. 79(Icge 2016), 334–338. https://doi.org/10.2991/icge-16.2017.64

Rimbun, W., Sriyati, S., & Amprasto, A. (2018). The importance of teaching materials based local potential mangrove ecosystems: introduction study. In International Conference on Mathematics and Science Education of Universitas Pendidikan Indonesia, 3, 7–11.

Rini, D. S., & Faisal, F. (2015). Perbandingan Power of Test dari Uji Normalitas Metode Bayesian, Uji Shapiro-Wilk, Uji Cramer-von Mises, dan Uji Anderson-Darling. GRADIEN, 11(2), 1101-1105.

Rosmana, P. S., Ruswan, A., Sari, K., Rahmawati, N., Sativa, O., Maulana, R., ... & Agustia, Y. (2024). Pembelajaran Berbasis Proyek: Perancangan Modul Pembelajaran yang Mendorong Kolaborasi dan Kreativitas. Jurnal Pendidikan Tambusai, 8(1), 3494-3498.

Rosyid, N. U. (2020). Ekoliterasi Mangrove. SPASI MEDIA.

Salahuddin, M. A. A., Rohayani, I. S., & Candri, D. A. (2021). Species diversity of birds as bioindicators for mangroves damage at Special Economic Zones (SEZ) Mandalika in Central of Lombok, Indonesia. IOP Conference Series: Earth and Environmental Science, 913(1). https://doi.org/10.1088/1755-1315/913/1/012058

Santoso, D., Syukur, A., & Zulkifli, L. (2022). Development of Science Teaching Materials Based on Ecological Value of Mangrove Ecosystems as a Strategy to Improve Science Literacy of Junior High School Students on the South Coast of East Lombok. Jurnal Penelitian Pendidikan IPA, 8(1), 283–290. https://doi.org/10.29303/jppipa.v8i1.1325

Santoso, R., Roshayanti, F., & Siswanto, J. (2021). Analisis literasi lingkungan siswa SMP. JPPS (Jurnal Penelitian Pendidikan Sains), 10(2), 1976-1982.

Saputra, E. E., Veronika, F., & Wulandari, S. (2024). Studi Literatur: Eksplorasi Pembelajaran IPA Berbasis Lingkungan untuk Mendorong Kesadaran Lingkungan Pada Anak. Indonesian Journal of Innovation Science and Knowledge, 1(1), 21-34.

Saputri, D. N., Winarni, E. W., & Gunawan, A. (2019). Pengaruh Pemanfaatan Hutan Mangrove sebagai Sumber Belajar IPA terhadap Sikap Peduli Lingkungan Siswa Kelas IV SD Kota Bengkulu. Jurnal PGSD: Jurnal Ilmiah Pendidikan Guru Sekolah Dasar, 12(2), 150-158.

Sarastika, T. 2017. Pengelolaan Jasa Ekosistem Mangrove Berdasarkan Persepsi Masyarakat dalam Pengurangan Risiko Bencana di WilayahPesisir Kota Pekalongan.

Sawitri, A. D., Priyanti, P. W., Wanah, N., & Prayogo, M. S. (2024). Membangun Generasi Peduli Lingkungan: Analisis Literatur Pembelajaran Sains di Tingkat SD/MI. INKUIRI: Jurnal Pendidikan IPA, 13(1), 106-113.

Shobirin, M. (2024). Pengembangan Modul Pembelajaran Biologi Berbasis Lingkungan Lokal: Studi Kasus Ekosistem Pesisir. WriteBox, 1(4).

Sholeh, M. I., Tasya, D. A., Syafi'i, A., Rosyidi, H., Arifin, Z., & binti Ab Rahman, S. F. (2024). Penerapan Pembelajaran Berbasis Proyek (PjBL) Dalam Meningkatkan Kemampuan Berpikir Kritis Siswa. Jurnal Tinta: Jurnal Ilmu Keguruan Dan Pendidikan, 6(2), 158-176.

Sholihat, D., & Anwar, A. (2023). Rumpun ilmu Pengetahuan Alam dalam Perspektif Islam dan Barat. Jurnal Sains dan Teknologi, 5(2), 676-686.

Solihin, A., Choirunnisa, N. L., & Mintohari, M. (2024). Eksplorasi Etnosains Monumen Kapal Selam Surabaya Sebagai Sumber Belajar IPAS Sekolah Dasar. Jurnal Review Pendidikan Dasar: Jurnal Kajian Pendidikan dan Hasil Penelitian, 10(2), 137-148.

Steven, K., & Saearani, M. F. T. B. (2024). Paradigma dan Isu dalam Pendidikan Seni: Strategi Untuk Pengembangan Pendekatan yang Relevan dan Berkelanjutan. Didaktika: Jurnal Kependidikan, 13(3), 3833-3846.

Sugiyono, D. (2014). Metode Penelitian Kombinasi (Mixed Methods), Bandung: Alfabeta, 2013. Jurnal JPM IAIN Antasari Vol, 1(2).

Sugiyono. (2011). Metode Penelitian Kuantitatif, Kualitatif, dan Kombinasi (Mix Methods). Bandung: Penerbit

Sugiyono. (2015). Metode penelitian Kombinasi (Mixed Methods). AL Fabeta.

Suhandi, A. M., & Robi'ah, F. (2022). Guru dan tantangan kurikulum baru: Analisis peran guru dalam kebijakan kurikulum baru. Jurnal basicedu, 6(4), 5936-5945.

Supriadi. 2017. "Pemanfaatan Sumber Belajar Dalam Proses Pembelajaran." Lantanida Journal 3(2):127–39.

Suprihatin, E. (2017). Peningkatan Aktivitas Dan Hasil Belajar IPA Tentang Bagian-Bagian Tumbuhan Melalui Pendekatan Contextual Teaching And Learning Pada Siswa Kelas IV SDN Heuleut Tahun Pelajaran 2015/2016. Jurnal Edukasi (Ekonomi, Pendidikan dan Akuntansi), 5(1).

Suryantika, I., & Aliyyah, R. R. (2023). Implementasi Kurikulum Merdeka: Strategi Pembelajaran di Luar Kelas pada Sekolah Dasar. Karimah Tauhid, 2(6), 3103-3134.

Susanti, F. D. (2021). Potential of mangrove ecosystem as learning sources of Biology through online learning. AMCA Journal of Science & Technology, 1(1), 12–16. https://doi.org/10.51773/ajst.v1i1.28

Susdarwati, S., Jumadi, J., Firdaus, M., & Purbowati, D. (2024). Berpikir Kritis Siswa Dalam Pembelajaran IPA: Tinjauan Filsafat Pedagogi Kritis Islami. Bayfa Cendekia Indonesia.

Sutanto, H. P. (2017). Education for sustainable development in West Nusa Tengara. Cakrawala Pendidikan, 3, 320-341.

Sutrisna, N. (2021). Analisis kemampuan literasi sains peserta didik SMA di Kota Sungai Penuh. Jurnal inovasi penelitian, 1(12), 2683-2694.

Tahmid, T., Nurkhoiri, N., & Syaiful, M. (2024). Implementasi Perangkat Belajar Sains Berbasis ESD pada Materi Pencemaran Lingkungan untuk Peningkatan Literasi dan Keterampilan Berpikir Kritis Siswa: Implementasi Perangkat Belajar Sains Berbasis ESD pada Materi Pencemaran Lingkungan untuk Peningkatan Literasi dan Keterampilan Berpikir Kritis Siswa. Diklabio: Jurnal Pendidikan dan Pembelajaran Biologi, 8(2), 235-245.

Taqwan, S. H. B. (2019). Pengaruh pembelajaran luar kelas (outdoor learning) terhadap kemampuan pemecahan masalah siswa kelas vii smp negeri 05 seluma. Jurnal Pendidikan Matematika Raflesia, 4(1), 10-18.

Taufik, A. N., Berlian, L., Wahyuni, A. R., & Khofifah, M. (2024). -Profile of Ecoliteracy Ability of Science Students On Environmental Issues: Ecoliteracy Ability. PENDIPA Journal of Science Education, 8(3), 415-421.

Teddy, K. (2023). Implementasi PjBL-STEM berbasis ESD (Education for sustainable development) pada topik energi terbarukan untuk meningkatkan kemampuan berpikir sistem.

Tristananda, P. W. (2018). Membumikan Education for Sustainable Development (ESD) di Indonesia dalam menghadapi isu–isu global. Purwadita: Jurnal Agama dan Budaya, 2(2), 42-49.

Undari, M. (2023). Pengaruh penerapan model PJBL (Project-Based Learning) terhadap keterampilan abad 21. Jurnal Tunas Bangsa, 10(1), 25-33.

UNESCO. (2017). Education for Sustainable Development Goals: Learning Objectives; UNESCO: Paris, France. In International Journal of Trend in Scientific Research and Development (Vol. 2, Issue 1). https://doi.org/10.31142/ijtsrd5889

UNESCO. (2020). Education for sustainable development: a roadmap. United Nations Educational, Scientific and Cultural Organization. https://doi.org/https://doi.org/10.54675/YFRE1448

UNESCO. (2023). ESD for 2030: What's next for Education for Sustainable Development? United Nations Educational, Scientific and Cultural Organization. https://www.unesco.org/en/articles/esd-2030-whats-next-education-sustainabledevelopment

Usmadi, U. (2020). Pengujian persyaratan analisis (Uji homogenitas dan uji normalitas). Inovasi Pendidikan, 7(1).
Vioreza, N., Hilyati, W., & Lasminingsih, M. (2023). Education for Sustainable Development: Bagaimana Urgensi dan Peluang Penerapannya pada Kurikulum Merdeka?. PUSAKA: Journal of Educational Review, 1(1), 34-48.
Wedyawati, N., & Lisa, Y. (2018). Kelayakan Buku Ajar Mata Kuliah Pembelajaran IPA SD Bagi Mahasiswa PGSD. Edukasi: Jurnal Pendidikan, 16(2), 155-168.
Wibowo, H. S. (2023). Pengembangan Teknologi Media Pembelajaran: Merancang Pengalaman Pembelajaran yang Inovatif dan Efektif. Tiram Media.
Wicaksono, B. A., Khotimah, K., Segara, N. B., & Prastiyono, H. (2023). Analisis Potensi Ekosistem Mangrove Center Tuban Sebagai Sumber Belajar Pendidikan Lingkungan Bahari Dalam Pembelajaran IPS. SOSEARCH: Social Science Educational Research, 3(2), 66-80.
Wijaya, E. Y., & Dkk. (2016). Transformasi Pendidikan Abad 21 Sebagai Tuntuan Pengembangan Sumber Daya Manusia Di Era Global. Universitas Kanjuruhan Malang, 263 (vol.1).
Wulandari, T. D., Widiyatmoko, A., & Pamelasari, S. D. (2022, August). Keefektifan pembelajaran ipa berbantuan virtual reality untuk meningkatkan kemampuan kognitif siswa SMP di abad 21: Review artikel. In Proceeding Seminar Nasional IPA (pp. 106-115).
Yolanda, A., Sihotang, M., Zebua, J. A., Hutasoit, M., & Sinaga, Y. L. (2024). Strategi Pembelajaran Kontekstual untuk Meningkatkan Pemahaman Konsep Siswa Sekolah Dasar. Pragmatik: Jurnal Rumpun Ilmu Bahasa dan Pendidikan, 2(3), 301-308.
Yulia, L. (2024). PENGARUH MODEL PEMBELAJARAN DISCOVERY LEARNING TERHADAP HASIL BELAJAR IPA MATERI PERUBAHAN WUJUD BENDA KELAS V DI SEKOLAH DASA (Doctoral dissertation, Universitas PGRI Palembang).
Yusmar, F., & Fadilah, R. E. (2023). Analisis rendahnya literasi sains peserta didik indonesia: Hasil PISA dan faktor penyebab. LENSA (Lentera Sains): Jurnal Pendidikan IPA, 13(1), 11-19.
Zubaidah, S. (2016, December). Keterampilan abad ke-21: Keterampilan yang diajarkan melalui pembelajaran. In Seminar Nasional Pendidikan (Vol. 2, No. 2, pp. 1-17).