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# What Are the Pedagogical Needs of Teachers in Promoting Scientific Literacy Through Electronic Modules?

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**Abstract:** Scientific literacy is a fundamental twenty-first-century competency, yet Indonesian students' scientific literacy remains low based on the 2022 PISA results. This study aims to analyze the pedagogical needs of elementary school teachers in developing electronic modules to improve students' scientific literacy in Grade 5 science learning. This study employed a qualitative approach with a descriptive qualitative design involving eight Grade-5 elementary school teachers in cluster M, Madiun, East Java, Indonesia. Data were collected through semi-structured in-depth interviews and analyzed using thematic analysis to explore in depth the teachers' pedagogical needs in developing scientific literacy through the use of electronic modules. Results: The findings reveal dimensions of teachers' pedagogical needs including (1) the need to strengthen teachers' understanding of scientific literacy concepts, (2) the need for curriculum-aligned and in-depth materials supported by structured scientific readings to facilitate conceptual understanding, (3) the need for methods and learning strategies providing systematic scenarios, supporting differentiation, and improving teachers' pedagogical competence in teaching scientific literacy, (4) a gap between positive perceptions of electronic modules and the absence of implementation experience due to limited access and digital competence, (5) the need for technical features including contextual multimedia, interactive activities, higher-order thinking skills-based assessments, and lightweight electronic module designs compatible with infrastructure limitations. The findings indicate that the development of electronic modules to improve students' scientific literacy must be responsive to teachers' pedagogical needs by integrating conceptual, methodological, and technical aspects.

**Keywords:** Scientific literacy; Electronic modules; Pedagogical needs; Elementary school teachers; Science learning

## 1. Introduction

Scientific literacy has become a fundamental competency that students must master in the 21st century to actively participate in a society increasingly dependent on science and technology. Scientific literacy encompasses knowledge of scientific concepts and processes required to identify questions, obtain new knowledge, explain scientific phenomena, and draw evidence-based conclusions (OECD, 2023b). Strong scientific literacy enables individuals to become active citizens who can make rational decisions based on scientific evidence and contribute to technological progress and innovation (Istyadji & Sauqina, 2023; Reddy, 2021). Scientific literacy is a general skill that reflects the public's understanding of natural and environmental phenomena, as well as other matters derived from scientific knowledge (Guerrero & Sjöström, 2024; Valladares, 2021). In reality, the scientific literacy of Indonesian students remains low compared with that of other countries. Based on the 2022 PISA results, Indonesia ranked 67th out of 81 participating countries in science with an average score of 383 (OECD, 2023b). The low scientific literacy is attributed to science learning that emphasizes memorizing and understanding concepts while failing to habituate students to analyze scientific data and facts (Jufrida et al., 2019). Low scientific literacy indicates a gap between school science learning and the competency demands of the modern era, which is a consequence of the limited training provided to students in solving exercises requiring scientific literacy and their lack of familiarity with critically analyzing problems.

Field conditions indicate that students experience difficulties in describing scientific phenomena, applying analytical skills, and interpreting data scientifically (Pols et al., 2021). This low understanding of science is partly caused by the emergence of misconceptions in learning, the inability to connect topics, and difficulties in applying them in everyday life. In line with this opinion, science learning is still characterized by the transfer of science as a product (facts, laws, and theories) that must be memorized so that the aspects of science as a process and attitude are completely neglected (Cahyaningtyas & Desstya, 2024). Science learning in Indonesia still faces various challenges that hinder students' optimal development of scientific literacy. Science learning in Indonesian schools tends to focus on mastering theoretical concepts and memorizing facts, while scientific process skills and real-life application receive little attention (Atmojo et al., 2024). The learning approach remains dominated by teacher-centered practices that lead to passive students who are less engaged in knowledge construction (Morris, 2025). In addition, limited media and learning resources that can facilitate the development of scientific literacy pose challenges for teachers in conducting high-quality instruction (Palines & Cruz, 2021).

The role of teachers as facilitators becomes crucial in efforts to enhance students' scientific literacy through the design and implementation of appropriate learning. The success of science learning depends on teachers' ability to design meaningful learning experiences and cultivate higher-order thinking skills (Kotsis, 2024; Winarto et al., 2022). However, many teachers face difficulties in implementing scientific literacy concepts in the classroom due to limited learning resources and digital competence. Teachers are required to master science content deeply and integrate scientific concepts into everyday life (Klemenčič et al., 2023; Nida et al., 2020). Educators need to be able to identify digital platforms that can maximize the quality of their teaching. Interactive multimedia helps teachers convey abstract material so that students can understand it well (Sukariasih et al., 2019). The use of interactive multimedia can deepen students' understanding of learning materials, which has an impact on improving learning outcomes (Selviana & Andriani, 2025). E-modules can be created using multimedia creation software, such as Canva. The Web 2.0 tools are effective in attracting students' attention and encouraging interactive learning (Demirkan & Tok, 2024).

In science learning, various efforts have been made to improve students' understanding of scientific concepts, including the use of e-modules as innovative and adaptive learning media (Baring & Berame, 2022). E-modules enable richer and more interactive presentation of content compared with conventional materials by integrating multimedia elements such as text, images, animations, videos, and simulations (Kerimbayev et al., 2023) E-modules theoretically hold a position as a solution for teachers in implementing scientific literacy due to their undeniable capabilities, particularly in providing structured, independent, and contextual learning. They are designed to integrate real-life contexts. The characteristics of e-modules offer students opportunities to learn independently according to their own pace and learning styles, thus supporting student-centered learning (Kerimbayev et al., 2023). With these characteristics, e-modules play a major role in facilitating students to understand scientific processes independently, especially when teachers face limitations, administrative burdens, and pedagogical abilities. The Scientific Reading Based Project (SRBP) is one learning model that can be used to develop scientific literacy through the integration of scientific reading activities and project creation (Suryandari et al., 2021). The SRBP model facilitates students in developing reading strategies to extract scientific information and apply it in solving contextual problems (Restiani et al., 2024; Suryandari et al., 2020). The combination of the SRBP model with e-modules has strategic potential to optimize scientific literacy learning by utilizing digital technology.

The potential of e-modules in supporting scientific literacy learning has been recognized, but successful implementation depends heavily on module designs that are responsive to the pedagogical needs of teachers as primary implementers. Module design that is responsive to teachers' pedagogical needs means the consideration of learning strategies, student characteristics, learning objectives, and the teacher's role in directing and facilitating the learning process. Previous studies have focused more on the design and effects of e-modules on student learning outcomes (Alyusfitri et al., 2024; Delita et al., 2022), while an in-depth understanding of teachers' pedagogical needs remains limited. Teachers possess knowledge of student characteristics, learning challenges, and school infrastructure. Misalignment between module design and teachers' real needs may reduce adoption and lead to suboptimal implementation, ultimately hindering the development of scientific literacy (Dinçer, 2024). By identifying teachers' pedagogical needs comprehensively, this study provides an empirical basis for designing e-modules that align with the demands of scientific literacy and can be implemented by teachers across diverse capacities, school contexts, and infrastructures.

## 2. Method

### 2.1 Research Design

This study employed a descriptive qualitative design approach to explore in depth the pedagogical needs of teachers in developing scientific literacy through the use of e-modules. A qualitative approach was chosen because it allows researchers to understand complex phenomena from the participants' perspectives and to explore meanings, experiences, and teachers' pedagogical practices based on their lived experiences (Creswell & Creswell, 2018). A descriptive qualitative design was considered appropriate for this study because it aims to explore and describe phenomena as experienced by the participants (Sandelowski, 2000). The qualitative approach was used to gather comprehensive information about teachers' specific pedagogical needs to support the design and development of e-modules to enhance students' scientific literacy.

### 2.2 Research Subject

The research subjects consisted of eight Grade 5 elementary school teachers in Cluster M, East Java, Indonesia. This site was chosen based on the consideration that schools in the cluster had integrated digital learning but did not yet possess comprehensive knowledge for improving scientific literacy through e-modules. The research subjects were selected using purposive sampling, namely selecting participants based on specific characteristics relevant to the research objectives (Tenny et al., 2022). Participant criteria included (a) teachers who had been actively teaching Grade 5 for at least three years, (b) teachers who had previously used digital learning media, and (c) teachers with experience teaching science.

### 2.3 Data Collection

Data collection was conducted from January 27 to February 14, 2025. The data collected consisted of interview results to identify teachers' needs for developing e-modules. Semi-structured interviews were used as the primary instrument to explore teachers' pedagogical needs in depth because they provide flexibility to explore topics thoroughly while maintaining research focus (DeJonckheere & Vaughn, 2019). To ensure systematic and complete data collection, an interview question grid (Table 1) was prepared covering aspects of teachers' pedagogical needs in developing e-modules to enhance students' scientific literacy.

**Table 1.** Interview question grid

| Aspect | Sub-Indicator |
|---|---|
| Understanding scientific literacy | a. Scientific literacy concepts<br>b. Implementation of scientific literacy in science learning |
| Needs for e-module materials and content | a. Curriculum alignment<br>b. Depth and scope of content<br>c. Integration of scientific readings |
| Needs for learning methods and strategies | a. Methods and implementation strategies<br>b. Learning differentiation |
| Experience using digital media | a. Teacher competence<br>b. Experience using e-modules<br>c. Challenges and obstacles in e-modules<br>c. Perceptions of the effectiveness of e-modules |
| Technical needs and features of e-modules | a. Multimedia features<br>b. Learning activities<br>c. Assessment<br>d. Technological support |

Interviews with teachers were conducted based on a systematic and structured interview protocol to ensure consistency and data quality. The interview protocol included preparing an interview script based on research indicators, arranging interview schedules with participants, using recording devices and obtaining participants' permission to record conversations, selecting a conducive setting, demonstrating enthusiasm, politeness, and respect, using appropriate body language, being ready to modify questions spontaneously when needed, and allowing participants to express additional ideas or expectations.

### 2.4 Data Analysis

Interview data were analyzed using the qualitative data analysis model (Miles & Huberman, 1994), in which an interactive and iterative process of data collection, data reduction, data display, and conclusion drawing or verification was employed. The steps of data analysis are presented in Figure 1.

Data on the pedagogical needs of Grade 5 elementary school teachers were first collected through interviews. After data collection was completed, data reduction was conducted through classification, focusing, simplification, and organization. The data were then displayed in various visual formats to observe the overall picture and detailed parts and to identify patterns, themes, and relationships relevant to the research questions. Finally, conclusions were drawn by identifying general patterns, major themes, and key findings emerging from the data, giving meaning to the findings by connecting them to relevant contexts, theories, and literature, and comparing data from different participants, categories, and sources to identify similarities and differences. Furthermore, inductive reasoning was used in which general conclusions were drawn from specific cases in the form of interpretive results (Woo et al., 2017), thereby obtaining an objective and authentic understanding of teachers' pedagogical needs in improving scientific literacy through e-modules.

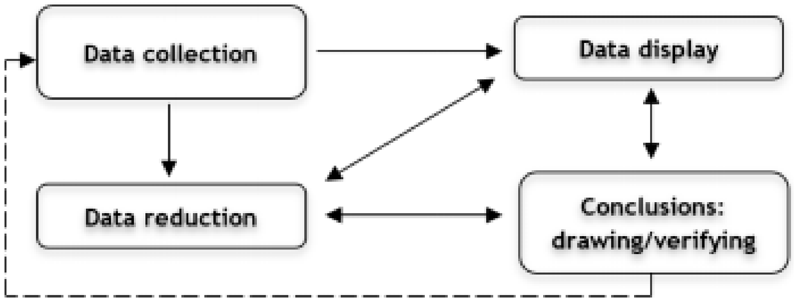


**Figure 1.** Interactive analysis steps (Miles & Huberman, 1994)

## 3. Results

### 3.1 Understanding of Scientific Literacy

Interview analysis revealed variations in teachers' understanding of the concept of scientific literacy. Three out of eight participants (G1, G2, and G4) demonstrated a more comprehensive understanding of scientific literacy as the ability to use scientific knowledge and apply it in daily life.

- *"Scientific literacy means that students can use scientific knowledge to solve everyday problems and make decisions based on evidence." (G1)*
- *"Scientific literacy is when students can explain an event that occurs and connect it with science concepts." (G2)*
- *Meanwhile, the other five teachers (G3, G5, G6, G7, and G8) demonstrated a more limited understanding, tending to interpret scientific literacy as the ability to read scientific texts to answer questions.*
- *"The important thing is that students can understand scientific texts and answer the questions in the book." (G3)*
- "As long as students can work on the questions, it means they already have scientific literacy." (G7)

These differences in understanding indicate that some teachers do not yet possess a mastery of scientific literacy aligned with the PISA framework, particularly in identifying scientific issues and using scientific evidence to evaluate and make decisions. Most teachers still position scientific literacy as a basic cognitive achievement without integrating it into daily life, resulting in science learning that does not fully promote students' critical thinking. The variation in teachers' understanding of scientific literacy reveals the need for teachers to develop science learning that integrates scientific literacy to improve the quality of the learning process and student outcomes. These findings are directly related to the implementation of science learning in the classroom. The relationship between conceptual understanding and implementation is presented in Table 2.

**Table 2.** Implementation of scientific literacy in Grade 5 science learning

| Aspect of Implementation | Frequency of Application | | | Main Challenges |
|---|---|---|---|---|
| | Often | Sometimes | Rarely | |
| Contextual learning | G1, G2 | G3, G4, G5, G6, G7 | G8 | Limited instructional time and a lack of contextual examples relevant to elementary students |
| Integration of environmental issues | G2 | G1, G3, G4, G7 | G6, G8 | Uncertainty about how to connect scientific issues with the content |
| Experiment/project activities | G1, G2, G4 | G3, G5, G6, G7, G8 | - | Belief that only certain topics are suitable for experiments or project-based learning |
| Observation of natural phenomena | G2 | G1, G3, G4 | G5, G6, G7, G8 | Difficulty in managing time |

Based on the data in Table 2, teachers who have a comprehensive understanding of scientific literacy (G1, G2, and G4) more frequently implement learning activities that promote students' scientific thinking skills. Conversely, teachers with a more limited understanding (G3, G5, G6, G7, and G8) tend to conduct textbook-based learning rather than applying concepts to real-life contexts. This implementation gap is influenced by several barriers expressed by teachers, including the belief that not all science topics can be integrated with experiments or projects. They assume that experiments are only suitable for certain topics, while many others can be taught using textbook explanations. This perception arises due to the characteristics of the material, classroom conditions, and limitations of its implementation. Some teachers find abstract topics, such as human blood circulation, the internal respiratory system, and organ function, quite difficult to implement through inquiry. Teachers believe that elementary school students are still in the concrete operational stage and, therefore, are unable to investigate biological processes that cannot be directly observed. This situation requires the use of symbolic representations and complex conceptual models. Teachers become concerned about implementing inquiry without adequate guidance. This has the potential to lead to misconceptions. Consequently, teachers tend to prefer lecture or direct methods over exploration.

Other topics considered difficult to engage with inquiry include simple electricity, magnets, and changes in state of matter, as these topics pose potential risks and require specialized equipment. Limited teaching aids, concerns about student safety, and classroom management are the main reasons that teachers avoid direct inquiry activities. This indicates a pedagogical need for teachers regarding the use of experiments/projects as strategies to develop scientific literacy across more science competencies in elementary school.

In addition, teachers' limited understanding of how to develop scientific literacy through everyday life contexts also becomes a major barrier. This is evident in the teachers' efforts to connect learning content with real-world contexts, which are still not optimal. One teacher explained, "I try to connect the water cycle with the surrounding environment, such as floods during the rainy season, but I'm still unsure how to guide students to analyze the causes scientifically, not just memorize the process." (G3). This finding supports the interpretation that teachers' lack of understanding of scientific literacy in real-life contexts directly affects the limited learning practices that foster students' scientific thinking in active and meaningful ways.

### 3.2 Needs for Materials and Content in E-Modules

The relevance and success of implementing e-modules in Grade 5 science depend greatly on the quality of the materials and content included. All participants emphasized the importance of aligning the material with the current curriculum.

- *"The module must be aligned with the Merdeka Curriculum so it does not confuse students and makes it easier for us as teachers to integrate it into learning."* (G2)
- *"The module content needs to match the latest learning outcomes so it stays within the standards."* (G4)

As educators, teachers have the responsibility to ensure that all learning outcomes are achieved. The material in the currently used textbooks is concise and does not fully guide students toward a comprehensive understanding of concepts. Teachers explained that several Grade 5 science topics are abstract and complex, and difficult to explain through verbal explanation only. These topics require visual content to help students learn and understand the relationships between learning concepts. *"The student textbook material is too brief. Students often end up memorizing without truly understanding the relationships between concepts."* (G8). Similarly, another participant stated that *"some topics need more detailed explanations so that students understand the cause-and-effect relationships."* The depth of content is highly relevant to developing more comprehensive learning materials to optimize students' scientific thinking skills. Grade 5 science topics considered to require support from e-modules to improve scientific literacy are visualized in Figure 2.

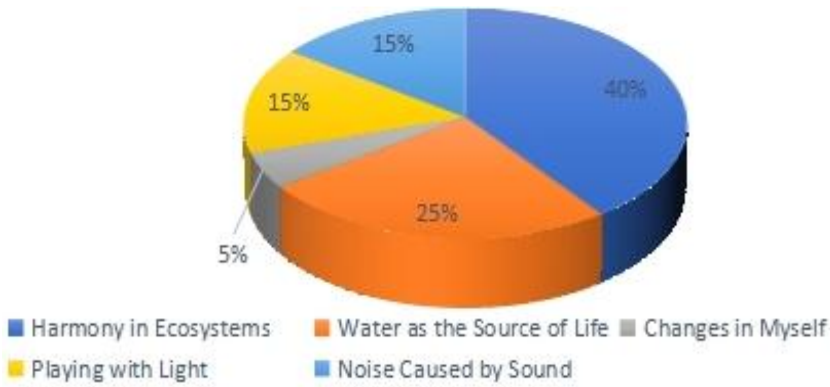


**Figure 2.** Grade 5 science topics that require e-modules

The data show that Harmony in Ecosystems is the topic that most requires e-module support to enhance students' scientific literacy. This is due to the complexity of concepts students must understand, including reciprocal relationships between living things and their environment, energy transfer within ecosystems, and the consequences of ecosystem imbalance. These challenges require students to master scientific literacy by identifying scientific issues, explaining scientific phenomena, and using scientific evidence. Teachers realized that students' ability to read and understand scientific texts is an important part of scientific literacy. Four of the eight teacher participants (G3, G5, G7, and G8) emphasized that Grade 5 students often struggle when reading scientific texts containing complex explanations.

- *"Students need readings that guide them in understanding cause-and-effect processes in ecosystems, not just memorizing concepts."* (G8)
- *"When scientific terms appear in texts, students often struggle to understand them."* (G3)
- *"Sometimes readings are not relevant to students' daily lives. They lack concrete examples, so students find it hard to connect the concepts with the real world."* (G7)

The integration of structured and leveled scientific readings in e-modules becomes a highlighted need. These readings serve as sources of information and guide students gradually in constructing scientific understanding. By providing scientific readings appropriate to students' age and developmental level, e-modules can enhance students' scientific literacy. This need aligns with the SRBP model, particularly in the scientific reading phase, which becomes the foundation for all project activities. In this phase, students read scientific texts deeply to obtain information used as the basis for designing and completing learning projects. Through this integration, students are encouraged to trace cause-and-effect relationships, analyze evidence, and draw scientific conclusions relevant to environmental phenomena around them.

### 3.3 Needs for Learning Methods and Strategies

The development of e-modules must be aligned with learning activities suited to the cognitive and socioemotional characteristics of Grade 5 students. Teachers emphasized that scientific literacy requires a learning process that involves scientific thinking, problem solving, and the application of concepts in contextual situations. To facilitate these goals, teachers need to implement strategies that enable active student engagement during learning. Implementation guidelines in the form of learning scenarios are a basic need, especially for teachers who are using e-modules for the first time. Systematic scenarios can help teachers navigate the learning flow more effectively while still providing room for adjustment according to classroom dynamics.

- *"Every student has different characteristics. Some are already independent, while others still need guidance. With a clear learning scenario, it is easier for me to adjust activities to the classroom condition."* (G1)

The need for learning scenarios is related to teachers' ability to apply differentiation strategies to accommodate the diverse characteristics of students. Teachers understand that students have varying ability levels, learning styles, and learning paces, so the e-module must provide flexibility in its use.

- "*Students' abilities are very diverse because some still struggle to understand scientific texts. The module needs to provide content with various levels of complexity*." (G4)
- *"Students have different learning styles. With such a diverse class composition, sometimes I find it difficult to give enough attention to each group. Fast learners get bored waiting, while slower learners feel left behind."* (G3)

These findings show that differentiation in e-modules is an essential need to help teachers overcome gaps in ability and learning styles. This need requires teachers' readiness and competence in implementing the module optimally. Teachers need a deeper understanding of scientific literacy and how to teach it effectively. Although all teachers agree on the importance of scientific literacy, most still lack a strong conceptual understanding of how to connect it with learning activities, assessment, and real-life contexts.

- *"So far my science teaching still focuses on memorizing concepts and doing exercises. I need to learn how to design learning that truly trains students' scientific thinking and problem-solving skills, especially with the help of e-modules."* (G7)

### 3.4 Experience Using Digital Media

Data regarding teachers' experience using digital media for science learning are presented in Table 3.

**Table 3.** Teachers' experience using digital media

| Type of Digital Media | Frequency of Use | |
|---|---|---|
| | Sometimes | Rarely |
| PowerPoint | G1, G2, G4, G6 | G3, G4, G5, G8 |
| Online quizzes | G2 | G1, G3, G4, G5, G6, G7, G8 |
| Learning video/YouTube | G1, G2, G3, G4, G7 | G5, G6, G8 |
| E-modules | - | - |

Interview findings indicate that none of the Grade 5 teachers have ever used e-modules in science learning. The digital media most frequently used are PowerPoint and learning videos, while e-modules are not yet part of their instructional practice. Teachers rely mostly on textbooks provided by the government, which they consider sufficient as the main learning resource.

- *"For science learning, I only use the textbook and PPT. I have never used an e-module."* (G5)
- *"I often use PowerPoint and YouTube videos to visualize abstract science concepts because they are practical and require no extensive preparation."* (G1)
- *"I know about e-modules, but I have never tried them in science lessons because it is difficult to find one that is suitable for 5th grade students."* (G8)

Given that no teachers had ever used e-modules, their understanding and expectations of e-modules were then explored. Teachers expressed positive hopes and expectations for using e-modules if they were available and easily accessible.

- *"I know about e-modules, but I have never tried them in science learning because it is difficult to find one suitable for Grade 5 students. I do not have the time or skills to create it myself."* (G2)
- *"With an e-module containing images, videos, and animations, students can understand science concepts more easily and learn independently without having to wait for my explanation."* (G3)

At the same time, teachers also expressed significant concerns regarding challenges and obstacles in using e-modules.

- *"I worry that students will lose focus and get carried away playing with their gadgets when using e-modules. Moreover, I also have to supervise each student using a device."* (G4)
- *"Sometimes the internet is unstable or goes out, which will hinder the use of the e-module."* (G6)

These findings show a gap between teachers' interest in using e-modules and the limitations in access and digital competence. Teachers expressed very positive perceptions and recognized that digital learning resources could potentially strengthen students' understanding of science concepts. However, existing limitations make teachers rely on government textbooks and simple digital media.

Upon closer examination, these limitations revealed findings stemming from the limited opportunities teachers receive to use or develop e-modules, such as through training, workshops, or other means. Generally, training is only provided to representatives from each school gathered for a major event. Unfortunately, the training ends at that point without any dissemination to other teachers who did not attend. Furthermore, the lack of gadgets to support the availability of e-modules also hinders the implementation of e-modules in learning. Only a few schools provide gadgets for their students. Even some parents don't always have cell phones or laptops for their children to use at home, as these phones are often outdated. Although teachers have no direct experience using e-modules, all participants expressed readiness to try if a module suitable for Grade 5 science learning was available and could be used without complicated procedures.

### 3.5 Technical Needs and Features of E-Modules

The development of e-modules in science learning must be supported by adequate technical features. Multimedia features are essential to visualize abstract scientific concepts. Integration of visual elements such as illustrations, images, videos, and interactive quizzes can reduce misconceptions related to relationships among components in the Harmony in Ecosystems topic. The need for multimedia that is contextual to students' environment is crucial so that learning becomes more meaningful and relevant to daily life.

- *"Pictures of ecosystems should use examples that are close to the students' lives so they can imagine the concepts."* (G6)
- *"In my class some students still struggle with reading fluency. If the e-module contains audio-visual features, it can help them listen while visualizing the Harmony in Ecosystems topic."* (G3)

Teachers also emphasized the importance of activities that encourage active student engagement. These activities serve as tools to stimulate critical thinking, collaboration, and discussion among students. Varied learning activities are essential so the module can facilitate enjoyable and meaningful learning experiences.

- *"Students need to be actively involved in problem-solving activities to train their critical thinking. There must be a clear sequence of learning steps, starting from observing, planning solutions, collecting data, and drawing conclusions."* (G2)
- *"Students enjoy collaborative activities such as creating concept map projects because they can work together, discuss problems, and directly engage in learning."* (G4)

Teachers also expressed the need for structured guidance and scaffolding in learning activities. This is based on the fact that Grade 5 students still require step-by-step guidance. Therefore, the e-module must provide supporting elements such as guiding questions, worksheet templates, and activities designed to progress from simple to complex concepts. This need is reinforced by teachers' emphasis on the importance of immediate feedback in interactive activities. Effective feedback can show correct answers and explain why students' answers are incorrect. This mechanism is crucial because it helps students learn directly from their mistakes and reduce misconceptions without waiting for the teacher's explanation. Regarding assessment, most teachers expressed the need for varied evaluation formats that incorporate higher-order thinking skills. Evaluation should facilitate analytical processes and problem-solving that require students to link concepts with real-life situations. This need indicates a shift from lower-order cognitive assessment to more analytical assessment.

- *"The evaluation questions should not only be memorization. It is better if there are tasks that require students to explain using their own words based on the reading or project."* (G4)
- *"To measure scientific literacy, students should be given case-based questions. For example, they are given data about the decline of a population and asked to analyze the impact."* (G1)

The implementation of multimedia features, learning activities, and comprehensive assessments depends heavily on adequate technological infrastructure. Analysis of the participating schools shows significant variation in device availability and internet quality.

Based on Table 4, there are gaps in internet conditions across participating schools. Therefore, ease of access and module compatibility with various devices must be considered so the module can facilitate learning effectively.

- *"The module must be accessible on various devices because not all students have laptops at home. It would be better if the module did not require much storage, considering many students use their parents' phones with limited memory."* (G8)
- *"Our school uses Chromebooks, so the module must be compatible and not require complicated installation."* (G5)

**Table 4.** Infrastructure profile of participating schools

| School | Device Availability | Internet Condition |
|---|---|---|
| SDN 1 (G1) | Chromebook | Good |
| SDN 2 (G2) | Tablet | Good |
| SDN 3 (G3) | Tablet | Fair |
| SDN 4 (G4) | Laptop | Good |
| SDN 5 (G5) | Chromebook | Fair |
| SDN 6 (G6) | Chromebook | Fair |
| SDN 7 (G7) | Chromebook | Good |
| SDN 8 (G8) | Tablet | Fair |

These findings show that the effectiveness of e-modules depends on their ability to operate stably despite infrastructure limitations. Differences in internet quality, variations in devices used by students and schools, and limited storage capacity are determining factors that must be considered in module development. Teachers need modules that are lightweight, device-compatible, installation-free, and usable even with unstable connections. These conditions confirm that technical design is a prerequisite to ensure that modules can be implemented in classrooms. This e-module can also overcome limitations in internet connection quality, as it is available offline in PDF format, making it easier for users without requiring a continuous internet connection. This offline access provides flexibility for teachers and students in implementing learning, particularly in areas with limited internet access, allowing for effective and sustainable learning.

## 4. Discussion

### 4.1 Understanding of Scientific Literacy

The varied levels of understanding of scientific literacy among the participating teachers present a fundamental challenge for the development of e-modules. The findings show that only 37.5% of teachers have a comprehensive understanding of scientific literacy. This understanding aligns with the PISA definition, which emphasizes scientific literacy as the ability to use scientific knowledge to understand phenomena and make decisions relevant to their lives (OECD, 2023a). Teachers with a limited understanding of scientific literacy (62.5%) tend to equate scientific literacy with the ability to read scientific texts, without understanding the essence of scientific literacy as a functional ability. This finding aligns with Bossér (2024)'s research, which states that teachers often fall into conventional teaching, making it difficult for them to transform the concept of scientific literacy into concrete classroom practice. This conceptual gap directly affects classroom implementation. Teachers' understanding of scientific literacy influences the quality of students' learning experiences (Suárez-Mesa & Gómez, 2024). Scientific literacy should ideally develop through direct experiences and exploration of scientific phenomena (Ploj Virtič, 2022). Teachers who understand the inquiry model can design lessons that give students opportunities to investigate and discover knowledge themselves (Urdanivia Alarcon et al., 2023). However, field findings suggest the opposite of this ideal practice, as teachers tend to rely on textbooks and explanations when facing time constraints or believe that not all materials are suitable for experiments or projects.

### 4.2 Needs for Materials and Content of E-Modules

The need for materials and content in e-modules emerges as a consequence of the limited learning resources that can help teachers develop students' scientific literacy comprehensively. Based on the findings, module development must be designed according to the learning outcomes in the Merdeka Curriculum implemented in Indonesia. Learning outcomes function as the main guideline in the curriculum to determine the targets students must achieve and serve as references in planning and implementing learning (Mahajan & Singh, 2017). The independent curriculum is linked to scientific literacy as a core competency that needs to be developed in students through appropriate learning. This approach aligns with the global shift from a content-oriented curriculum to a scientific literacy competency (Ibnusaputra et al., 2025). The independent curriculum represents a paradigm shift in science learning that integrates applied contexts, scientific thinking, and problem-solving so that the theory can strengthen students' scientific literacy within a global competency framework.

Alignment of instructional materials with the Merdeka Curriculum is essential because this curriculum accommodates flexible student-centered learning and holistic competence development (Ministry of Education Culture Research & Technology, 2024). However, the problems raised by teachers regarding textbook content that is too brief indicate a gap between available learning resources and instructional needs. This finding supports the findings of Li & Wang (2024), which reveal that textbooks often focus on delivering facts and procedures rather than encouraging in-depth concept exploration. This results in rote learning without meaningful understanding. This condition further reinforces the need for instructional materials that can enrich learning experiences, especially in complex topics such as Harmony in Ecosystems in science learning.

The need to integrate scientific literacy in the topic of Harmony in Ecosystems aligns with the PISA framework that defines scientific literacy as the ability to engage with issues related to science and scientific ideas as reflective citizens (OECD, 2023a). However, students' difficulties in understanding complex scientific texts reflect challenges in developing comprehensive scientific literacy (Goudsouzian & Hsu, 2023; Jian, 2021). The need for reading materials that help students understand cause and effect processes aligns with the view that scientific literacy is not only about the ability to read scientific texts but also the ability to think critically about scientific information (Junanto et al., 2024). This critical thinking ability is strengthened through the principle of meaningful learning from Ausubel, which states that learning becomes more meaningful when students can relate new scientific concepts to their prior knowledge and experiences (Bryce & Blown, 2024). The need for reading materials that are relevant to students' daily lives helps them connect learning with real-world phenomena, which can improve understanding and critical thinking skills. Furthermore, to ensure this critical understanding develops effectively, structured and leveled texts are needed, reflecting the importance of scaffolding in learning (Petersen, 2022; Senisum et al., 2022). The alignment between teacher needs and the syntax of the SRBP model shows this model's relevance for elementary science learning. The SRBP model positions scientific reading as the foundation for inquiry and project activities so students can use information from texts to solve problems (Chrysti et al., 2020; Suryandari et al., 2019). This aligns with the findings of Esparza et al. (2023), which show that integrating literacy and science improves students' achievement in science content as well as reading skills by encouraging student engagement in authentic scientific practices, including reading to learn, writing to explain, and using textual evidence to support scientific claims.

Through the SRBP model, students actively construct new knowledge by integrating information from scientific articles into creative and collaborative learning projects. This learning process, which directs students to learn through discovery and problem-solving, enables them to build knowledge that is meaningful and relevant to everyday life. The SRBP learning model also integrates critical scientific reading activities with research-based projects, enabling students to not only understand theory but also apply it in exploratory activities.

### 4.3 Needs for Learning Methods and Strategies

The findings show that teachers need structured learning scenarios to use media effectively. Learning scenarios can function as roadmaps that help teachers navigate lesson flow more systematically (Adler et al., 2025). They need to be adapted to address challenges in aligning learning activities with students' cognitive, social-emotional, and ability differences (Sailer et al., 2021). Teachers' awareness of diverse characteristics and the need for differentiated instruction shows an understanding of inclusive learning principles. Differentiation is a proactive instructional approach that modifies content, processes, and learning products to accommodate varied readiness levels, interests, and learning profiles (Gheyssens et al., 2022; Goyibova et al., 2025). In science learning aimed at enhancing scientific literacy, this differentiation is essential because concept complexity requires varying levels of support based on students' cognitive readiness (Bhardwaj et al., 2025).

On the other hand, teachers' need for pedagogical support reflects a competency gap in understanding the scientific literacy conceptually and practically. Teachers acknowledge that science learning still focuses on memorization rather than on developing scientific thinking and problem-solving. This aligns with the findings of Jimenez-Liso et al. (2021), which assert that many teachers have a limited understanding of scientific literacy due to insufficient training focused on scientific practices and their integration into classroom activities. To bridge this competency gap and shift science learning from memorization to scientific thinking and problem-solving, a more comprehensive strategy is required through implementing the SRBP model. This model is an effective framework because it integrates scientific literacy with project-based learning and promotes scientific thinking, problem solving, and real-world application of concepts (Chrysti et al., 2020).

### 4.4 Experience of Using Digital Media

Teachers' experience of using digital media shows that technology use in science learning is still limited to simple media such as PowerPoint and videos. Reliance on one-way media indicates that teachers have not had the opportunity or competence to use digital media that is interactive and adaptive and supports independent knowledge construction (Tomczyk, 2024). This limitation reflects the use of technology at the substitution and augmentation levels, which only replace conventional methods without significant changes to instructional design (Raave et al., 2024). The fact that no teacher has ever used e-modules in science learning indicates a major gap between the potential of educational technology and its implementation in schools. Teachers' difficulty in finding suitable e-modules for Grade 5 indicates the lack of an ecosystem of high-quality and accessible educational resources (Raave et al., 2024).

Teachers' expectations and positive perceptions of e-modules indicate that they understand the pedagogical potential of digital media to strengthen scientific literacy. The expectation that multimedia-based e-modules can facilitate students' independent learning supports the importance of digital scaffolding. This is supported by Lee et al. (2024), who assert that learning technology can act as external scaffolding to develop students' self-regulation skills. However, teachers' concerns about distractions and device monitoring show classroom management challenges. These concerns indicate that the pedagogical risks of using e-modules without clear strategies may lower instructional quality. Digital devices can create distractions if not designed and managed well (Pérez-Juárez et al., 2023). In addition to distraction issues, infrastructure barriers such as unstable internet access increase complexity. The research by Antonietti et al. (2022) confirms that technology adoption depends on first-order barriers such as device and infrastructure access and second-order barriers related to beliefs, competence, and teachers' pedagogical knowledge.

### 4.5 Technical Needs and Features of E-Modules

Interview results on technical needs and features indicate that the effectiveness of technology-integrated science learning depends heavily on multimedia design and infrastructure accessibility. Teachers need illustrations, videos, audio, and interactive quizzes, which indicates that elementary science learning requires visual representations to bridge abstract concepts. This aligns with Mayer's Cognitive Theory of Multimedia Learning (Mayer, 2024), which states that when students receive information through verbal and visual channels simultaneously, cognitive load can be managed better and conceptual understanding becomes deeper. Integrating visual elements such as illustrations, animations, and videos in Harmony in Ecosystems can help students visualize and integrate complex relations within ecosystems. Teachers' emphasis on multimedia that reflects students' environments, such as local ecosystems, shows the need for contextual relevance. This is consistent with the findings of Darling-Hammond et al. (2020), which emphasize that learning experiences relevant to students' lives can increase motivation and strengthen conceptual understanding because students see real applications of concepts.

Furthermore, the teachers’ emphasis on the importance of learning activities that encourage active student engagement reflects a paradigm shift from passive behaviorist learning to active constructivist learning. Collaborative activities that students enjoy, such as creating projects, reflect the importance of collaborative learning in developing conceptual understanding. These activities allow students to share ideas, discuss alternative explanations, and construct a shared understanding of complex scientific phenomena. To support this paradigm shift and ensure that students can manage such complex tasks, scaffolding and structured guidance are necessary. In the context of e-modules, these can be implemented through guiding questions, structured templates, and activity designs with progressive levels of complexity. This perspective is reinforced by the findings of Mamun and Lawrie (Al Mamun & Lawrie, 2024), which highlight that digital scaffolding provided gradually can improve students’ analytical skills while minimizing the emergence of misconceptions during independent exploration.

Technical needs and features of e-modules also include assessments that employ higher-order thinking skills to develop students’ scientific literacy comprehensively. Teachers stated the need for evaluation features that are not limited to multiple-choice questions but also include formative assessments such as interactive quizzes, self-reflection activities, guiding questions, and project tasks that can assess students’ abilities to understand concepts, analyze phenomena, and connect concepts to real-life contexts. In science learning, assessment must shift from merely testing recall of information to authentic measurement of how students construct knowledge and apply scientific thinking (Darling-Hammond et al., 2020; Kotsis, 2024). However, the successful implementation of these features is significantly constrained by the readiness of the infrastructure in the field. These infrastructure gaps have important implications for e-module design, which must be developed based on principles of equity and accessibility to ensure that all students can access quality learning without being hindered by technological limitations.

This study aims to identify and analyze the pedagogical needs of elementary school teachers in developing e-modules to enhance students' scientific literacy. The focus on elementary school teachers is based on the importance of building the foundation of scientific literacy from an early age.

## 5. Conclusions

Based on the findings and discussion above, it can be concluded that teachers need a stronger conceptual understanding of scientific literacy, structured and contextual learning materials, and clear pedagogical strategies to guide inquiry-based and project-based learning that integrates scientific reading with authentic scientific practices. Regarding digital media experience, the study reveals a significant gap between teachers' awareness of the potential benefits of e-modules and their actual implementation in learning. Nevertheless, teachers have positive attitudes and readiness to adopt e-modules if they are available, easy to use, and do not require complicated procedures. For technical features, teachers highlight the need for interactive activities that promote active engagement, critical thinking, collaboration, and student discussion, supported by technical designs that take infrastructure limitations into account. This study has several limitations, as it only involves eight elementary school teachers within one school cluster, resulting in findings that remain limited. Therefore, future research is recommended to expand the study to a larger number of schools and incorporate classroom implementation stages.

## Author Contributions

Conceptualization, N.D.R.; data curation, N.D.R., D.S., and K.C.S.; formal analysis, N.D.R., D.S., and K.C.S.; research, N.D.R.; methodology, N.D.R., D.S., and K.C.S.; project management, N.D.R., D.S., and K.C.S.; resources, N.D.R., D.S., and K.C.S.; software, N.D.R. and D.S.; supervision, D.S., K.C.S., and K.; validation, D.S. and K.C.S.; display, N.D.R., D.S., and K.C.S.; drafting—original draft, N.D.R., D.S., K.C.S., and K.; writing—proofreading and editing, M.S. All authors have read and agreed to the published version of the manuscript.

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## Data Availability

The data used to support the research findings are available from the corresponding author upon request.

## Conflicts of Interest

The authors declare no conflict of interest.

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