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Integrating Science Literacy in Elementary Education: Teachers' Perspectives and Practices in a Rural Indonesian Madrasah

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ABSTRACT

This study investigates teachers' perspectives in fostering science literacy among students at Madrasah Ibtidaiyah Miftahul Ulum Kesamben Wetan Driyorejo Gresik. The research is grounded in the importance of science literacy as a key competency in 21st-century education, particularly at the elementary level. A qualitative case study approach was employed, with data collected through interviews, observation, and documentation involving the principal, teachers, and students. The findings indicate that science literacy implementation is reflected in three main dimensions: identifying scientific problems, explaining scientific phenomena, and using scientific evidence. In identifying scientific problems, teachers utilize environmental observation and community context due to limited school facilities. In explaining phenomena, students engage in contextual learning activities such as analyzing food content, visiting educational sites, and conducting simple plant experiments, supported by differentiated learning based on student abilities and learning styles. In using scientific evidence, students are actively involved in learning processes that emphasize critical thinking, experimentation, and conclusion drawing through interactive and enjoyable learning experiences. The study concludes that despite infrastructural limitations, teachers effectively integrate science literacy through contextual and experiential learning strategies. These findings contribute to strengthening PISA-based science literacy theory and highlight practical implications for improving elementary science education in resource-limited settings. Further research is recommended to expand the scope across multiple institutions using comparative or mixed-method approaches.

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INTRODUCTION

The rapid development of industry in the 21st century is marked by significant advances in science and technology (Adhi, 2022; Al Hyari, 2023), which have the potential to fulfill human needs. The growth of science and technology greatly influences various fields, particularly education. Fundamentally, education is a primary effort to help society gain insights and knowledge about their

potential. High-quality education can produce competent students, and student competence begins with a process of education that is both effective and of high quality. As a developing country, Indonesia particularly requires qualified human resources (Choi, 2016), and the advancement of science and technology strongly impacts the progress of education in the nation.

Education today is oriented toward learning processes that enable students to face the demands of the modern era, characterized by globalization and technological advancement (Gormezano & Kehoe, 1975; Liu et al., 2022). Learning activities should not only focus on mastering knowledge but also on the process of applying that knowledge. Students are expected to construct their own understanding based on natural phenomena around them. Therefore, the role of teachers is essential in designing learning experiences that actively engage students in discovering new knowledge and developing critical thinking skills (Tang et al., 2021). In this regard, enhancing students' science literacy must start at the level of Madrasah Ibtidaiyah.

Literacy can be classified into several types, including science literacy, reading and writing literacy (Abbas, 2023; Ali, 2021), numeracy literacy, and others. However, this study focuses specifically on science literacy. Aligned with 21st-century skills, students must possess learning and innovation abilities. They are expected to think scientifically in problem-solving. At the elementary education level, science plays a crucial role because it equips students to navigate the global era (Daheri, 2022; Darmawan et al., 2023). Therefore, science literacy skills are necessary to solve problems effectively. Science literacy involves the ability to listen, speak, write, and read (Arifin, 2023) using knowledge grounded in scientifically proven evidence, allowing students to develop their understanding naturally. Science literacy is an essential skill that every student must acquire. Conceptual knowledge alone is insufficient without critical reasoning skills. Hence, teachers must not only focus on conceptual understanding but also consider other important aspects in their teaching approach.

Science literacy refers to an individual's ability to apply their knowledge to identify questions, construct new understanding, provide scientific explanations, draw conclusions based on evidence, and develop reflective thinking to help address scientific problems and ideas. Therefore, science literacy is crucial for students to adapt and solve problems in daily life based on scientific evidence. Low science literacy among Indonesian students is generally caused by learning activities that do not aim to develop science literacy (Rokhmah, 2020; Salimi, 2021). Student literacy can also be influenced by curriculum, learning models, teaching methods, media, and instructional materials provided by teachers. Thus, the role of teachers is critical in improving the quality of education.

Currently, science education in Indonesia is quite concerning. On average, Indonesian students' science literacy remains below the international mean. In 2009, the PISA (Programme for International Student Assessment) reported that Indonesia ranked 60th out of 65 countries, with an average science score of 383 (international standard score of 500). PISA is an internationally standardized survey assessing the competencies of 15-year-old students in reading, mathematics, and science, conducted every three years since 2000. Considering this low ranking in science literacy, improvements in Indonesia's education system are necessary. In response, the government revised the curriculum from the 2013 Curriculum to the Independent Curriculum Implementation (IKM) to encourage teachers to be more creative and innovative in teaching (Prasetyono et al., 2021; Qolbiyah et al., 2022).

At the elementary level, science education is particularly important as it provides students with essential skills to face the advancements of science and technology in the 21st century. Consequently, science instruction should integrate and implement science literacy in learning activities. Science literacy is not a new concept in education. Over the last two decades, it has become a key focus in the educational field (Adiyono et al., 2023; Aisyah et al., 2024). Teachers must design varied learning

experiences to foster broader student understanding and enable students to express opinions factually and naturally by applying science literacy comprehension. Although science literacy studies have evolved toward scientific and social interactions, teaching based on scientific knowledge is challenging. One common problem in elementary science education is low science literacy (Osborne, 2023). A clear sign of student disengagement is the lack of connection between learning content and real-life contexts. Given these conditions, future teachers face significant challenges in achieving global quality and standards. Teachers need to enhance their science literacy knowledge to guide students toward meaningful work (Jufrida et al., 2019), active learning, empowerment (Roberts & Bybee, 2014), technology use (Holbrook & Rannikmae, 2007), and improved student competencies.

Based on the description above, the researcher conducted a study at Madrasah Ibtidaiyah Miftahul Ulum Kesamben Wetan Driyorejo Gresik, located in a rural area. This school serves as a private driving school for other schools, especially in implementing science literacy at the Madrasah Ibtidaiyah level. The researcher is interested in studying this school because preliminary observations revealed various methods teachers use in applying science literacy in their instruction. The researcher chose this topic because many students still struggle to understand the science literacy concepts applied by teachers. Students' abilities to comprehend and interpret scientific knowledge remain low, making the teacher's role in learning critically important. The objectives of this study are to understand teachers' perspectives on developing science literacy among students at Madrasah Ibtidaiyah Miftahul Ulum Kesamben Wetan Driyorejo Gresik and to examine the methods employed by teachers to enhance students' science literacy skills at the same school.

METHODS

The research was conducted at Madrasah Ibtidaiyah Miftahul Ulum Kesamben Wetan Driyorejo Gresik, a rural yet strategically located school. The study was carried out over approximately three months (Arif, 2024). This location was chosen because the school has been a pioneer in religious and academic activities in the area, including achieving notable recognition in district-level competitions. The site provided rich data relevant to the research focus on developing science literacy among students. This study employed a qualitative approach, emphasizing descriptive data rather than numerical analysis (Rahmayanti & Arif, 2021). The researcher acted as the primary instrument, collecting and interpreting data through direct interaction, observation, and interviews. The qualitative method allowed for an in-depth exploration of teachers' perspectives and practices in fostering science literacy. A case study design was used to provide a detailed and realistic depiction of the classroom environment, teaching methods, and student engagement in science learning (Yin, 2018).

Data were collected from primary and secondary sources. Primary data were obtained directly from interviews with the school principal and teachers, as well as observations of classroom activities and student engagement. Secondary data were gathered from school documents such as curricula, lesson plans, teaching materials, and student records, providing additional context to support the primary data. The main techniques of data collection included observation, interviews, and documentation. Structured observation allowed the researcher to systematically record classroom practices and teaching strategies. Interviews with teachers and the principal provided insights into their perspectives and methods for developing students' science literacy. Documentation offered supplementary evidence from school records and teaching materials to validate findings (Maarif et al., 2022).

Data analysis followed a qualitative, descriptive-analytic procedure, involving three main stages: data reduction, data presentation, and conclusion drawing. Data were systematically organized,

summarized, and interpreted to identify patterns, relationships, and key findings. This approach ensured that the study produced meaningful insights into teachers' roles in promoting science literacy, while maintaining accuracy and reliability throughout the research process (Patton, 2015).

RESULTS AND DISCUSSION

Result

The ideal condition of a school is one that has adequate facilities and infrastructure to support learning activities. In implementing science literacy-based learning, the condition of the school, such as cleanliness, a pleasant environment, available facilities, and the learning media applied, is essential. Considering the surrounding community also affects science literacy, especially with the current development of technology and education among society. Therefore, when identifying scientific problems to be applied by teachers, the conditions around the school are usually observed. According to Mr. M.I., the principal of Madrasah Ibtidaiyah Miftahul Ulum Kesamben Wetan Driyorejo Gresik:

> "Teachers usually observe the conditions around the school and the development of the surrounding community."

This view is also echoed by the class teacher, Mrs. J.S., who stated that in identifying scientific problems, teachers pay attention to the school's facilities as well as community development:

> "To identify scientific problems, we must observe the conditions around the school, especially the available facilities, because technology is developing rapidly."

Students also contribute to this process. For instance, H., the class 5 leader, stated:

> "We usually learn about heat properties and plant growth through direct practical experiments or observation."

The availability of facilities and infrastructure significantly influences the identification of scientific problems. Limited facilities make the use of the surrounding environment a primary factor in identifying scientific problems. As explained by Mr. M.I.:

> "Due to limited facilities, the school has not provided special tools for teachers to identify scientific problems. Usually, the environment is used through observation, but teachers are generally free to explore in teaching activities. If a teacher requires tools, the school fully supports them."

Mrs. J.S. also confirmed this:

> "The surrounding environment is the main factor in identifying problems using observation, as facilities are limited. Students are given problems directly from nature."

Based on the findings, it can be concluded that in identifying scientific problems, the school has not provided special facilities. Teachers usually rely on observation, analyze problems, and develop solutions through direct observation or practical experiments.

Explaining Scientific Phenomena

Implementing science literacy in learning enhances students' critical thinking skills. At Madrasah Ibtidaiyah Miftahul Ulum Kesamben Wetan Driyorejo Gresik, science literacy has been applied in simple ways. Mr. M.I. explained:

> "Yes, even in simple ways, such as experimenting with the contents of food and drinks, visiting museums to observe and document, and planting, caring for, recording, and observing plant growth in science lessons."

Teachers prepare active and enjoyable learning using various learning resources. Mrs. J.S. stated:

"Teachers usually create active, enjoyable learning and provide various learning resources for students."

Students also feel the impact:

"The lessons are enjoyable, which encourages us to ask questions and participate actively in learning."

The role of the principal and teachers is vital. Mr. M.I. shared:

"The principal is responsible for every science literacy program, giving teachers freedom to innovate, such as organizing visits to temples or museums."

Mrs. J.S. added:

"Teachers not only create enjoyable learning but also involve students in real, hands-on topics, which enhances critical thinking."

Challenges exist, such as budget limitations or varying student interests. Mr. M.I. explained:

"Teachers sometimes hesitate to be creative due to budget concerns, but simple activities like planting, caring for, and observing plants can still promote science literacy."

Mrs. J.S. noted:

"There are challenges, like differences in student interests and available budget."

In summary, the school explains scientific phenomena by providing real problems and involving students in learning. Challenges include varying student interests and limited budgets, but simple, enjoyable learning activities are implemented.

Using Scientific Evidence

Teachers must be creative and exploratory in every lesson to develop students' science literacy. Mr. M.I. stated:

"There is no formal school program for science literacy, but daily activities and extracurricular programs like scouting allow observation and learning outside school, such as museum visits."

Mrs. J.S. added:

"School programs usually take place outside school, like visiting museums or temples, while class activities involve practical experiments on plant growth, observing seeds turning into healthy plants."

Student involvement is key to identifying learning interests and styles. Mrs. J.S. said:

"By identifying students' different interests and grouping them accordingly, all students can understand the material. Teachers must prepare the resources needed by students."

The principal provides guidance and support:

"Teachers should be creative and explore learning methods, modifying lessons and grouping students based on ability to deliver active learning."

The findings indicate that students participate in programs both outside school (observing temples or museums) and inside class (planting, caring for, and recording plant growth). Students are grouped according to their abilities and learning styles.

Challenges and Solutions

Although the school has applied science literacy, challenges remain, such as limited facilities, budget constraints, and teacher creativity. Differences in students' interests and learning styles also require teachers to use varied strategies to ensure all students understand the lessons. The school organizes visits to museums or temples every two years for science programs. In class, teachers utilize the surrounding environment for science literacy activities to reduce costs. To address limited teacher creativity, teachers participate in seminars or webinars on learning. Differences in student interests and

learning styles are addressed by grouping students according to their abilities and preferences, allowing all students to grasp the lesson objectives.

Table 1: Summary of Findings on Science Literacy Implementation

Aspect of Science Literacy	Key Findings	Interpretation
Identifying Scientific Problems	Teachers observe surrounding environment and community; limited facilities make environment the main learning source	Science problems are contextual and environment-based due to infrastructure limitations
Explaining Scientific Phenomena	Learning uses simple experiments, museum visits, and plant observation; activities are designed to be active and enjoyable	Learning is experiential and promotes critical thinking through real-world contexts
Using Scientific Evidence	Students are involved in experiments, observations, and grouping based on ability and interest	Evidence-based learning is implemented through hands-on and collaborative activities
Challenges	Limited facilities, budget constraints, differences in student interests, and teacher creativity issues	These barriers affect the optimal implementation of science literacy
Solutions	Use of environmental learning, extracurricular activities, teacher training, and student grouping strategies	Adaptive strategies help maintain effective science literacy implementation

Based on the research findings, the implementation of science literacy at Madrasah Ibtidaiyah Miftahul Ulum Kesamben Wetan Driyorejo Gresik shows that the learning process largely relies on the surrounding environment as the main learning resource, particularly in identifying scientific problems due to limited school facilities. In explaining scientific phenomena, teachers apply experiential learning through simple experiments, educational visits, and direct observation of real objects such as plant growth, designed to make learning more active and meaningful. Meanwhile, in using scientific evidence, students are directly involved in practical activities, observations, and grouping based on their abilities and learning interests, thereby fostering critical thinking and collaborative skills. However, the implementation of science literacy still faces several challenges, including limited facilities and infrastructure, budget constraints, and differences in students' characteristics and interests. Therefore, the school applies various adaptive strategies such as environment-based learning, outdoor activities, teacher training, and student grouping to ensure that the objectives of science literacy learning are optimally achieved.

Discussion

Identifying Scientific Problems

Identifying scientific problems refers to questions that must be answered based on scientific evidence. Therefore, individuals need to recognize and understand scientifically investigated questions in specific situations, locate scientific information, identify keywords within scientific texts (Heffernan & Teufel, 2018; Shah et al., 2003), and recognize basic scientific research methods or models (El-Arini & Guestrin, 2011). This includes determining what is being asked, which variables are changed, and what procedures are used for data collection. At the elementary school level, science literacy equips students to face various challenges in the global era (McFarlane, 2013; Turiman et al., 2012). Therefore, teachers consistently integrate science literacy into learning through various approaches, models, methods, and media-based strategies. However, rapid technological development in the 21st century has created

global challenges (Malik, 2018), requiring students to be trained in scientific problem-solving by designing concepts and projects based on environmental observation and technology use. This helps students develop critical thinking skills (Alsaleh, 2020; Persky et al., 2019).

The importance of science literacy in basic education requires support from all stakeholders. Its implementation also requires adequate facilities and infrastructure (Dragoş & Mih, 2015). Science learning in elementary-level madrasah is ideally oriented toward the integration of science, environment, technology, and society (Sjöström & Eilks, 2018). Learning is directed toward hands-on experiences, allowing students to design simple projects based on scientific concepts. Teachers are free to use various methods as long as the main goal of science literacy is achieved. However, due to limited facilities, teachers often rely on direct experience learning and utilize the surrounding environment through observation and simple experiments. Students are therefore engaged in hands-on activities to identify scientific problems (Smith et al., 2012).

The environmental conditions surrounding Madrasah Ibtidaiyah Miftahul Ulum Kesamben Wetan Driyorejo Gresik, including infrastructure, surroundings, and community development, significantly influence the teaching and learning process. Students tend to focus better in a clean and conducive environment, which helps teachers achieve learning objectives effectively. However, students are also affected by technological advancement (Elhai, 2023), both positively and negatively. In addition, environmental changes caused by technological development and industrial growth also impact nature. Therefore, students' science literacy skills are expected to help them find scientific solutions to real-world problems caused by industrial progress (Fortus et al., 2022).

Based on findings at Madrasah Ibtidaiyah Miftahul Ulum Kesamben Wetan Driyorejo Gresik, teachers identify scientific problems by observing the surrounding environment and community development, which are then linked to learning themes. Science literacy habituation is considered important to improve students' knowledge and skills. Due to limited facilities and infrastructure, teachers generally apply observation methods and utilize the surrounding environment as the primary learning resource.

Explaining Scientific Phenomena

Current textbooks tend to emphasize content dimensions rather than process and context dimensions as required by PISA standards. Nowadays, sources of knowledge are not limited to printed books but also include digital books and various online media (Nyambane, 2021). Considering the importance of science literacy in education, developing a literacy culture has become a necessity for all members of the madrasah community (Budnyk et al., 2021). Science literacy implementation is expected to foster a learning culture in which teachers provide active and enjoyable learning experiences.

Explaining scientific phenomena requires the ability to apply scientific knowledge in given situations, describe occurring events (Duchan, 1986), and explain appropriate results. Teachers are given the freedom to apply creative methods such as experiments or direct practical activities, as well as utilizing the surrounding environment as a learning resource. Through environmental utilization, students are encouraged to conduct simple scientific observations because they can directly interact with their surroundings as a source of learning (Abdullah, 2024).

According to Winarni et al., (2022), the use of the environment in science literacy learning can improve student learning outcomes. Through simple hands-on learning and environmental observation, science competency goals can be optimally achieved. In addition, students are able to identify questions, obtain new information, explain scientific phenomena, and draw conclusions directly from observations. Providing scientific explanations requires an understanding of how information is obtained and how individuals trust scientific claims (McCain, 2015; Sklar, 2014).

Therefore, students also need procedural knowledge and awareness of their role in validating scientific knowledge. At Madrasah Ibtidaiyah Miftahul Ulum Kesamben Wetan Driyorejo Gresik, students are given direct scientific problems to observe, discover, and record their findings. This enables them to explain facts, concepts, principles, laws, and theories derived from the information obtained.

Based on findings at Madrasah Ibtidaiyah Miftahul Ulum Kesamben Wetan Driyorejo Gresik, students are engaged in activities such as analyzing food and beverage content, visiting museums or temples, and observing plant growth through planting, maintenance, and recording activities. Science literacy development is also supported by grouping students according to learning styles and interests, ensuring that students with low, medium, and high abilities can understand the material optimally.

Using Scientific Evidence

Using scientific evidence requires individuals to interpret scientific findings as evidence to draw conclusions (Goodman & Royall, 1988), identify supporting data, communicate reasoning, and reflect on the social implications of scientific and technological development. Active learning strategies emphasize learning by doing, which involves engaging students directly in learning activities so that they become more active and motivated. Through student involvement, learning becomes more effective and produces optimal outcomes (Fazey et al., 2005). Therefore, teachers must actively involve students individually and in groups, create opportunities for experimentation, and guide students in drawing conclusions from learning experiences (Souto-Otero, 2012).

In the context of student involvement, teaching and learning activities should create a fun and engaging atmosphere (Robinson & Kakela, 2006). Enjoyable learning allows students to develop creativity (Manalu, 2024; Subairi, 2025), express their potential, and freely communicate ideas according to their own learning styles (Lanny et al., 2024). Based on findings at Madrasah Ibtidaiyah Miftahul Ulum Kesamben Wetan Driyorejo Gresik, students are directly involved in learning activities aimed at developing intelligence, thinking skills, and the ability to process and conclude information. Teachers create active and enjoyable learning environments to prevent student boredom. The school has also implemented programs such as educational visits to museums and temples. Through these activities, students are directly involved in observational learning, particularly in historical contexts, which allows them to draw conclusions from real experiences. Thus, active learning is a crucial element that determines the success of the teaching and learning process (Kimonen & Nevalainen, 2005; Pelley, 2014; Şahin, 2007).

CONCLUSION

Teachers do not only work in formal educational institutions but also play roles in non-formal settings such as mosques, prayer rooms, homes, and the wider community. In the educational process, teachers have an essential role in teaching and training students that cannot be replaced by any form of technology, as teachers are the central figure in learning. Therefore, teachers are a key component in school literacy programs responsible for shaping students' knowledge, skills, and attitudes. Science literacy is the ability to recognize scientific problems, explain phenomena scientifically, and use scientific evidence. It includes skills in reading, writing, thinking, and communicating to solve problems logically. Based on PISA indicators, science literacy consists of three aspects: identifying scientific problems, explaining scientific phenomena, and using scientific evidence. The findings show that in identifying scientific problems, teachers at Madrasah Ibtidaiyah Miftahul Ulum Kesamben Wetan Driyorejo Gresik observe the surrounding environment and community conditions and connect them with learning materials using observation methods due to limited facilities; in explaining

scientific phenomena, students learn through activities such as analyzing food or beverages, visiting museums or temples, and planting and observing plant growth, which are adjusted to students' abilities and learning styles; while in using scientific evidence, students are directly involved in learning activities to develop critical thinking skills, process information, and draw conclusions through active and enjoyable learning activities.

The theoretical implication of this study strengthens the PISA-based science literacy concept, which emphasizes the importance of scientific process skills in elementary education. The practical implication shows that teachers can effectively develop science literacy despite limited facilities by utilizing the surrounding environment and applying experiential learning. The limitation of this study lies in its focus on only one madrasah and the limited variation of data obtained from a local context, so the findings cannot be widely generalized. Therefore, future research is recommended to examine science literacy in several madrasahs using a comparative approach or mixed methods in order to obtain a more comprehensive understanding of strategies for developing science literacy in primary education.

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