

## Raising the Issue of Local Wisdom in Science Learning and Its Impact on Increasing Students' Scientific Literacy

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### Abstract

In the context of global educational challenges, scientific literacy remains a foundational goal yet is often hindered by traditional teaching methods that lack cultural and contextual relevance. This study addresses the intersection of local wisdom with science education as a strategy to enhance students' scientific literacy, grounded in the belief that culturally resonant teaching can improve learning outcomes. This study explores the impact of integrating local wisdom into science education on enhancing students' scientific literacy. Employing an experimental pretest-posttest control group design, the research involved 86 Indonesian high school students, divided evenly between a control group receiving traditional science instruction and an experimental group whose curriculum was enriched with local wisdom content. Over a six-week period focused on climate change, the experimental group's instruction intertwined indigenous knowledge with scientific concepts, aiming to create a culturally contextualized learning experience. The results, derived from quantitative measures were analyzed using ANOVA and post hoc tests. Findings indicate a statistically significant improvement in the scientific literacy of the experimental group compared to the control group, with the former demonstrating a substantial increase in post-test scores. The study confirms that local wisdom can be a potent tool in science education, leading to higher engagement and improved scientific literacy. This research contributes to the field by providing empirical evidence supporting culturally responsive teaching approaches and underscores the potential of local wisdom in bridging the gap between traditional knowledge systems and scientific methodologies.

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## INTRODUCTION

The intersection of traditional knowledge and contemporary science education represents a crucial frontier in the quest to enhance scientific literacy among students. In recent years, the integration of local wisdom into academic curricula has garnered attention for its potential to offer contextualized learning experiences that resonate with students'

cultural backgrounds (Suprpto et al., 2021). This approach not only enriches the learning environment but also bridges the gap between indigenous knowledge systems and modern scientific methodologies. The concept of local wisdom entails the practices, beliefs, and knowledge that have been developed over generations within various communities and have been instrumental in their survival and adaptation to the local environment (Diab et al., 2022).

Scientific literacy, a foundational goal of science education, equips individuals with the skills, knowledge, and attitudes necessary to make informed decisions and engage with scientific issues in their daily lives (Peffer et al., 2020). Despite its importance, challenges persist in achieving high levels of scientific literacy among students globally. Traditional science teaching methods, which often rely on rote memorization and lack contextual relevance, have been criticized for their limited effectiveness in fostering deep understanding and appreciation of scientific concepts in the context of local wisdom (Verawati et al., 2022). This has led to a growing consensus on the need to explore innovative pedagogical strategies that can enhance engagement and learning outcomes (Herodotou et al., 2019).

The integration of local wisdom into science learning presents a promising avenue for addressing these challenges. By grounding scientific concepts in the local culture and environment, educators can provide students with relatable and meaningful learning experiences. This approach not only promotes the appreciation and preservation of cultural heritage but also enhances students' understanding and interest in science (Suciati, 2023). Moreover, it supports the development of critical thinking and problem-solving skills by encouraging students to draw connections between traditional knowledge and scientific exploration (Noorhapizah et al., 2020).

However, the implementation of local wisdom in science education poses its own set of challenges. These include the identification and selection of appropriate local knowledge, the adaptation of curricular materials, and the training of educators to effectively blend traditional wisdom with scientific principles (Suciati, 2023). Furthermore, there is a need for empirical evidence to support the effectiveness of this approach in improving scientific literacy. This necessitates rigorous research to explore the impact of integrating local wisdom on students' learning outcomes and their ability to apply scientific knowledge in real-world contexts (Setiawan et al., 2017). The study by Indana et al. (2018) provides valuable insights into the scientific literacy skills of junior high school students, indicating that there is a need for improvement in this area. The research highlights the importance of science literacy in addressing real-life science issues and emphasizes the role of science in developing students' knowledge and skills. This supports the idea that integrating local wisdom into science learning can enhance students' science literacy by providing them with practical and relevant knowledge that can be applied to real-world situations.

The objective of this study is to investigate the role of local wisdom in science learning and its impact on increasing students' scientific literacy. By examining the integration of indigenous knowledge into the science curriculum, this research aims to shed light on how local wisdom can enrich science education and contribute to the development of scientifically

literate individuals. This involves exploring the pedagogical strategies employed to incorporate local wisdom into science teaching and assessing their effectiveness in enhancing students' understanding and interest in science.

The integration of local wisdom into science learning is seen as an opportunity to address the challenges of enhancing scientific literacy. This approach involves leveraging Indonesia's diverse local wisdom, which has been underutilized in education, to develop a local wisdom-based learning. Previous research by Suciati (2023) has identified that integrating local wisdom in science education can face obstacles, particularly in aspects like lesson planning and implementation. However, it also represents a significant opportunity for educators to develop curricula that not only preserve local culture but also improve scientific understanding and literacy. Further studies highlight that local wisdom-based science learning can positively impact students' creative thinking skills. By incorporating local knowledge and practices into science education, students are provided with a more relatable and context-rich learning environment. This approach not only fosters an appreciation for local culture but also enhances critical thinking and problem-solving abilities, which are essential components of scientific literacy (Wati et al., 2023).

Current study aims to provide a comprehensive understanding of how local wisdom can be effectively incorporated into science education and its potential impact on students' learning outcomes. By bridging the gap between traditional knowledge and scientific inquiry, this research contributes to the development of more contextualized and engaging science education practices, ultimately fostering a deeper appreciation and understanding of science among students. Specifically, this study answers the following research questions.

- How is the impact of integrating local wisdom into science education on enhancing students' scientific literacy?

## **METHODS**

### **Study Design**

This research adopted an experimental design, specifically a pretest-posttest control group design (Fraenkel et al., 2012), to investigate the impact of integrating local wisdom into science learning on students' scientific literacy. The study was structured around the participation of two groups: an experimental group that received science instruction enriched with local wisdom content, and a control group that engaged in traditional science learning without a focus on local wisdom. Both groups underwent a pretest to assess their initial scientific literacy levels, followed by a six-week intervention period consisting of six teaching sessions. The intervention focused on climate change as the primary topic, ensuring that the content was both relevant and challenging. To maintain the integrity of the research and minimize instructional bias, both groups were taught by professional educators well-versed in the subject matter and the specifics of the experimental design.

The selection of climate change as the central theme allowed for a rich exploration of local wisdom, linking traditional knowledge with contemporary scientific understanding.

This approach aimed to provide the experimental group with a deeper, more contextualized understanding of climate change, potentially enhancing their scientific literacy. Following the six instructional sessions, a posttest was administered to both groups to measure the impact of the intervention. The careful planning and execution of these sessions were critical in maintaining the fidelity of the experimental design and ensuring the reliability of the research outcomes.

### **Sample**

The study sample consisted of 86 students from a private school in Indonesia, evenly divided into two groups of 43 students each for the experimental and control conditions. The participants were adolescents, aged between 15 and 16 years, with a nearly equal distribution of males and females, all of whom were of native Indonesian ethnicity. This demographic selection was intentional, aiming to provide a diverse yet homogeneous sample that could yield generalizable findings within the specific cultural context.

In adhering to ethical standards for research involving human participants, the study secured permission from the educational institution and obtained direct consent from all student participants. The ethical considerations included ensuring the privacy and confidentiality of student data, as well as the voluntariness of participation. This compliance with ethical guidelines not only protected the participants but also reinforced the integrity and credibility of the research process.

### **Instrument**

To assess students' scientific literacy, the research employed a comprehensive set of instruments designed to measure various dimensions of scientific understanding and application. These instruments included standardized test items that evaluated students' knowledge of scientific concepts, their ability to apply this knowledge in real-world contexts, and their critical thinking and problem-solving skills. The tests were developed with careful consideration of validity and reliability, ensuring that they accurately reflected the aspects of scientific literacy the study aimed to measure.

In addition to the standardized tests, observational checklists and student reflection journals were used to gather qualitative data on the learning process and students' engagement with the material. These instruments provided insights into the effectiveness of local wisdom integration in science education, offering a more nuanced understanding of its impact on students' scientific literacy. The combination of quantitative and qualitative data collection methods enriched the research findings, offering a comprehensive view of the educational intervention's outcomes.

### **Procedure**

The research procedure began with the administration of the pretest to both the experimental and control groups, establishing a baseline measure of scientific literacy. Following this, the experimental group engaged in the six-week instructional intervention,

where science learning was intertwined with local wisdom related to climate change. The control group received traditional science instruction without the integration of local wisdom. Throughout the intervention, the same professional educators delivered the curriculum to both groups to maintain teaching quality and consistency. After completing the six instructional sessions, a posttest was administered to both groups to evaluate the impact of the intervention on students' scientific literacy.

### Data Analysis

Data analysis involved both descriptive and statistical techniques to thoroughly examine the effects of the educational intervention. Descriptive analysis provided an overview of the participants' performance on the pretest and posttest, highlighting changes in scientific literacy levels within and between the experimental and control groups. This included averages, standard deviations, and distributions of scores, offering insight into the general trends and variations in student performance. Statistical analysis utilized the Analysis of Variance (ANOVA) test to determine the significance of the differences observed between the experimental and control groups' posttest scores. The ANOVA was chosen for its ability to compare means across multiple groups, making it an ideal tool for assessing the impact of the intervention on scientific literacy. This analysis helped to establish whether the integration of local wisdom into science learning significantly improved students' scientific literacy compared to traditional teaching methods. The statistical significance was set at  $p < 0.05$ , ensuring that the findings were robust and reliable.

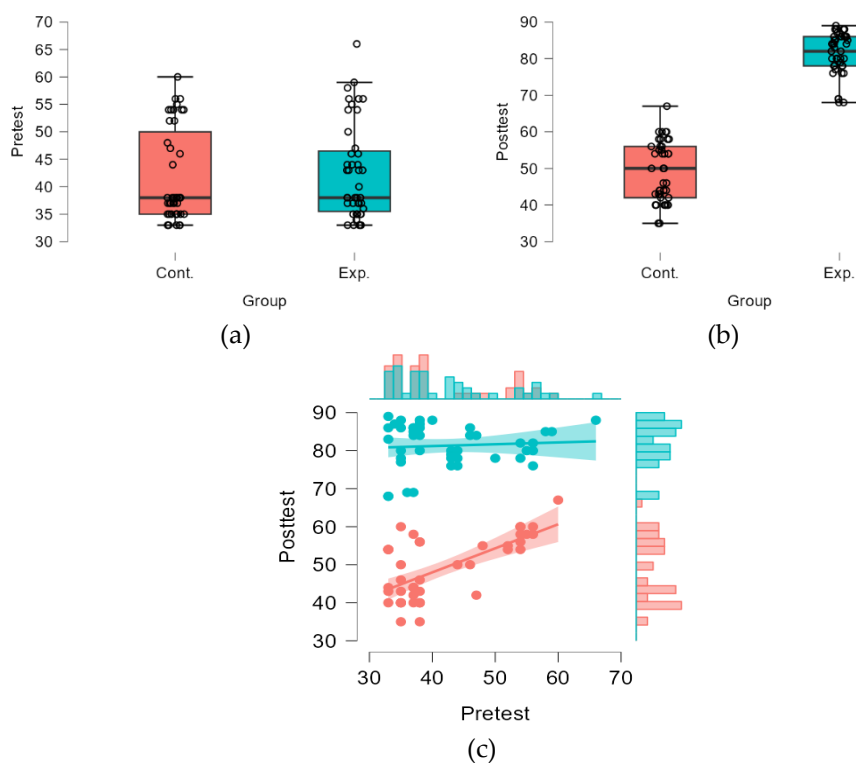
## RESULTS AND DISCUSSION

Within the realm of science education, the fusion of traditional knowledge and pedagogical practice stands as a beacon of innovation in the quest to elevate scientific literacy. In this context, a study has been carried out to investigate the impact of integrating local wisdom into science learning on students' scientific literacy. The results of the descriptive analysis of this research are presented in Table 1 and Figure 1.

**Table 1.** Results of descriptive analysis of students' scientific literacy

Variable	Pretest		Posttest	
	Control	Experimental	Control	Experimental
Valid	43	43	43	43
Mean	41.628	42.605	49.023	81.326
Std. Error of Mean	1.297	1.341	1.255	0.861
Std. Deviation	8.502	8.792	8.227	5.647
Coefficient of variation	0.204	0.206	0.168	0.069
Variance	72.287	77.292	67.690	31.891
Minimum	33.000	33.000	35.000	68.000
Maximum	60.000	66.000	67.000	89.000

Table 1 provides a detailed comparison of students' scientific literacy before and after participating in an educational intervention that integrated local wisdom into science learning. The control group, which received traditional science instruction, showed an improvement in their mean score from 41.628 to 49.023, indicating some progress in scientific literacy. In contrast, the experimental group, which experienced science learning enriched with local wisdom, demonstrated a significant leap in their mean score from 42.605 to 81.326. This stark difference highlights the effectiveness of incorporating local wisdom into science education. The standard deviation, a measure of score dispersion, decreased in the experimental group post-intervention, suggesting a more consistent understanding of scientific concepts among these students. The minimum and maximum scores, along with the coefficient of variation and variance, further underscore the dramatic improvement in the experimental group, reflecting a more uniform and higher level of scientific literacy compared to the control group.



**Figure 1.** Descriptive plots of students' scientific literacy scores in the experimental and control groups: (a) box plot for pretest, (b) box plot for posttest, and (c) scatter plot for pretest-posttest

Figure 1 comprises three descriptive plots that illustrate the distribution and relationship of scientific literacy scores for the control and experimental groups before and after the intervention. The first plot (Figure 1a) is a box plot comparing the pretest scores between the control and experimental groups. Both box plots show a central rectangle spanning the first quartile to the third quartile, a segment inside the rectangle showing the median. The distribution of pretest scores in both groups is relatively similar, with the median

score for the experimental group being slightly higher. This suggests that both groups started from a comparable level of scientific literacy. The second box plot (Figure 1b) shows the posttest scores. The control group's scores show a modest improvement with a median that is higher than in the pretest, yet the scores remain tightly packed. In stark contrast, the experimental group's posttest scores are not only higher on average, as evidenced by the higher median, but also show a greater spread, with some scores reaching as high as the upper 80s. This indicates a substantial improvement in scientific literacy for the experimental group compared to the control group. The third plot (Figure 1c) is a scatter plot with a fitted line that demonstrates the relationship between the pretest and posttest scores for each student. The plot is divided into two sections by color, red for the control group and blue for the experimental group, with histograms on the top and right margins showing the distribution of posttest and pretest scores, respectively. The positive slope of the fitted lines for both groups indicates that students with higher pretest scores tend to have higher posttest scores. However, the slope is steeper for the experimental group, suggesting that the intervention had a stronger positive effect on students with higher initial literacy. The scatter plot also shows that the posttest scores in the experimental group are clustered at the higher end, which is consistent with the significant increase in their mean score as reported in Table 1.

In summary, these visual representations corroborate the findings from Table 2, where the integration of local wisdom into science learning showed a significant and strong effect on improving scientific literacy in the experimental group. The plots visually demonstrate that not only did the experimental group start with a similar level of scientific literacy as the control group but they finished with a higher level of literacy, emphasizing the effectiveness of the learning intervention. Furthermore, an ANOVA test was carried out on students' scientific literacy scores, the results are presented in Table 2 and post hoc test in Table 3.

**Table 2.** The ANOVA test results on students' scientific literacy scores

Case	SS	df	MS	F	p	VS-MPR	$\eta^2$
<b>Within Subjects Effects</b>							
RM Factor 1	22862.145	1	22862.145	608.023	< .001	1.277×10 <sup>+37</sup>	0.410
RM Factor 1 * Group	10548.890	1	10548.890	280.550	< .001	3.467×10 <sup>+25</sup>	0.189
Residuals	3158.465	84	37.601				
<b>Between Subjects Effects</b>							
Group	11905.587	1	11905.587	136.878	< .001	3.384×10 <sup>+16</sup>	0.213
Residuals	7306.279	84	86.980				

Note: RM = Repeated Measures (pretest-posttest), SS = Sum of Squares, MS = Mean Square, VS-MPR = Vovk-Sellke Maximum p -Ratio

Table 2 presents the results of the Analysis of Variance (ANOVA) test, which was conducted to assess the impact of the educational intervention on students' scientific literacy. The within subjects effects, analyzing the repeated measures (pretest-posttest), and the between subjects effects, examining differences between groups, both showed highly significant results ( $p < .001$ ). The F-values, representing the ratio of variance between the groups to the variance within the groups, were remarkably high for both the repeated

measures factor and the interaction between this factor and the group variable. This indicates a strong effect of the educational intervention. The  $\eta^2$  values, which measure the proportion of the total variation attributable to the factor, suggest that a significant portion of the variance in posttest scores can be explained by the group membership (experimental vs. control). The Vovk-Sellke Maximum p-Ratio further supports the statistical significance and strength of these findings, suggesting a very low probability of these results being due to chance.

**Table 3.** The post hoc test results

Case		Mean Diff.	SE	t	Cohen's d	p <sub>tukey</sub>
Cont., Pretest	Exp., Pretest	-0.977	1.702	-0.574	-0.124	0.940
	Cont., Posttest	-7.395	1.322	-5.592	-0.937	< .001
	Exp., Posttest	-39.698	1.702	-23.322	-5.030	< .001
Exp., Pretest	Cont., Posttest	-6.419	1.702	-3.771	-0.813	0.001
	Exp., Posttest	-38.721	1.322	-29.280	-4.906	< .001
Cont., Posttest	Exp., Posttest	-32.302	1.702	-18.978	-4.093	< .001

Note: Computation of Cohen's d based on pooled error, p-value adjusted for comparing a family of 6

Table 3 delves into the specific differences between the groups and test times through post hoc tests, employing mean differences, standard errors, t-values, Cohen's d for effect size, and adjusted p-values. The comparisons reveal that the experimental group's posttest scores were significantly higher than those of the control group, both in terms of their own pretest scores and when compared directly to the control group's posttest scores. The effect sizes, indicated by Cohen's d, were notably large for these comparisons, especially between the experimental group's posttest and both the control's posttest and the experimental's own pretest scores. This suggests a substantial impact of the intervention on enhancing scientific literacy. The adjusted p-values confirm the statistical significance of these differences, with the experimental group showing remarkable improvements not only compared to their baseline but also relative to the control group's achievements. These results underscore the potential of integrating local wisdom into science education as a means to significantly elevate students' scientific literacy.

The dramatic improvement in scientific literacy among the experimental group, as indicated by the data, suggests that integrating local wisdom into science education can be a potent catalyst for enhancing students' understanding and appreciation of scientific concepts. This supports the growing body of educational research which advocates for culturally responsive teaching methods. For instance, previous study also found that when science education is connected to students' life worlds, the engagement and learning outcomes improve significantly (Morales, 2015; Wati et al., 2023).

The marked increase in post-intervention scores in the experimental group, as shown in Table 1, underscores the potential benefits of a contextualized science learning. These findings are in line with the works of Lee et al. (2012) and Aikenhead (2017), who argue that students' cognitive development is better supported when their cultural background is taken into



account in the learning process. The significant difference in the coefficient of variation between pretest and posttest in the experimental group compared to the control group further reinforces the notion that local wisdom can make science learning more accessible and relevant to students.

The statistical significance of the results, detailed in Table 2, with very low p-values and high F-values in the ANOVA, highlights the robust impact of the intervention, as also noted by Badeo and Duque (2022). This statistical evidence strengthens the argument presented by Murphy (2003) that educational approaches which connect scientific content to the local culture can lead to a deeper cognitive engagement with science. The  $\eta^2$  values indicating a large effect size further align with the findings of Handayani et al. (2018), who suggest that science education that incorporates indigenous knowledge can lead to higher motivation and improved understanding among students.

The visual evidence from Figure 1, particularly the scatter plot, presents a compelling narrative of individual student improvement. The steeper slope for the experimental group indicates not only a general improvement but also suggests that students who started with higher pretest scores may have benefited more from the local wisdom-infused curriculum. This observation might echo the findings of Lipka et al. (2014), who found that contextualized science education can be especially beneficial for students who already have a foundation of scientific knowledge, perhaps because these students can better integrate new information with existing knowledge.

The observed benefits of integrating local wisdom into science teaching resonate with the theoretical framework of constructivism, which posits that learners construct new knowledge based on their existing cognitive structures. This aligns with the research by Barnhardt and Kawagley (2008), which indicates that when students' cultural backgrounds and local knowledge are acknowledged and valued in the classroom, their ability to connect with and understand scientific concepts is enhanced. However, while the findings are promising, they also invite further inquiry into the scalability of such interventions and their applicability across diverse cultural contexts. Previous studies, such as those by Hairida and Setyaningrum (2020), have suggested that while local wisdom can be a powerful tool in science education, its implementation must be carefully tailored to the specific cultural context of the students. For example, the study by Hadisaputra et al. (2020) provides evidence supporting the use of local wisdom-based practicum in improving students' attitudes, science literacy, and learning outcomes. The research, conducted with students in Sumbawa Island, Indonesia, utilized a quasi-experimental design and quantitative data analysis to demonstrate the positive impact of local wisdom-based practicum on students' science literacy. The findings indicate that students who engaged in local wisdom-based practicum activities showed higher mean scores for attitudes, science literacy, and learning outcomes compared to the control group (Hadisaputra et al., 2020). This aligns with current studies that have also highlighted the benefits of integrating local wisdom into science education to enhance students' scientific literacy.

The current research presented provides strong empirical support for the incorporation of local wisdom into science education as a means to enhance scientific literacy. It contributes to a growing consensus in the field that education that is sensitive to students' cultural backgrounds can lead to more meaningful and effective learning. Future research should focus on longitudinal studies to assess the long-term impact of this approach and explore the mechanisms by which local wisdom can be most effectively integrated into various educational settings.

## **CONCLUSION**

The study's findings provide compelling evidence that incorporating local wisdom into science education significantly enhances students' scientific literacy. The experimental group, which received instruction enriched with local wisdom, not only showed marked improvement in scientific literacy scores but also demonstrated a deeper engagement with scientific concepts compared to the control group. This suggests that when students can connect learning materials to their cultural and environmental context, they develop a stronger and more substantive understanding of science. The research thus underscores the value of integrating indigenous knowledge into the science curriculum, which can serve as a bridge between traditional cultural knowledge and modern scientific understanding, fostering a more holistic educational experience.

The integration of local wisdom into science education represents a promising pedagogical strategy that merits further exploration and application. It aligns with educational reforms that advocate for more culturally responsive teaching approaches, which are crucial in our increasingly diverse and interconnected world. By embracing the local wisdom of students, educators can create a more inclusive and effective learning environment that not only preserves cultural heritage but also prepares students to navigate and contribute to the scientific community with greater competence and confidence.

## **LIMITATION**

One notable limitation of this study is its focus on a single cultural context and a specific topic within science education. The findings, while significant, are derived from a relatively small and homogenous sample size, which may affect the generalizability of the results to other educational settings or cultural backgrounds. Additionally, the study was conducted over a short period, which does not allow for the assessment of the long-term retention of scientific literacy or the sustained impact of integrating local wisdom into science curricula.

## **RECOMMENDATION**

Future research should aim to replicate this study across various cultural contexts and with larger, more diverse populations to validate and potentially generalize the findings. It would also be beneficial to examine the long-term effects of this educational approach on students' scientific literacy and their ability to apply scientific understanding in real-world situations. Furthermore, research should explore the integration of local wisdom into other

areas of the science curriculum to fully understand the breadth and depth of its impact on student learning outcomes.

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The authors have sufficiently contributed to the study, and have read and agreed to the published version of the manuscript.

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#### **Conflict of interests**

The authors declare no conflict of interest.

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