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ORIGINAL

Ethnoscience Materials to Build Scientific Literacy

Materiales de etnociencia para construir alfabetización científica

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ABSTRACT

Introduction: students' scientific literacy skills were often overlooked due to teaching materials that failed to incorporate local cultural context. This study aimed to identify teaching materials currently employed in elementary science education fourth-grade students in 'Sekolah Penggerak' programs in Sukoharjo Regency, Central Java, Indonesia, and assess students' scientific literacy within this context.
Method: the study employed a descriptive qualitative approach with participants including fourth-grade educators and students from elementary schools in the "Sekolah Penggerak" program in a Javanese province, Indonesia. Two schools participated: State Elementary School 02 Duwet and State Elementary School 04 Ngadirejo. Data were obtained through surveys and interviews using purposive sampling techniques. Questionnaires were distributed to students, while interview data were gathered from teachers.
Results: the majority of teaching resources were government- or publisher-provided books that lacked cultural relevance and were not designed to improve scientific literacy. Teachers had not created instructional materials that were literacy-focused or culturally appropriate. Scientific literacy levels among students were found to be very low.
Conclusions: the findings demonstrated the urgent need to develop ethnoscience-based instructional materials that integrated local culture, technology, and inquiry-based learning methodologies. Such resources would strengthen students' comprehension, increase their scientific literacy, and provide tangible learning experiences that connected scientific concepts to their cultural context.

Keywords: Science Education; Teaching Materials; Ethnoscience; Scientific Literacy.

RESUMEN

Introducción: las habilidades de alfabetización científica de los estudiantes a menudo se pasaban por alto debido a que los materiales didácticos no incorporaban el contexto cultural local. Este estudio tuvo como objetivo identificar los materiales didácticos actualmente empleados en la enseñanza primaria de las ciencias y evaluar la alfabetización científica de los estudiantes en este contexto.
Método: el estudio empleó un enfoque cualitativo descriptivo con participantes incluyendo educadores de cuarto grado y estudiantes de escuelas primarias en el programa "Sekolah Penggerak" en una provincia de Java, Indonesia. Participaron dos escuelas: la Escuela Primaria Estatal 02 Duwet y la Escuela Primaria Estatal 04 Ngadirejo. Los datos se obtuvieron a través de encuestas y entrevistas utilizando técnicas de muestreo intencional. Se distribuyeron cuestionarios a los estudiantes, mientras que los datos de las entrevistas se recopilaron de los maestros.
Resultados: la mayoría de los recursos didácticos eran libros proporcionados por el gobierno o las editoriales que carecían de pertinencia cultural y no estaban diseñados para mejorar la alfabetización científica. Los

maestros no habían creado materiales didácticos centrados en la alfabetización o culturalmente apropiados. Se encontró que los niveles de alfabetización científica entre los estudiantes eran muy bajos.
Conclusiones: los hallazgos demostraron la necesidad urgente de desarrollar materiales didácticos basados en la etnociencia que integren la cultura local, la tecnología y las metodologías de aprendizaje basadas en la indagación. Dichos recursos fortalecerían la comprensión de los estudiantes, aumentarían su alfabetización científica y proporcionarían experiencias de aprendizaje tangibles que conectarían los conceptos científicos con su contexto cultural.

Palabras clave: Science Education; Teaching Materials; Ethnoscience; Scientific Literacy.

INTRODUCTION

The capability to understand and express opinions regarding scientific issues is defined as scientific literacy. Through scientific literacy, someone can utilize their understanding of science, technology and society through logical reasoning.[1] Scientific literacy abilities include investigating inquiries, gaining new concepts, interpreting scientific phenomena, making evidence-based conclusions, comprehending the core principles of science, understanding the impact of technology and science shape the natural world as well as cultural environment and intellectual, enthusiasm and engagement in science-related issues.[2] Scientific literacy is a necessary ability in science learning and one of the abilities that can support 21st-century skills.[3]

The Programme for International Student Assessment (PISA) 2022 findings indicate that Indonesia is still facing low levels of scientific literacy, with a score of 383.[1] The low scientific literacy is due to science learning only emphasizing aspects of understanding based on memory and has not yet reached the stage of analysis based on scientific data.[4] The habit of memorizing hinders students to understanding knowledge. Low scientific literacy is considered a consequence of insufficient training provided to students in solving practice problems that require scientific literacy, and they are not accustomed to analyzing issues.[4] Factors causing low scientific literacy in Indonesia are influenced by students, teachers and schools.[5] Factors from students are: ineffective teaching strategies, limited access to resources, a lack of interest in science, and re-reading science material that has been studied. Teacher factors include teachers' lack of knowledge, the inappropriate choice of teaching strategies and learning environments to enhance active learning, and the rare training of students to develop concepts. School factors include the learning environment and climate as well as facilities and infrastructure that do not support learning and practicums.

Natural science concepts in learning are closely tied to community life and local wisdom.[6] Local wisdom includes various traditions, customs, taboos, and rules inherited by the community.[7] In fact, science learning does not yet connect science material with the cultural environment surrounding society, so students cannot exploit their ability to recognize the surrounding environment. Another fact that occurs is the teaching materials used do not relate to the local environment and culture around the students.[8]

The teaching materials used, primarily textbooks only come from the government and commercial publishers, so the teaching materials do not make students active and do not involve local culture in them. The teaching materials, which come only from the government and commercial publishers, fail to engage students and incorporate local culture. Students demonstrate limited ability to utilize their knowledge to interpret, explain, and draw conclusions based on simple investigations related to scientific disciplines in real-life situations.[9]

Scientific literacy is considered important in research, as it represents an element of 21st century skills[3] and based on the 2022 PISA results Indonesia's scientific literacy ability is still categorized as low.[1] Indicators of scientific literacy include are identifying scientific issues, explaining scientific phenomena, and using scientific evidence.[10] Then, ethnoscience is important to research because currently the learning approach must manifest as values, traditions, and technology developed by society that contain scientific knowledge.[11]

Based on the problems that occur, efforts that can be made are by using ethnoscience-based teaching materials. Teaching materials are arranged systematically to achieve learning objectives.[12] The benefits of using teaching materials are to help manage learning such as determining strategies and structured learning processes, making students actively involved in learning, and helping students learn independently while managing time independently when not studying at school.[13] The integration of ethnoscience in the teaching materials can help students more easily explore facts and phenomena in their area and integrate them with science, and makes learning becomes meaningful and fun.[14,15] Ethnoscience involves the process of converting indigenous science into formal scientific knowledge.[16] Ethnoscience emphasizes the local cultural knowledge and the surrounding environment.[14]

Ethnoscience-based teaching materials have the advantage of being able to help students think scientifically about phenomena they encounter every day, prepare students to think critically, creatively and responsibly towards the surrounding environment, and help connect learning with community life based on local culture.[9,16]

Teaching materials based on ethnoscience can enhance students' academic performance and make learning more interesting, as well as increase scientific literacy in students. Teaching materials can be effective when evaluated based on students' mastery classical content, basic competencies development, and conceptual understanding.[17]

Research on analysis of needs for ethnoscience-based teaching materials has been carried out, including: Ardianti et al[18] found that Students expect stories to be filled with pictures and fun activities. Dewi et al[19] was identified there are obligatory to develop ethnoscience-based books in chemistry, because the learning that has taken place is not associated with the local culture of students and does not accommodate students' scientific literacy. and Oktaviani and Desstya[20] was identified there are limitation in the application teaching materials based ethnoscience both in practical implication and terms content. Dewi et al[6] found that it is necessary to develop students' scientific literacy in chemistry learning that is associated with ethnoscience in students' daily lives so that learning becomes contextual. Then, although many studies have shown that teaching materials based ethnoscience can enhance the understanding of science concepts.[21] There are still limitations regarding the needs assessment of teaching materials that aim to enhance elementary school students' scientific literacy in science learning.

Previous research has not addressed a needs analysis specifically focusing on science learning style materials for elementary schools, nor has it explored the requirements for integrating ethnoscience into teaching materials. Thus, the research novelty focuses on the assessment in elementary school science learning in Sukoharjo Regency, Central Java, Indonesia, conducted in August 2024, to facilitate design and development of teaching materials based ethnoscience to enhance students' scientific literacy. The research objectives are to identify the teaching materials currently used in science education and assess students' competence in scientific literacy in elementary school science learning among fourth-grade students in 'Sekolah Penggerak' programs.

METHOD

Research design

A descriptive qualitative approach is utilized in this research. Descriptive qualitative is a type of study that investigates a phenomenon to retell the information received descriptively.[22] Qualitative descriptives in this research are shown in the presentation of information obtained from the data. A qualitative approach is conducted to gather comprehensive information about the need analysis to facilitate design and development of teaching materials based ethnoscience in science learning elementary school to enhance students' scientific literacy.

Research subjects

The research subjects used were students and teachers of class IV of one of the program "Sekolah Penggerak" in Sukoharjo Regency. The program "Sekolah Penggerak" that is the subject of this research is State Elementary School 02 Duwet and State Elementary School 04 Ngadirejo. The quantity of class IV teachers are 1 person from State Elementary School 02 Duwet and 1 person from State Elementary School 04 Ngadirejo, 6 students from class IV. State Elementary School 02 Duwet dan State Elementary School 04 Ngadirejo was chosen as the research location because it is one of the "Sekolah Penggerak"s in Sukoharjo district. "Sekolah Penggerak" was chosen as a place because it is a school that dedicated and focused to fostering comprehensive learning outcomes, especially literacy competencies.[23] "Sekolah Penggerak" has implemented an independent curriculum that makes local wisdom a separate subject, integrates local wisdom in all subjects, and in the "The Pancasila Student Profile Strengthening Project (P5)".[24] Then, class IV teachers have a history of teaching in class IV for at least 3 years. A purposive sampling technique was employed to choose the subject, meaning that sampling was based on specific considerations.[25] The limitation of purposive sampling in this study is the potential for selection bias and limited generalizability of findings, which must be considered when interpreting results.

Data collection

Data collection was conducted on August 20, 2024, at State Elementary School 02 Duwet and on August 24, 2024, at State Elementary School 04 Ngadirejo. The research data collected were the outcomes of interviews with teachers and questionnaires of class IV students to identify the teaching materials currently used in science education and assess students' scientific literacy. The questionnaire utilized a 1-5 likert scale.[26] Likert scale one states that respondents strongly disagree, Likert scale two states that respondents disagree, Likert scale three states that respondents are neutral, Likert scale four states that respondents agree, Likert scale 5 states that respondents strongly agree.

Interviews with the teachers were conducted based on an interview protocol which includes: creating an interview script that has been adapted to the research indicators, making agreements with the interviewees to determine the time of the interview, using a recording device and permission to the relevant parties to record the interview, choosing a quiet and comfortable location, showing an enthusiastic and polite attitude to the interviewee, using correct body language, preparing to make revisions of the questions on the spot if there are additional helpful questions, and ending the interview by allowing the interviewee to convey further expectations after the interview.

The research focuses on two main variables, namely scientific literacy ability and ethnoscience-based teaching materials in the form of textbooks. Ethnoscience-based teaching materials are a component of the learning process that complements practical activities, enabling students to engage in active, collaborative, and contextual learning about culture and their daily activities.[27] The material in ethnoscience-based teaching materials contains local culture and is suitable for application in learning.[28]

Scientific literacy is an individual's ability to explain scientific phenomena, evaluate and design scientific research, and interpret scientific data and evidence.[1] According to Amanah et al.[10] scientific literacy encompasses identifying scientific issues, explaining scientific phenomena, and utilizing scientific evidence.

Table 1. Scientific literacy indicators

Scientific Literacy Indicators	Sub Indicator
Ability to explain scientific phenomena	a. Identify scientific issues. b. Formulate scientific questions.
Ability to evaluate and design scientific investigations	a. Planning scientific research to solve problems in everyday life. b. Evaluate scientific investigations by interpreting evidence.
Ability to interpret scientific data and evidence	a. Conclude the results of the investigation based on the scientific evidence. b. Convey the findings of the investigation.

Table 2. Ethnoscience-based teaching material indicators

Aspect	Sub Indicator
Self-Instruction	Teaching materials are easy for students to use without the help of other parties. Instructions for activities in the teaching materials are clear.
Self-Contained	Complete teaching materials according to learning objectives. Teaching materials are linked to local culture.
Stand Alone	The use of teaching materials does not require other media/devices
Adaptive	The application of technology in the teaching materials. Teaching materials are flexible
User Friendly	There are indications for the use of teaching materials There is a list of glossaries

Data validity

The analysis used is interactive analysis by Miles and Huberman. The data that has data is then selected and classified according to the criteria (data reduction). The data is presented in charts, tables, or graphics (data presentation), and conclusions can be drawn from the reduced data (conclusion drawing/verification). Thus, drawing conclusions in this research goes through the stages of classifying, then presenting the data and generalizing the findings. For qualitative interview data, thematic analysis was employed to identify recurring patterns and themes related to teaching materials usage and scientific literacy challenges.

The descriptive statistical technique used to summarize the information obtained involves interpreting the results of the Likert scale score 1-5, where $P = f/N \times 100\ \%$ (P = percentage of the number f of answers, f = average score, N = total ideal score of all items). The categorization of the Likert scale results is 81-100 is very good, 61-80 is good, 41-60 is sufficient, 21-40 is bad, and 0-20 is very bad. This categorical scale was established based on equal interval ranges to provide a consistent interpretation of students' competency levels.

Research procedure

The research procedure was initiated with careful planning by defining the research objectives and creating research instruments. Data was gathered through interviews and by distributing questionnaires to participants. The collected information was then analyzed through processes including reduction, display, and formulating a conclusion. To guarantee the reliability and credibility of the findings, the researchers conducted validation checks on the data from both the questionnaires and interviews. Finally, the research findings were compiled and documented in a comprehensive report.

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RESULTS

Teaching materials used in science learning

The identification of teaching materials used in elementary school science learning in the "Sekolah Penggerak" program was evaluated based on five key indicators of ethnoscience-based teaching materials. The questionnaire results revealed significant variations across different aspects of teaching material quality. The questionnaire results can be reflected in figure 1.

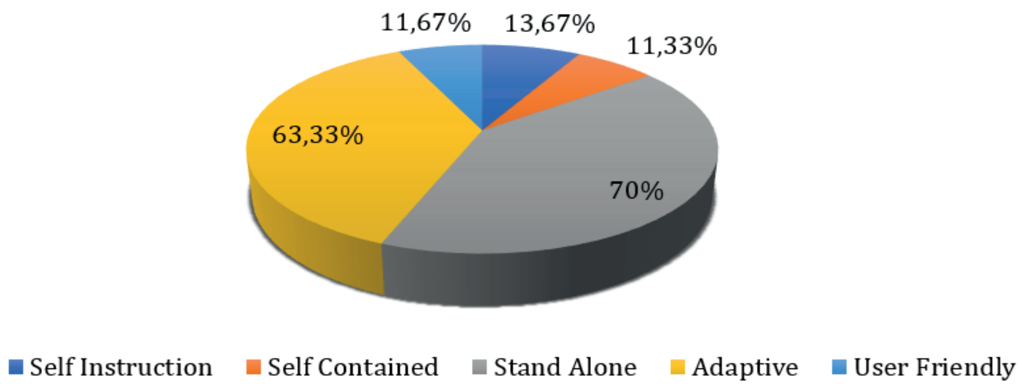

Figure 1. Science teaching materials that have been used diagrams

Figure 1 shows the distribution of teaching material quality indicators among participating students. The analysis of 6 students' responses indicated that three indicators (self-instruction, self-contained, and user-friendly) scored in the very bad category (scores ranging from 0 % - 20 %), while two indicators (stand-alone and adaptive) achieved the moderate to good category (mean scores of 61 %, 88 % respectively).

Table 3. Interview results about the teaching materials used

Aspect	Sub indicators	Answer
Self Instruction	Teaching materials are easy for students to use without the help of other parties.	"Students have difficulty using teaching materials independently, they still need to be accompanied." (First teacher source) "Students still need assistance." (Second teacher source)
	Instructions for activities in the teaching materials are clear.	"Students need assistance to follow the instructions for teaching materials." (First teacher source) "Students are usually less careful when reading the instructions, so they have to be directed." (Second teacher source)
Self Contained	Complete teaching materials according to learning objectives.	"It aligns with the learning objectives." (First teacher source) "Already consistent with the learning objectives." (Second teacher source)
	Teaching materials are linked to local culture.	"There is no connection with local culture." (First teacher source) "Lack of linking with local wisdom." (Second teacher source)
	Teaching materials contain activities that can enhance scientific literacy	"Does not yet contain learning activities that support science literacy." (First teacher source) "Not yet, maybe it can be integrated with learning models that can support scientific literacy." (Second teacher source)
Stand Alone	The use of teaching materials does not require other media/devices.	"Teaching materials do not require supporting media. However, if you want to be assisted by technology it will be more interesting." (First teacher source) "No need, but if there is an additional video it is more interesting for students." (Second teacher source)
Adaptive	Teaching materials apply technology in them.	"Not yet using technology in the use of teaching materials." (First teacher source) "Not applying technology." (Second teacher source)
	Teaching materials are flexible (can be used within a certain time period and anywhere).	"Less flexible, because of its large size." (First teacher source) "Not too big, still the usual book size. But if it's smaller, it's more flexible." (Second teacher source)
User Friendly	Instructions for using the teaching materials are provided.	"There are no indications at the beginning of use." (First teacher source) "I forget, but it doesn't seem to exist." (Second teacher source)
	There is a list of terms.	"There is a glossary on the last page." (First teacher source) "Yes, there is glossary." (Second teacher source)

The self-instruction indicator received an inferior category (score 13,67 %), indicating that current teaching materials require significant teacher assistance for student use. The self-contained indicator also scored very badly (score 11,33 %), primarily due to the absence of local cultural integration in existing materials. User-friendly aspects scored 11,67 %, reflecting difficulties students face in independently navigating teaching materials.

In contrast, the stand-alone indicator achieved a good category (70 %), suggesting that materials generally do not require additional media or devices. The adaptive indicator received a good category (63,33 %), indicating some level of flexibility in material usage, though technology integration remains limited.

Additionally, teacher interviews revealed that the teaching materials employed during instruction were primarily sourced from government-issued resources, with no independent development of teaching materials by the teachers. This dependence on external sources was particularly evident in the absence of ethnoscience-based materials, which were notably absent from current teaching practices. A summary of the teachers' responses regarding the existing teaching materials is presented in the accompanying table.

Table 3 presents detailed interview responses regarding each indicator. Teachers consistently reported that students require assistance to use teaching materials independently, with one teacher stating, "Students have difficulty using teaching materials independently; they still need to be accompanied." Regarding cultural relevance, both teachers confirmed the lack of connection between teaching materials and local culture, with responses indicating "There is no connection with local culture" and "Lack of linking with local wisdom."

Most significantly, teachers acknowledged that current materials do not contain activities that enhance scientific literacy. As noted by one teacher: "Does not yet contain learning activities that support science literacy." This finding directly correlates with the low scientific literacy scores observed among students.

Students' scientific literacy ability

The questionnaire results and interviews about students' scientific literacy in "Sekolah Penggerak" elementary school science learning, based on the science literacy indicators, are presented in table 1. Figure 2 illustrates the distribution of scientific literacy abilities among the 6 participating fourth-grade students.

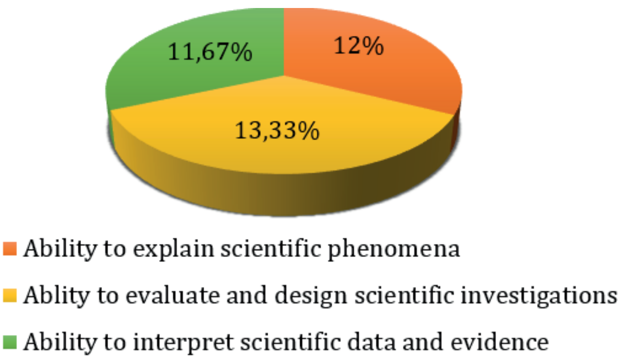

Figure 2. Students' scientific literacy ability diagram

The findings of the student questionnaires exhibit that all indicators of scientific literacy fall into the "very bad" category (scores ranging from 0 % - 20 %). The ability to explain scientific phenomena is a very bad category (score 12 %). The ability to evaluate and design scientific investigations is a very poor category (score 12 %). The ability to interpret scientific data and evidence is a very bad category (score 12 %). These scores indicate that students demonstrate minimal competency in fundamental scientific literacy skills. This finding is further supported by interviews with teachers, which highlighted challenges in identifying and addressing scientific issues. The teachers elaborated on these challenges, providing insights into the limitations of current teaching practices and resources as they expressed in the excerpts taken from the interviews below:

- *"Learners still have to be given a trigger question when asked to understand a problem during learning. Even to explain an image or video, they must still be given a trigger question."* (Second teacher source)
- *"I usually still help students to understand a picture or problem. So, I still accompany them. If they are not assisted, the identification results are usually different or deviated from the topic."* (First teacher source)

Students face significant challenges in formulating scientific questions and often require teacher assistance to do so. Interviews with teachers revealed additional insights, with teachers stating that:

- *"Still having difficulty, because they have to be accompanied and given trigger questions."* (Second teacher source)

- *"Students still have difficulties when asked to make questions. There are several factors such as some of them have not been able to make question sentences, and they still have to be given a trigger question and need to be guided when making questions. So, they are not yet able to independently make scientific questions."* (First teacher source)

Based on the interview results, it was concluded that students still experience difficulties in understanding problems, explaining images or videos, and posing scientific questions. They often require trigger questions and teacher guidance to ensure the identification results and questions they create are relevant to the topic. This finding is significant compared to the questionnaire results for the ability to explain scientific phenomena, which "very bad" category at a score 12 % (score ranging 0,20 %).

Learners' ability to evaluate and design scientific investigations is difficult for learners to master. Learners depend on teacher direction and are not trained to plan problem solving independently. Teachers are used to relying on printed books from the government and partner publishers. The dependence of students on teachers to plan problem-solving causes students to have difficulty evaluating the results of problem-solving independently. The teachers from the interviews expressed their concerns in the excerpts below:

- "Students always follow my directions to conduct the experiment and usually we evaluate the results together." (First teacher source)
- "Students still need to be guided to experiment. They are not always confident and always ask 'Is this right?' (Second teacher source)

Based on the interview results, it was concluded that students still experience difficulties in conducting and evaluating experimental results independently. Students still require guidance from teachers, lack confidence, and often ask teachers for confirmation of the accuracy of their answers. These results are significant compared to the questionnaire results for the ability to evaluate and design scientific investigations indicator, which "very bad" category at a score 13,33 % (score ranging 0-20 %). These results suggest significant challenges in planning and conducting scientific research. Students showed particular difficulty in identifying variables and formulating investigation procedures independently.

The analysis of students' ability to interpret scientific data and evidence revealed that they struggle to draw logical conclusions. However, students are able to provide simple conclusions based on their observations during experiments or problem-solving activities. Furthermore, their communication skills align with the conclusions they formulate.

- *"Students are able to draw conclusions from the findings of the experiment. However, we usually do it together."* (First teacher source)
- *"Communicating skills are usually done during group presentations."* (First teacher source)
- *"Students are capable of drawing conclusions from the experimental findings with simple sentences."* (Second teacher source)
- *"Presentations are done in groups. The way they communicate the results is done in a simple way and I usually guide them."* (Second teacher source)

Based on the interview results, it was concluded that students were able to infer from the experimental results using simple sentences, but still with teacher guidance. Then, participants were taught skills in communicating their experimental results, demonstrated through group presentation activities, but students still needed teacher guidance. These results are significant compared to the questionnaire results on the indicator of the ability to interpret scientific data and revealed evidence, which falls into the "very bad" category at a score of 11,67 % (score ranging 0-20 %).

The findings from interviews and questionnaires indicate that students' scientific literacy skills fall into the "very bad" category. This can be attributed to several factors: students' over-reliance on teachers, who must consistently provide trigger questions to facilitate learning; teachers' limited ability to prepare teaching tools that effectively integrate scientific literacy; and a general lack of self-confidence among students. These findings indicate a systematic challenge in scientific literacy development, closely linked to the limitations identified in teaching materials.

DISCUSSION

Teaching materials used in science learning

Based on the results the ethnoscience-based teaching materials used are still limited to teaching materials from the government and the partner publisher. The instructions in the teaching materials are not easily understood by students independently. The very bad scores in self-instruction capabilities indicate that current materials fail to meet the developmental needs of fourth-grade students. Self-instruction is when teaching materials can be used separately by learners without the help of others. Self-instruction should contain clear instructions for learning activities that are appropriate to the learner's developmental level. Piaget stated that class IV students are at the stage of concrete operational thinking,[29,30] so contextual teaching materials are needed. Students at the concrete operational stage are not yet able to think abstractly.

Teaching materials are not linked to the students' local content. This causes students to think abstractly. According to Piaget, that grade IV students need contextualized learning. One of the solutions that can be done is to integrate ethnoscience in teaching materials.[31,32] Ethnoscience-based teaching materials are capable to stimulate students to think contextually, because ethnoscience presents indigenous culture that is closely allied to students' everyday experiences with scientific context in a formal context.[14,33]

Ethnoscience integrated in teaching materials can increase students' desire to learn, effectively, enhancing the enjoyment of learning and making it meaningful.[15] This is because ethnoscience has the concept of turning indigenous science into scientific science.[34] In addition, integrating ethnoscience in teaching materials can enhance students' scientific literacy.[32,33] Jufrida et al[33] stated that ethnoscience can improve science literacy because learners learn science concepts through cultural or local wisdom around them. Culture is an integral part of education, because it can enhance the character of the nation.[35]

The good category (score ranging 61-80 %) in stand-alone capabilities suggests that while materials do not require additional media, they miss opportunities for technology integration that could enhance learning engagement. Standalone and adaptive are two interrelated things. A standalone teaching material that can be used independently without relying on or being combined with other media. As for adaptive, teaching materials should adapt to the technology and development of current science.[18] Integrating technology can increase students' interest in learning and make students actively involved in learning.[36]

Furthermore, flexible teaching materials can help students more easily absorb and master the knowledge provided. Flexible is usually associated with learner-centered learning. It means that learners can choose what they want (whatever), when they want to learn (whenever), where they want to learn (wherever), and how they learn. Furthermore, flexible teaching materials can be used anywhere and anytime. One way to make teaching materials more flexible is to determine a size that is not too large. An important consideration when utilizing teaching materials is the level of practice that ensures that learning can take place in any situation, any time, and anywhere.

The user-friendly limitations (score 11,67 %) reflect broader challenges in instructional design for elementary students. The absence of clear usage instructions and limited glossary provisions create additional barriers to independent learning. User friendly is a component of teaching materials that helps students easily use independently and feels comfortable for students.[18] Things that can help students easily use teaching materials independently are the existence of a glossary and clear instructions for using teaching materials.

A glossary is needed because it can help reduce the gap in students' understanding. Some students are considered teachers to have understood the term science; therefore, the existence of a glossary can help students who are not able to understand the term.[37] The clear instructions can increase students' participation in research activities and improve students' understanding of science vocabulary.[38]

Students' scientific literacy ability

The uniformly very low scientific literacy scores across all indicators (ranging from 0 to 20 %) reveal systematic challenges in science education delivery. These findings reflect deeper issues than individual student capabilities, pointing to institutional and pedagogical factors that limit scientific literacy development.

Supported by the results of interviews with teachers and questionnaire to students, there is a very bad category at a score 12 % (score ranging 0-20 %). The ability of students to explain scientific phenomena can be attributed to their dependence on teacher instructions and guidance. Students require trigger questions to help them articulate the scientific phenomena presented. Several factors influence this issue, which can be categorised into internal and external factors. Internally, the lack of motivation within students contributes significantly to this limitation. Externally, the teaching materials used often fail to provide concrete examples from the students' surroundings, creating a challenge for them to comprehend and interpret the content. This finding agrees with Sutrisna[39] a contributing factor to students' low scientific literacy is the disconnect between learning process and contextual scientific phenomena. Based on internal and external factors, low scientific literacy occurs.

According to the results of interviews and questionnaires conducted, students lack confidence in science learning to explain scientific phenomena independently, evaluate and design scientific investigations independently, and interpret scientific data and evidence independently. Students always rely on teachers and wait for their teachers' guidance. Therefore, teachers must be able to relate the concept of science to scientific phenomena in daily life during learning.

Externally, the teaching materials used by teachers during learning are only from the government and publisher partners, so the teaching materials are not linked to the local culture of the students. The teaching material must also contain the relationship between science concepts and scientific phenomena in daily life.

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Thus, teachers and teaching materials have an essential role in strengthening students' ability to explain scientific phenomena. The failure to meet all the indicators for ethnoscience-based teaching materials, as demonstrated by the interview and questionnaire results, resulted in the learning objectives not being achieved. This means that students could not easily understand the science concepts presented in the lesson. The purpose of teaching materials in science learning can help students understand science and science process skills.[40]

The indicator for design and evaluate scientific investigations is very bad category at a score 13,33 % (score ranging 0-20 %). According to interview and questionnaire results students struggle to independently prepare investigation plans and require teacher assistance to interpret evidence that has been collected. This dependency on teachers is primarily due to their limited ability to identify variables in scientific investigations. This limitation reflects the absence of problem-based learning approaches that could help students understand research variables and design investigations related to their local environment. This learning model can be in the form of discovery learning, inquiry, and problem-based learning.[39] Related to daily life problems, students can understand research variables, and make them understand how to design investigations according to scientific issues that occur around them.

The "very bad" category at a score 11,67 % (score ranging 0-20 %) was obtained in the scientific data interpretation and evidence. Students were unable to conclude the results of investigations independently and lacked confidence in communicating their findings. According to Sutrisna[39] the low ability to evidence and interpret scientific data is due to insufficient training of students to complete the analysis of problems in the form of pictures, tables, graphs, and discourses.

According to interview and questionnaire results, students' lack of self-confidence in conducting scientific data interpretation and evidence leads them to rely on teachers. Scientific data interpretation is typically displayed using pictures, tables, graphs, and discourse. This means that if students always rely on teachers, they will lack confidence in their ability to interpret scientific data and evaluate evidence. The habit of doing evaluation questions that contain scientific literacy can assess students' scientific literacy skills. This means that to improve the ability to interpret and prove scientific data, teachers must optimize science learning that includes scientific literacy activities.

Improving scientific literacy requires comprehensive changes to teaching materials and pedagogical approaches. To enhance students' scientific literacy, integrating ethnoscience and inquiry-based learning into science education is recommended. Ethnoscience-based learning enhances scientific literacy by presenting problems that are closely related to students' daily lives, encouraging discussions based on their contextual experiences, and fostering a sense of responsibility toward their cultural environment.[33]

Inquiry is the teaching approach that helps students to understand and connect concepts.[41] Inquiry-based learning contributes to improved scientific literacy by actively engaging students in planning experiments, conducting investigations, observing phenomena, analysing data, and drawing conclusions from experimental results.[32,42] Inquiry-based learning can also increase students' interest in investigating scientific issues that occur in their lives.[39]

Grounded in the results and discussions presented, the development of teaching materials based on ethnoscience is essential. Ethnoscience-based materials facilitate students' ability to interpret abstract concepts by connecting them with observable phenomena in their surroundings. These materials help bridge students' prior knowledge with scientific ideas, promoting a more profound understanding. Teachers have also expressed a preference for teaching materials that incorporate interactive learning models and methods, aligning with science learning standards such as inquiry-based learning.

Scientific literacy can be enhanced through learning designed by teachers by providing students with daily life problems implemented with discovery, problem-based learning, and inquiry.[39] In addition, Inquiry learning has been proven to be effective in improving scientific literacy because it encourages students to actively explore, think, ask questions, conduct experiments, and draw conclusions related to phenomena around them.[43] Additionally, teachers emphasised the importance of integrating technology into teaching materials, particularly visual tools, to aid in the representation of abstract concepts and enhance students' engagement. The use of technology in education increases learning independently by students, facilitating learning outside the classroom, supporting problem solving, and providing opportunities for students to seek lifelong knowledge.[44]

The relationship between teaching material limitations and scientific literacy challenges is evident in these findings. Students' difficulties across all literacy indicators directly correlate with the absence of culturally relevant, inquiry-based materials that could support independent learning and scientific thinking development. This correlation underscores the urgent need for ethnoscience-based teaching materials that integrate local culture, technology, and inquiry-based learning methodologies.

In the science education context, technology further aids in constructing inquiry-based learning experiences and promoting a more interactive and practical learning process. Several examples of the application of inquiry-based learning technology are able to improve the learning experience, namely the use of PhET Simulation in physics learning, which can improve students' conceptual understanding, because through PhET simulation,

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students will be able to explore phenomena, manipulate variables, and test hypotheses actively.[45] The use of the WeInquiry platform can improve scientific literacy because the WeInquiry platform facilitates inquiry steps during interactive learning.[46]

CONCLUSIONS

The research outcomes indicate that teachers in the "Sekolah Penggerak" program have not developed ethnoscience-based teaching materials, relying solely on textbooks provided by the government and commercial publishers. Textbooks provided by the government and commercial publishers used in science learning were found to be not entirely compliant indicator ethnoscience-based teaching material (self-instruction, self-contained, and user-friendly) scored in the very bad category (scores ranging from 0 % - 20 %), while two indicators (stand-alone and adaptive) achieved moderate to good category (mean scores of 61 % - 88 % respectively). Consequently, students' abilities in scientific literacy across all measured indicators (explaining phenomena, designing investigations, and interpreting data) are categorized as very bad, with mean scores ranging from 0 to 20 % on a 5-point scale.

This study demonstrates a direct correlation between the limitations of current teaching materials and students' poor scientific literacy performance. The absence of cultural relevance, limited self-instruction capabilities, and a lack of inquiry-based activities in existing materials contribute significantly to students' dependence on teacher guidance and their inability to engage in independent scientific thinking.

The assessment for developing ethnoscience-based teaching materials highlights their critical importance in making science learning more concrete and contextual for fourth-grade students in Indonesian elementary schools. By integrating everyday indigenous knowledge with formal scientific principles, ethnoscience-based teaching materials can foster the development of students' scientific literacy skills while honoring their cultural heritage and promoting deeper understanding of scientific concepts.

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