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Integrating Local Wisdom into Science Instruction to Strengthen Scientific Literacy: A Qualitative Study of a Rural Indonesian Junior High School

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Abstract: This qualitative descriptive study examined the integration of local wisdom into science instruction to strengthen students' scientific literacy at SMP Negeri 1 Muara Rupit, a rural junior high school in South Sumatra, Indonesia. Participants included the principal, four science teachers, and ten students, selected purposively. Data were collected through classroom observations, semi-structured interviews, and documentation analysis (lesson plans, student worksheets, photographs) over four months. The interactive model of Miles, Huberman, and Saldaña guided data analysis. Findings revealed that local wisdom-based science instruction was implemented through planning, implementation, and evaluation stages. Teachers integrated local environmental contexts river ecosystems, agricultural activities, and local vegetation into learning objectives, instructional activities, and classroom discussions. This contextual approach enhanced students' conceptual understanding, science process skills (observation, questioning, discussion), environmental awareness, and classroom engagement. However, the integration of comprehensive scientific literacy dimensions (evidence-based reasoning, systematic inquiry, analytical explanation) remained limited and unsystematic within instructional planning and assessment. Supporting factors included school leadership support, rich environmental resources, and student enthusiasm. Inhibiting factors comprised limited facilities, insufficient instructional time, and varying teacher readiness. The study concludes that local wisdom-based science instruction has significant potential to strengthen scientific literacy through contextual and meaningful learning experiences, but requires more systematic planning, scientific literacy-oriented assessment, and teacher professional development. Implications recommend designing structured local wisdom-based instructional frameworks and assessment instruments targeting higher-order scientific reasoning.

Keywords: Contextual Learning, Local Wisdom, Science Learning Management, Scientific Literacy, Students' Engagement

A. Introduction

Science education at the junior high school level plays a strategic role in developing students' literacy capacities, including reading literacy, numeracy, scientific literacy, and socio-cultural values (Bumi et al., 2025). At this educational stage, scientific literacy becomes increasingly important because students begin to enter the formal operational stage, which requires analytical thinking, scientific reasoning, and evidence-based problem-solving abilities (Kadir et al., 2025). Scientific literacy is no longer limited to mastering scientific concepts but also encompasses the ability to understand scientific issues, apply scientific knowledge to solve contextual problems, and make responsible decisions in everyday life (Series, 2020).

Strengthening scientific literacy has become one of the central concerns of twenty-first-century education in response to the growing complexity of environmental, health, and sustainability challenges. However, the achievement of students' scientific literacy in developing countries, including Indonesia, continues to face significant obstacles. Many students still experience difficulties in connecting scientific concepts with real-life contexts and in applying scientific reasoning to solve authentic problems. These conditions indicate that science learning management has not fully promoted contextual, meaningful, and scientific literacy-oriented learning practices (Bórquez-sánchez, 2025).

Several previous studies have emphasized that science learning dominated by abstract explanations, teacher-centered instruction, and textbook dependency tends to hinder the development of students' scientific literacy. At the junior high school level, such conditions contribute to students' low conceptual analysis skills, weak causal reasoning, and limited ability to relate science concepts to environmental phenomena. Therefore, a learning approach that bridges scientific concepts with students' everyday experiences is urgently needed to create more meaningful and sustainable learning processes (Lawa et al., 2025).

One relevant and contextual approach is local wisdom-based learning. Local wisdom refers to the knowledge, values, and practices developed within local communities through long-term interactions between humans and their environment. In educational contexts, local wisdom functions as an authentic learning resource that reflects students' social, cultural, and ecological realities. The integration of local wisdom into science learning enables students to study scientific concepts through phenomena closely related to their daily lives, such as local agricultural activities, natural resource utilization, and community practices in maintaining environmental balance (Rosyidah et al., 2025).

From a learning management perspective, integrating local wisdom involves not only classroom implementation but also systematic planning, organization, execution, and evaluation of learning activities. Recent studies have shown that science learning integrated with local contexts can improve conceptual understanding, critical thinking skills, and students' engagement in learning. Furthermore, this approach contributes to strengthening students' cultural identity and character development. The use of cultural and environmental contexts in science learning significantly improves students' ability to explain scientific phenomena and apply scientific concepts in daily life. The integration of local wisdom in secondary science education enhances scientific literacy while also fostering students' environmental awareness and ecological responsibility (The & Of, 2025).

Despite these findings, most previous studies have predominantly employed quantitative approaches focusing on learning outcomes, while in-depth investigations of the actual processes of local wisdom-based science learning and students' learning experiences remain limited, particularly in rural contexts. In addition, few studies explicitly examine the relationship between local wisdom-based learning and the comprehensive dimensions of scientific literacy, including scientific knowledge, scientific processes, and the application of science in everyday life (Mashami, 2025).

Preliminary observations conducted on January 15, 2026, at SMPN 1 Muara Rupit revealed that science learning was still predominantly managed through conventional approaches characterized by lecture methods, textbook reliance, and written assignments with minimal integration of local contexts. The surrounding environment had not been systematically utilized as a learning resource in lesson planning or instructional design. Science topics such as ecosystems, environmental pollution, and natural resources were generally taught theoretically without connecting them to the local realities of Muara Rupit, which actually possesses rich contextual potential, including swamp agriculture, the utilization of the Rawas River, and local community practices in land and water management. Practical and field observation activities were also limited, reducing students' opportunities to directly observe scientific phenomena within their environment.

Based on these conditions, this study aims to explore how local wisdom is integrated into science learning management to improve students' scientific literacy at SMPN 1 Muara Rupit. Rather than examining the effectiveness of a particular intervention, this study seeks to provide an in-depth description of actual classroom practices and identify the potential integration of local wisdom within science learning management. This research is expected to contribute theoretically to the development of contextual science education and practically to the improvement of meaningful, culturally responsive, and scientific literacy-oriented learning practices in junior high schools.

B. Methods

This research is descriptive qualitative research in order to gain an in-depth understanding of the contribution of local wisdom-based science learning management to the strengthening of students' scientific literacy at SMPN 1 Muara Rupit. To explore the naturally occurring learning processes, students' learning experiences, and the socio-cultural context around science instruction, a qualitative design was deemed appropriate because the study did not aim to test hypotheses and measure causality relationships statistically. The qualitative approach allowed the researchers to explore the meanings, perceptions, and experiences of the participants in integrating local wisdom into practices of science learning. This approach is relevant because local wisdom-based learning is highly contextual and is strongly influenced by environmental conditions, cultural values, and interaction between teachers and students.

The research was conducted at SMPN 1 Muara Rupit, Indonesia. The research participants were selected purposively because they were directly involved and had experience in the science learning activities related to the integration of local wisdom. The participants were principal of the school, science teachers and students deemed capable of providing rich and relevant information on the implementation of contextual science learning and scientific literacy development. Participants' involvement in instructional planning, classroom implementation, and learning experiences related to local environmental and cultural contexts was a key criterion for selection (Siska, 2026).

Table 1. Research Participants

Participant Category	Number	Selection Criteria	Role in Study
Principal	1	The principal responsible for school management and policies related to science learning and local wisdom integration.	Provided information regarding school policies, institutional support, and the implementation of local wisdom-based science learning.
Science Teachers	4	Science teachers who have experience in planning and implementing science learning integrated with local wisdom.	Provided information about lesson planning, instructional implementation, teaching strategies, local wisdom integration, and challenges encountered during classroom instruction.
Students	10	Students actively involved in science learning activities and able to communicate their learning experiences and perceptions.	Shared learning experiences, understanding of science concepts, engagement in learning activities, and responses toward local wisdom-based science learning.

Data were collected through classroom observations, semi-structured interviews and documentation studies in an ongoing and natural manner within the research process. The classroom observations were directed at how teachers incorporate local wisdom in science learning activities, students' participation in scientific processes, and the interactions in the classroom which help in the development of scientific literacy. Observations were repeated several times to ensure consistency of data and to minimize observational bias. Field notes were written descriptively and reflectively to capture classroom dynamics and contextual learning practices (Creswell, John W. ; Poth, 2018).

Semi-structured interviews were conducted with the principal, science teachers and students to get a comprehensive view of the implementation of local wisdom-based learning. The interviews with the principals focused on policies of the school and institutional support for contextual learning. The interviews with teachers were focused on lesson planning, teaching strategies, the inclusion of local wisdom, and the challenges in implementing it. Through student interviews, we explored their learning experiences, understanding of the science concepts, and their attitudes towards contextual learning related to the local culture and environment. All interviews were audio recorded and transcribed verbatim to ensure data accuracy and completeness.

Observation and interview data were supplemented with documentation techniques. The documents collected included lesson plans, teaching materials, student worksheets, photographs of classroom activities and school documents concerning science learning and the integration of local wisdom. To determine the consistency between instructional planning and implementation in the classroom and to strengthen the triangulation of data, documentation analysis was carried out (Zhao et al., 2023).

The instruments used in this research were the observation guidelines, interview protocols, and documentation checklists which were systematically compiled based on the research objectives, scientific literacy dimensions, and concepts of learning based on local wisdom. The instrument indicators are based on the dimensions of scientific literacy such as scientific knowledge, science process skills, and contextual application of science concepts (Y. Liu et al., 2024). Instruments were developed to determine teachers' references to science content in local environmental contexts, students' involvement in scientific inquiry activities, and the application of science concepts to daily life.

Data were collected and analyzed simultaneously by means of the interactive model of (Miles et al., 2018) which comprises data reduction, data display and conclusion drawing. Interview transcripts, field notes and documents were sorted, organized and coded in accordance with the research focus. The relevant data were classified into themes of instructional planning, integration of local wisdom, scientific literacy practices, and students' responses. The data were then presented in a narrative form with tables and matrices to identify patterns and relationships between findings. The additional observations and the data comparisons were used continuously to verify the conclusions for the credibility and consistency. Trustworthiness was ensured through source triangulation, technique triangulation, member checking and prolonged engagement. Data from principals, teachers, and students were triangulated for consistency and findings from observations, interviews, and documents were checked for bias. Member checking was conducted to verify the preliminary interpretations with the participants, particularly the teachers and the principal, to ensure the findings accurately reflected participants' experiences and perspectives (Creswell, John W. ; Poth, 2018; Miles et al., 2018).

C. Results and Discussion

Results

This study was conducted at SMP Negeri 1 Muara Rupit, Musi Rawas Utara Regency, South Sumatra, Indonesia. The school has implemented the Merdeka Curriculum and currently holds an "A" accreditation status. The findings presented in this section were obtained through classroom observations, semi-structured interviews, and documentation involving the principal, science teachers, and students. Data analysis was conducted through data reduction, data display, and conclusion drawing to obtain a comprehensive understanding of the implementation of local wisdom-based science learning management in strengthening students' scientific literacy. The findings are organized into four major themes: planning, implementation, evaluation, and supporting and inhibiting factors of local wisdom-based science learning.

Planning of Local Wisdom-Based Science Learning

The findings demonstrated that lesson planning represented an essential initial stage in managing science learning integrated with local wisdom. Teachers at SMP Negeri 1 Muara Rupit had begun incorporating local environmental contexts into instructional objectives, learning materials, and classroom activities. The integration of local wisdom primarily appeared in teachers' efforts to contextualize science concepts using environmental phenomena familiar to students, such as river ecosystems, local vegetation, and community agricultural activities. The principal explained that the school leadership consistently encouraged teachers to relate classroom instruction to the students' surrounding environment in order to create more meaningful and contextualized learning experiences (Brauckmann et al., 2023). According to the principal, teachers were regularly reminded during school meetings that science learning should not rely solely on textbooks but should also reflect the realities of students' daily lives in Muara Rupit. This institutional support indicated that the school had attempted to establish a contextual learning culture that acknowledged the educational potential of local wisdom and environmental resources.

Science teachers also reported that lesson objectives and instructional materials were intentionally adjusted to local environmental conditions. Teachers explained that they attempted to align learning objectives with the competencies required in the curriculum while simultaneously connecting those competencies to phenomena students encountered in their everyday lives. Teachers frequently selected topics such as river ecosystems, agricultural practices, and local plant diversity because these phenomena were directly observable in students' environments. Such contextualization helped reduce the abstract nature of science concepts and increased students' conceptual understanding. Students confirmed that learning activities connected to their surrounding environment made science lessons easier to understand. Several students explained that teachers often asked them to observe plants, soil conditions, or environmental objects around the school before discussing the observations during classroom sessions. Students believed that observing familiar objects directly enhanced their comprehension because they could connect scientific concepts with real-life experiences rather than merely memorizing information from textbooks (Abebe et al., 2023).

Observation results further reinforced these findings. During classroom instruction, teachers began lessons by introducing examples closely related to environmental conditions around the school. Teachers frequently referred to rivers, local agricultural activities, and surrounding vegetation as examples when explaining scientific concepts (Gugssa, 2023). Documentation analysis of lesson plans also showed that teachers had included learning objectives emphasizing contextual understanding of science concepts through environmental observation activities. Despite these positive developments, the findings indicated that the planning process had not yet explicitly integrated comprehensive scientific literacy indicators. Although teachers included environmental observation and classroom discussions within instructional activities, aspects of scientific literacy such as evidence-based reasoning, analytical inquiry, and systematic scientific explanation had not been formulated clearly within lesson objectives or assessment instruments. Consequently, the integration of local wisdom into lesson planning remained relatively limited and had not yet become a fully structured component of science learning management.

Table 2. Findings on the Planning of Local Wisdom-Based Science Learning

Planning Aspect	Findings
Learning Objectives	Contextualized with local environmental conditions
Learning Materials	Related to rivers, agriculture, and local ecosystems
Learning Activities	Included environmental observations and discussions
Teacher Strategy	Connecting science concepts with students' daily experiences
Scientific Literacy Orientation	Not yet systematically integrated

In this study, scientific literacy is defined as a multidimensional construct comprising understanding of scientific concepts, comprehension of the nature of science, and consciousness of the interaction of science and society. These dimensions are interconnected and collectively influence students' abilities to reason scientifically, interpret socio-scientific issues and apply knowledge in authentic contexts (Gandolfi, 2025). In science learning based on local wisdom, mastery of scientific terms and concepts is combined with epistemological understanding, how scientific knowledge is produced, verified, and disseminated, and the implications of scientific practices for society and the environment. Instruction contextualized in the local ecological and cultural realities lets students experience these dimensions holistically and not in

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parts. Figure 2 shows the integration and interaction of the three dimensions of scientific literacy, i.e., conceptual knowledge, nature of science understanding, and science–society interaction, to form comprehensive scientific literacy.

Figure 1. Planning Framework of Local Wisdom-Based Science Learning

Evaluation of Local Wisdom-Based Science Learning

Evaluation was regarded as a significant aspect of learning management, providing teachers with tools to assess the degree to which learning objectives had been met and to evaluate students' conceptual understanding and scientific skills. The results showed that the evaluation activities in local wisdom-based science learning were not only limited to cognitive testing but also, the students' ability to observe, identify, compare and discuss environmental phenomena. According to the principal, the teacher assessed the students through the assignment, classroom discussion and assessment of the students' results of observation. The principal said these evaluation activities helped teachers ascertain how well students understood science concepts and how well they connected those concepts to environmental conditions around them. The finding showed that evaluation procedures had started to emphasize more on learning processes and contextual understanding, and less on only the final examination scores. Teachers also reported that evaluation was done through various modes such as written tasks, oral discussion and observation-based assignments. Usually, after the activities of observation or discussion, students were asked to explain their results and formulate simple conclusions concerning the scientific concepts studied. Teachers felt that this method provided a more accurate insight into students' conceptual understanding as students were able to show their understanding in terms of contextual explanation rather than rote memorization alone (Mekheimer, 2025).

Students said teachers usually gave them questions or tasks related to what they had observed after they had done an observation activity or had a discussion in the classroom. These tasks prompted students to think about their observations and to recognize the relevance of scientific concepts to their everyday environment. The students viewed these evaluation activities as supportive since they contributed to a deeper understanding of the learning materials. Results of observation also showed that in the classroom, teachers frequently asked students to explain findings from observations. Teachers used probing questions after the discussion to assess students' understanding of the science concepts. The analysis of the documentation showed that the student worksheets contained assignments in which students described environmental phenomena and connected their observations with scientific concepts (Ayotte-Beaudet et al., 2023). However, the process of assessment still needed further development in assessing scientific literacy comprehensively. Although teachers had started to employ observation-based and contextual assessments, they had not yet systematically assessed higher-order scientific reasoning and analytical skills. Most evaluation activities remained focused on basic conceptual understanding and simple observation skills, rather than advanced scientific inquiry and evidence-based analysis.

Table 2. Findings on the Planning of Local Wisdom-Based Science Learning

Evaluation Component	Evaluation Practice
Written Assessment	Contextual questions and assignments
Observation Assessment	Student observation reports
Oral Assessment	Discussion and explanation of findings
Scientific Literacy Focus	Conceptual understanding and process skills
Evaluation Orientation	Contextual and process-oriented learning

The evaluation process of science learning based on local wisdom in SMP Negeri 1 Muara Rupit was conducted continuously through observation activities, classroom discussions, teacher feedback, reflective learning, and assessment of students' understanding. The evaluation was not limited to the assessment of cognitive achievement by means of written tests, but rather was based on the students' ability to relate scientific concepts to environmental phenomena from their everyday lives. Through activities of contextual evaluation, students were stimulated to explain the observation results and discuss the environmental issues; and to reflect on the relationships between local phenomenon and science concepts. The evaluation cycle allowed teachers to know students' conceptual understanding, science process skills, and participation during learning activities. The process also showed that the development of scientific literacy was achieved through the continuous interaction of contextual experiences, classroom reflection and teacher guidance.

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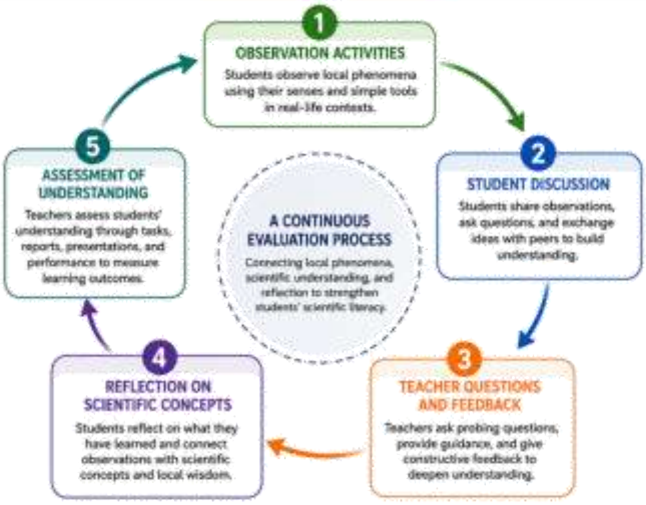

Figure 2. Evaluation Cycle in Local Wisdom-Based Science Learning

The figure shows the continuous and interactive evaluation cycle implemented in local wisdom-based science learning. The cycle starts with observation activities where students directly observe local environmental phenomena as part of contextual science learning. Then students engage in classroom discussions, sharing ideas, asking questions and communicating findings related to their observations (Gillies, 2023). In the next stage, teachers provide questions, guidance, and feedback to deepen students' conceptual understanding and to foster scientific reasoning. Students then connect the science ideas they have learned to the observations they have made during instruction (Remmen et al., 2020). Finally, teachers evaluate students' understanding through assignments, reports, discussions, and performance tasks. The cyclical nature of the process shows that evaluation in science learning based on local wisdom is not a one-time activity, but a continuous process that is designed to strengthen students' scientific literacy through contextual and reflective learning experiences.

Supporting and Inhibiting Factors

The result showed that there were several supporting and inhibiting factors that affected the implementation of local wisdom based science learning. The institutional support by the school leadership was one of the major supporting factors. The principal also supported teachers' use of the environment surrounding them as a resource for science learning. The institutional support provided opportunities for teachers to develop more contextual and meaningful instructional activities (Vaden et al., 2025). Another important supporting factor was the availability of natural resources around Muara Rupit. Real world examples such as rivers, farmland, plants and other environmental resources could be readily integrated into science education. Teachers commented that the local environment was very conducive to contextual science instruction, as a large number of science concepts could be directly illustrated by observable phenomena.

The enthusiasm and participation of the students also helped to implement the local wisdom-based instruction. Students were more active and motivated when learning activities were directly involved with environmental phenomena that they knew. This conclusion is based on observation data. Specifically, the students showed enthusiasm in activities related to environmental observation and contextual classroom discussions. Notwithstanding these favourable conditions, the implementation was hampered by several inhibiting factors. A major challenge was the availability of facilities and infrastructure for environmental-based learning activities. The principal acknowledged that the unavailability of facilities often meant that learning activities were limited to classroom-based instruction, which limited the opportunities for more varied contextual learning experiences.

Teachers also identified a lack of time for instruction as a major barrier. The contextual learning activities involving observation and discussion of the environment took longer than traditional classroom teaching (Bakogiannis et al., 2026). Consequently, not all planned activities could be carried out optimally with the time provided. Differences in students' learning skills also posed challenges for teachers, who had to adjust their teaching strategies to accommodate different levels of understanding in the classroom (B. Liu, 2024). Analysis of documentation showed that the school had made efforts to provide resources that support contextual learning despite the limited facilities. Teachers' instructional documents also revealed efforts to insert environmental contexts into science instruction. However, teachers still needed more support and professional development to implement systematically and effectively local wisdom-based science learning.

Table 3. Supporting and Inhibiting Factors in the Implementation of Local Wisdom-Based Science Learning

Supporting Factors	Inhibiting Factors
School leadership support	Limited facilities and infrastructure
Rich environmental resources	Limited instructional time
Student enthusiasm and participation	Variations in students' understanding
Availability of contextual learning examples	Limited systematic instructional design
Teacher initiative in contextual teaching	Need for improved teacher competence

Factors Supporting and Inhibiting the Implementation of Local Wisdom-Based Science Learning at SMP Negeri 1 Muara Rupit The effectiveness of contextual learning practices was determined by factors supporting and inhibiting the implementation of local wisdom-based science learning at SMP Negeri 1 Muara Rupit. These factors were derived from the internal condition and external environmental context of the school that affected the ways local wisdom was integrated in the science instruction. Supporting factors such as school leadership support, environmental resources and student participation created the opportunity for more meaningful learning experiences. However, the implementation process was hindered by a number of inhibiting factors such as lack of facilities, instructional time and the need for teacher readiness. Understanding these interlinked factors is important for developing more effective strategies to enhance students' scientific literacy through local wisdom-based science learning.

Figure 3. Factors Influencing the Implementation of Local Wisdom-Based Science Learning

The figure illustrates the interaction between supporting and inhibiting factors influencing the implementation of local wisdom-based science learning. On the left side, the supporting factors include support from school leadership, plentiful environmental resources, student enthusiasm and participation, teacher initiative and creativity, and community and cultural support. These factors are conducive to developing contextual and meaningful science learning experiences by enabling teachers to use local environmental phenomena as authentic learning resources (Clark et al., 2024). The right side has barriers of limited facilities and infrastructure, limited instructional time, differences in students' abilities, limited learning resources, and the requirement for continuous teacher professional development. These challenges affect the consistency and effectiveness of implementing contextual science learning.

The learning science based on local wisdom in the center of the figure is a contextual learning approach to reinforce the scientific literacy of the students. The figure also shows that the number of supporting and inhibiting factors is important for the success of learning implementation and students' development of scientific understanding, science process skills, and contextual reasoning abilities.

In general, the results indicated that the management of science learning based on local wisdom at SMP Negeri 1 Muara Rupit had begun to develop as part of contextual science education practices, although the implementation was still in the developing stage. Teachers had tried to link science concepts with environmental conditions surrounding students to improve conceptual understanding and scientific literacy (Andrews et al., 2020). The integration of local wisdom is also seen in the activity of lesson planning, instructional implementation and contextual evaluation by observing the environment. Interviews with the principal, teachers and students consistently found that the surrounding environment had been used as a resource for science learning. The principal stressed support from institutions for contextual instruction, teachers pointed out the importance of environmental examples in developing conceptual understanding, and students confirmed that contextual examples made science learning easier and more interesting. These findings were supported by observation and documentation data indicating the teachers' integration of local environmental phenomena in instructional activities as well as students' engagement in observation-based learning experiences.

The triangulation of data from interviews, observations, and documentation showed a high level of consistency between the data sources, which indicated that science learning based on local wisdom had been implemented in classroom practices. The results also showed, however, that the integration of scientific literacy was still limited because the instructional process had not yet fully emphasized analytical reasoning, evidence-based explanation, and systematic scientific inquiry. Scientific literacy indicators have not been explicitly defined in learning objectives, instructional activities and evaluation instruments. The results showed that science learning based on local wisdom has great potential in improving students' scientific literacy because students can relate scientific concepts to real-life experiences and environmental conditions around students. Contextual learning practices increased students' engagement and helped them understand the concepts. Nevertheless, the successful implementation of local wisdom integration in the management of science learning requires more systematic lesson planning, comprehensive evaluation oriented to scientific literacy, improved teacher competence, and stronger institutional support.

Discussion

The results of this study show that the management of science learning based on local wisdom at SMP Negeri 1 Muara Rupit has significant potential to strengthen students' scientific literacy through contextual and meaningful learning experiences. The discussion in this section interprets the research findings by linking them to theoretical perspectives and relevant previous studies about contextual learning, scientific literacy, constructivist learning, and local wisdom integration in science education. The discussion focuses on four major aspects, namely planning, implementation, evaluation, and supporting as well as inhibiting factors influencing the implementation of local wisdom-based science learning. The results showed that lesson planning was the first and strategic stage in the implementation of local wisdom-based science learning. Teachers at SMP Negeri 1 Muara Rupit had begun to integrate local environmental contexts into instructional objectives, learning materials, and classroom activities. This finding indicates that the teachers realized the importance of linking science concepts to students' real life experiences in order to enable meaningful learning processes. The incorporation of local phenomena such as river ecosystems, agricultural practices, and adjacent vegetation into science learning represents an attempt to contextualize instruction and minimize students' reliance on abstract conceptual understanding. This finding, based on contextual learning theory, suggests that learning is more meaningful when students can connect academic concepts to situations they experience in their everyday lives. Contextual learning posits that knowledge should not be separated from social and environmental realities because students construct understanding through interaction with their surroundings. The use of local environmental phenomena as learning resources makes students able to associate scientific concepts with experiences they already have. This will strengthen conceptual understanding and increase learning engagement. Students' social and environmental experiences are positioned as integral elements of the instructional process in local wisdom-based learning.

The role of the principal in encouraging teachers to use the surrounding environment as a learning resource also underlines the importance of educational leadership in fostering instructional innovation. The results show that school leadership's institutional support was positively contributing to the development of contextual learning practices. According to educational management theory, instructional leadership is an important factor affecting teachers' pedagogical innovation and the quality of classroom instruction. When principals foster contextual learning among teachers, they build school cultures that are more adaptable to students' needs and more responsive to contemporary educational challenges. The implementation of contextual and student-centered learning can be strengthened through educational leadership that supports pedagogical innovation. In addition, the inclusion of local environmental phenomena in lesson planning also directly helps to strengthen students' scientific literacy (Kumar et al., 2024).

Scientific literacy encompasses more than the memorization of scientific concepts; rather, it includes the ability to explain natural phenomena, interpret scientific information, and apply scientific understanding to solve real-life problems. When science concepts are linked to observable local phenomena, students have opportunities to see how scientific knowledge functions in everyday contexts. Consequently, students develop not only conceptual understanding but also contextual reasoning abilities necessary for development of scientific literacy. The ability to link scientific knowledge to real-world environmental and social issues is an essential aspect of scientific literacy. The use of local environmental contexts in instructional planning also illustrates the principles of constructivist learning. Constructivism stresses that learners actively build knowledge through interaction with experiences and environments. In the present study, teachers tried to design learning activities that allowed students to directly observe environmental phenomena and collaboratively discuss them in classrooms. In these activities students were not passive recipients of information but active constructors of scientific understanding (Mansour, 2024).

Students' active involvement in constructing knowledge through real experiences is an essential factor in meaningful learning. Another significant finding is the role of direct experiences in the environment to enhance the students' engagement and motivation during learning. Students reported that contextual learning activities using familiar environmental examples made science lessons easier and more interesting. This finding implies that contextual learning based on local wisdom can increase students' emotional and cognitive engagement because the learning materials are directly linked to their realities. Students' participation and conceptual understanding can be significantly improved through contextual learning based on real-life experiences line(Ingulfsen et al., 2023). The findings also indicated that although teachers had attempted to integrate local wisdom into lesson planning, the integration was relatively simple and not yet systematically structured within instructional documents. Local wisdom was often only used as an example of the context, but did not become an integral part of the instructional objectives, scientific inquiry activities, and assessment systems. This condition indicates that teachers still need help in designing a more comprehensive local wisdom-based instructional framework. Teachers' limited ability to systematically incorporate local contexts into instructional planning remains one of the main challenges in implementing contextual learning (Harris et al., 2025).

The results of the implementation stage also showed that science learning based on local wisdom provided positive contributions to students' understanding of context and their participation in class activities. Teachers used local environmental phenomena as introductory examples and engaged students in observation and discussion activities on their surroundings (Andrews et al., 2020). Such teaching practices allowed students to learn science concepts by directly experiencing observable phenomena, rather than merely through abstract explanations. This finding suggests, from the perspective of contextual learning theory, that knowledge is more meaningful when students have direct connections between academic content and real-world situations. Looking at river systems, plants, and environmental conditions in the area around the school, students were able to link scientific concepts to real-world situations.

This process led to deeper conceptual understanding as students built knowledge from meaningful experiences. Students' ability to explain scientific concepts more meaningfully can be enhanced through the use of local environmental phenomena in contextual science learning. The results of implementation also showed that the learning based on local wisdom supports the development of science process skills. Students observed, questioned, discussed, recorded findings and drew simple conclusions during classroom activities. These activities are important aspects of scientific literacy, as scientific literacy includes not only conceptual knowledge but also scientific inquiry skills and evidence-based reasoning skills . Students' participation in scientific processes that enable systematic and critical exploration of phenomena is fundamental to the development of scientific literacy. The observation activities in science lessons also reinforce the principles of inquiry-based learning. Inquiry learning stresses that students should engage in the discovery of scientific concepts through exploration and investigation. In this study, students observed environmental phenomena and discussed findings with teachers and peers in collaboration . The learning process developed curiosity and critical thinking in students, and at the same time strengthened conceptual understanding. Students' science process skills and scientific reasoning skills can be enhanced through inquiry-based learning using local environmental contexts (Melesse et al., 2025).

The results also showed that the contextual science learning was able to develop the students' environmental awareness and scientific attitudes. Students learnt scientific concepts by studying environmental phenomena around them but they also developed awareness about environmental sustainability and social responsibility. This finding implies that science learning based on local wisdom has a wider educational value in that it not only helps in cognitive development but also in character building and ecological awareness. Students' ecological responsibility and environmental awareness can be strengthened through environment-based science learning. The discussions in the classroom after observations of the environment also helped a lot to improve the students' scientific communication skills. Students were asked to account for their findings, to exchange ideas and to relate their observations to the scientific concepts discussed in class. These activities allowed students to develop communication and argumentation skills required for scientific literacy development. Collaborative scientific discussion can improve students' ability to explain scientific phenomena systematically and communicate scientific ideas effectively. However, the results also show that the implementation of scientific literacy-oriented learning was relatively basic and unsystematic. The activities of scientific inquiry were restricted to mere observation and discussion without further analytical investigation or systematic evidence based reasoning. This condition means that while contextual learning practices had begun to promote the development of scientific literacy, they had not yet fully reflected the instruction that was oriented towards a comprehensive scientific literacy. Teachers are often limited in implementing contextual learning when they focus only on contextual examples without developing systematic inquiry-based instruction (Kostøl & Remmen, 2022).

Evaluation findings also indicate that teachers had attempted to assess students' contextual understanding and learning processes through assignments, discussions and observation reports. The assessment tasks were not limited to traditional written tests; they also assessed students' ability to explain environmental phenomena and relate observations to scientific concepts. This is in line with process assessment principles which emphasize the importance of assessing not only learning outcomes but also learning processes. The perspective of scientific literacy assessment shows attempts to assess students' ability to apply scientific understanding in contextual settings through the practices of assessment carried out at SMP Negeri 1 Muara Rupit. In assessing scientific literacy the understanding of concepts should not be the only criterion, but also the ability of students to interpret scientific data, to explain natural phenomena and to apply scientific reasoning in problem solving. Assessment oriented toward scientific literacy should evaluate students' capacity to apply scientific knowledge in authentic environmental and social contexts. The use of classroom discussions and reflective explanation activities as evaluation methods also reflects principles of authentic assessment . In contrast, authentic assessment provides students an opportunity to show their understanding without only relying on memorization but through real-life tasks and contextual problem-solving activities. In this study, students explained environmental observations, discussed scientific concepts collaboratively, and enabled teachers to evaluate students' conceptual understanding more comprehensively. Scientific activity-based authentic assessment provides more valid evidence of students' scientific literacy development (Van et al., 2025).

However, the results show that the evaluation practices were still mainly aimed at general understanding and basic observation skills, rather than the comprehensive dimensions of scientific literacy. Assessment instruments specifically designed to measure scientific reasoning, inquiry skills, and evidence-based explanation skills had not been systematically developed. Teachers' limited ability to design comprehensive assessment instruments remains a major challenge in enhancing scientific literacy in schools.

The results show that more systematic assessment systems oriented to scientific literacy are needed to optimize the implementation of local wisdom-based science learning. Teachers require professional support in designing authentic assessment instruments that can fully assess students' conceptual understanding, inquiry skills, scientific communication abilities and contextual reasoning. Such evaluation systems would allow teachers to better and continuously monitor the development of students' scientific literacy (Rusilowati et al., 2020).

Figure 4. Conceptual Integration of Local Wisdom-Based Science Learning and Scientific Literacy Development

The figure above illustrates the conceptual relationship between local wisdom-based science learning and students' scientific literacy development. The framework demonstrates that local environmental contexts function as authentic learning resources integrated into instructional planning, implementation, and evaluation processes. Through contextual observation, inquiry activities, classroom discussions, and reflective assessment, students develop conceptual understanding, scientific process skills, environmental awareness, and contextual reasoning abilities. The figure also highlights that scientific literacy development occurs through continuous interaction between students' real-life experiences, local cultural values, and scientific inquiry processes. The findings concerning supporting and inhibiting factors further reveal that successful implementation of local wisdom-based science learning depends on multiple interconnected conditions. Institutional support from school leadership emerged as one of the most important supporting factors because it encouraged teachers to innovate and utilize local environmental resources in instruction. Educational leadership plays a crucial role in establishing school cultures supporting contextual and student-centered learning. Teachers' willingness and ability to implement innovative learning strategies are significantly influenced by institutional support (Y. Liu et al., 2025).

The richness of the local environment surrounding Muara Rupit also represented an important supporting factor. Rivers, agricultural land, plants, and other environmental resources provided authentic examples enabling teachers to connect science concepts with observable phenomena. Authentic environmental resources contribute significantly to contextual science learning because they enable students to engage directly with scientific phenomena in real-life situations. Environmental resources surrounding schools provide valuable opportunities for contextual and inquiry-based science learning. Students' enthusiasm and participation also contributed positively to the implementation of contextual learning. Students appeared more active and motivated when lessons involved familiar environmental contexts and direct observation activities. This finding suggests that contextual learning based on local wisdom can strengthen intrinsic learning motivation because students perceive learning activities as relevant to their realities. Students' engagement and learning motivation can be significantly improved through contextual science learning (Fortus & Touitou, 2021).

Despite these supporting conditions, several inhibiting factors limited the effectiveness of implementation. Limited facilities and infrastructure represented one of the primary obstacles preventing teachers from conducting more varied environmental-based learning activities. Inadequate facilities restricted learning activities primarily to classroom discussions and limited opportunities for extensive environmental exploration. The implementation of innovative and contextual learning in schools is often limited by inadequate facilities. Limited instructional time also emerged as a significant challenge because contextual learning activities involving environmental observation and discussion require more time than conventional instruction. Teachers often needed to simplify planned activities due to curriculum time constraints. This finding indicates that implementing local wisdom-based learning requires flexible instructional management and efficient lesson organization. Careful time management is required in contextual learning to ensure meaningful learning experiences while maintaining curriculum achievement. Another important challenge concerns teachers' readiness and pedagogical competence in integrating local wisdom systematically into science learning. Although teachers had begun utilizing local environmental examples, the integration often remained incidental rather than systematically structured within instructional frameworks. This finding indicates the necessity of professional development programs strengthening teachers' capacities to design contextual, inquiry-oriented, and scientific literacy-based instruction. Teachers' pedagogical competence plays a significant role in determining the success of contextual learning implementation (Klimpki et al., 2026).

The findings of this study also provide important implications for science education development in rural and culturally rich contexts. Local wisdom-based science learning enables schools to utilize surrounding environmental and cultural resources as authentic educational assets. Such learning approaches help bridge the gap between formal science education and students' socio-cultural realities, thereby making science learning more relevant, meaningful, and sustainable. Furthermore, integrating local wisdom into science education contributes to preserving local cultural knowledge while simultaneously strengthening scientific literacy competencies necessary for twenty-first-century education. The study also highlights the importance of integrating scientific literacy dimensions explicitly within instructional planning, implementation, and evaluation. Scientific literacy should not be treated merely as an additional outcome but should become a central orientation guiding science learning processes. Teachers need to develop learning activities encouraging observation, inquiry, evidence-based reasoning, communication, and contextual problem-solving systematically. Such instructional transformation would strengthen students' capacities to understand scientific phenomena critically and apply scientific understanding within everyday life contexts. Overall, the discussion demonstrates that local wisdom-based science learning possesses strong potential for strengthening students' scientific literacy because it provides contextual, authentic, and meaningful learning experiences. The integration of environmental phenomena into instructional processes enables students to construct scientific understanding actively through direct interaction with their surroundings. Nevertheless, achieving optimal implementation requires systematic instructional planning, comprehensive scientific literacy-oriented evaluation, institutional support, adequate facilities, and continuous teacher professional development (Shan, 2025). Consequently, strengthening local wisdom-based science learning should become part of broader educational efforts to create science education that is contextual, culturally responsive, environmentally aware, and oriented toward the development of students' scientific literacy competencies.

D. Conclusions

This qualitative study examined the integration of local wisdom into science instruction to strengthen students' scientific literacy at SMP Negeri 1 Muara Rupit, a rural junior high school in Indonesia. The findings demonstrate that local wisdom-based science instruction has been implemented through planning, implementation, and evaluation stages, utilizing local environmental phenomena river ecosystems, agricultural activities, and local vegetation as contextual learning resources. This contextual approach enhanced students' conceptual understanding, science process skills, environmental awareness, and classroom engagement. Students actively participated in observation, discussion, and explanation activities that connected scientific concepts to their daily lives. However, a critical finding is that the integration of comprehensive scientific literacy dimensions evidence-based reasoning, systematic inquiry, analytical explanation, and contextual problem-solving remained limited and unsystematic within instructional planning and assessment. While local wisdom served effectively as contextual examples to increase engagement and basic understanding, instruction did not consistently develop higher-order scientific reasoning abilities. This gap represents the central challenge for local wisdom-based science education in rural contexts. Theoretically, this study contributes to contextual learning and scientific literacy literature by demonstrating that "surface-level contextualization" (using local examples as motivation) is insufficient; deep integration requires embedding local phenomena within inquiry-based epistemic practices. Practically, the study recommends: (1) designing structured instructional frameworks that explicitly link local wisdom to scientific literacy indicators; (2) developing assessment instruments targeting evidence-based reasoning and systematic inquiry; (3) providing teacher professional development in contextual, inquiry-oriented instruction; (4) improving facilities for environmental observation activities. Limitations include single-site design and descriptive (non-causal) claims. Future research should: (a) develop and test local wisdom-based instructional models experimentally; (b) compare integration practices across multiple rural schools; (c) conduct longitudinal studies on scientific literacy development; and (d) examine student perspectives more extensively.

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