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Enhancing Scientific Literacy under the PISA 2025 Framework: A Comparative Study of SQ3R and Discovery Learning Models

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Abstract: Scientific literacy is a crucial skill for students to understand scientific phenomena and make informed decisions based on evidence. However, many Indonesian students still struggle with these skills, indicating unresolved issues in the classroom implementation of scientific literacy. This study aims to address this issue by examining the effectiveness of the SQ3R (Survey, Question, Read, Recite, and Review) learning model in improving junior high school students' scientific literacy skills compared to the Discovery Learning learning model. The research design was a quasi-experimental design with a control group, and a pretest and posttest were administered. This study involved 60 eight-grade students at SMPN 1 Mertoyudan. The experimental group consisted of 30 students who received instruction using the SQ3R method, while the control group consisted of 30 students who used the Discovery Learning method. Scientific literacy skills were measured using 13 questions, which were tested for validity and reliability ($\alpha=0.935$) based on the PISA 2025 science competency framework. Pretest and posttest data were analyzed using N-Gain scores and independent sample t-tests. The study showed that the SQ3R group demonstrated greater improvement in scientific literacy skills than the Discovery Learning group. The experimental group's average score jumped from 38 on the pretest to 83 on the posttest, with an N-Gain of 0.72, which is considered high. Meanwhile, the control group's score rose from 36 to 70, with an N-Gain of 0.52, which is considered moderate. An independent-samples t-test confirmed a significant difference between the two groups ($p < 0.001$). This study shows that the SQ3R learning model is superior to Discovery Learning in improving students' scientific thinking, reading comprehension, and critical evaluation of information, essential components of scientific literacy. The structured SQ3R approach encourages active student participation and a regular observation process, making it an effective strategy for improving scientific literacy at the junior high school level.

Keywords: scientific literacy, junior high school, SQ3R, science competency, reading strategy.

▪ INTRODUCTION

Indonesia needs to prepare for the Society 5.0 era. In facing the era of Society 5.0, where all aspects are technology-based, education must welcome students to develop the skills needed to work with technology (Ahmad et al., 2023). However, Indonesia has not yet entered the Industrial Revolution 4.0; in this era, education aligns with scientific literacy (Salsabilla & Liliana, 2022). Scientific literacy prioritizes thinking and acting skills that involve mastering scientific thinking to face and respond to social issues (Klemenčič et al., 2023). Scientific literacy is essentially nothing new in the world of education (DeBoer, 2019). However, scientific literacy implemented in Indonesia does not necessarily make students proficient in scientific concepts. This is evidenced by the latest TIMSS (Trends in International Mathematics and Science Study) data from Indonesia in 2015, which ranked Indonesia 44th out of 49 countries in the low participant acquisition category. This data is further supported by findings from the 2022 Programme for International Student Assessment (PISA) conducted by the OECD (Organization for

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Economic Cooperation and Development), which ranked Indonesia 67th out of 81 countries in the scientific literacy category (OECD, 2023).

A lack of scientific literacy skills was also found in a public junior high school in Magelang, particularly in the scientific competency dimension. This was evident during the learning process, where students struggled to explain phenomena scientifically, to critically evaluate data and evidence, and to evaluate and use scientific information for decision-making, all indicators of the scientific competency dimension. Science learning activities in the classroom employ several learning models tailored to the needs of the learning topic, with the majority being discovery learning. Discovery learning is a model that aims to have students learn independently through discussion and the exchange of ideas (Alfieri et al., 2011). Discovery learning, while encouraging exploration, often fails to systematically train students to evaluate evidence or interpret complex data (Minner et al., 2010). Discovery learning relies heavily on unguided exploration, which can burden students with limited prior knowledge, leading to misunderstandings and shallow engagement with scientific texts (Furtak et al., 2012). Several previous studies on the scientific literacy of junior high school students across various regions of Indonesia have yielded results that are relatively similar. Research conducted by Ridwan & Ramdhan (2020) showed that the average score of eighth-grade students' scientific literacy skills at a junior high school in Tasikmalaya City was very low, especially in the competency of assessing the use and misuse of scientific information. This finding aligns with those of Sujudi et al. (2020) at As-Shofa Islamic Junior High School in Pekanbaru City, which indicated that students' literacy skills were in the low category in the competencies of describing phenomena scientifically, recognizing problems, and utilizing scientific evidence.

Scientific literacy is based on four interconnected pillars: context, knowledge, competence, and scientific identity (Bybee, 2016). The majority of students in Indonesia master level 2 in science education, where students are proficient in everyday scientific knowledge and basic skills to identify accurate scientific explanations, analyze data, and formulate simple questions in designing experiments (OECD, 2023a). Students' scientific knowledge must be supported by adequate scientific competence, because, according to the OECD (2013), all scientific literacy competencies require knowledge (Bybee, 2011). Scientific competence is important for mastering and participating in the exchange of ideas, decision-making, and actions related to issues in science and technology, because it helps individuals think logically, analyze information objectively, and contribute to solving global problems (OECD, 2023b). These activities also require students to rely more on their brains, their ability to think, reason, and analyze (Noris & Phillips, 2003). In this regard, a new, more comprehensive learning model is needed for scientific literacy skills, one of which is the Survey, Question, Read, Recite, and Review (SQ3R) model.

The SQ3R learning model is understood as a method for analyzing texts or readings. International research on reading strategies has shown a strong relationship between a structured reading approach and the development of scientific literacy (Snow & O'Connor, 2016). SQ3R, originally designed to improve reading comprehension, has been associated with higher-order thinking and the integration of new information with prior knowledge (McNamara, 2007). However, its application in developing scientific literacy among junior high school students, especially in the context of PISA competencies, remains underexplored (Shanahan, 2019). The SQ3R model has five stages: Survey

(gathering information), Question (formulating questions), Read (reading the text and finding answers), Recite (reflecting on answers, taking notes, and discussing them together), and Review (reviewing) (Thomas & Robinson, 1972). From a theoretical perspective, SQ3R is expected to improve scientific literacy because its phases align with the three PISA competencies. The Question phase trains students to formulate investigative questions, which directly supports the competency to explain phenomena scientifically. The Read and Recite phase requires students to comprehend, evaluate, and synthesize information, thereby developing competencies to design and conduct scientific investigations and to interpret data and evidence scientifically. Finally, the Review phase strengthens metacognitive awareness, a crucial foundation for sustainable literacy. Activities in SQ3R support students' independent learning by allowing them to read the provided material, identify key issues, and express ideas related to those issues (Pressley & Afflerbach, 1995). The implementation of the SQ3R model is closely linked to metacognition, where students are actively involved in learning while the instructor serves as a motivator. With this approach, students are trained to think independently to find appropriate solutions to problems in the reading material (Azevedo & Cromley, 2004). Furthermore, the SQ3R model also provides more context for the text (Irani, 2020), a deeper interpretation of the subject matter in the reading text, thus making students more active and focused on the core material (Kolić-Vehovec et al., 2011).

Referring to the problems that have been described, the researcher intends to conduct research that focuses on the objective of analyzing the effectiveness of the SQ3R learning model in improving the scientific literacy skills of junior high school students, especially in the scientific competency dimension with the problem formulation "How effective is the SQ3R learning model in improving the scientific literacy of junior high school students?" Therefore, the researcher raised the research title "Effectiveness of the SQ3R Learning Model (Survey, Question, Read, Recite, and Review) in Improving the Scientific Literacy Skills of Junior High School Students.

▪ **METHOD**

Research Design

This study employed a quasi-experimental design with a pretest–posttest control group. The research was conducted at SMPN 1 Mertoyudan, Magelang, from February to May 2025. The PISA 2025 scientific competencies framework was chosen instead of PISA 2018 because, although still in draft form at the time of the study, it represents the future direction of international science assessment. Aligning this research with PISA 2025 ensures relevance to upcoming global standards and provides forward-looking insights.

Participants

This study involved 60 eighth-grade students selected by purposive sampling. The two classes (VIII B as the experimental class and VIII C as the control class) were chosen due to similarities in terms of teaching teachers, skill backgrounds, and average student learning outcomes, which were considered balanced based on previous mid-term exam scores (VIII B = 77.65, VIII C = 79.09). Students had not yet taken learning materials on Earth Structure and Plate Tectonics, Earthquakes, and Volcanoes. Each group consisted of 30 students. Both groups were taught by the same science teacher to minimize teacher

effects, and the researcher provided guidance and observation to ensure that the teaching model was applied with equal accuracy.

Instruments

Scientific literacy skills were measured using a test comprising 13 essay questions, developed based on the PISA 2025 science competency framework. Assessment used a 0–5 rubric. The answers were scored by two assessors (a researcher and a science teacher). This instrument was validated by five experts: two science education lecturers, two experienced science teachers, and one assessment expert. They evaluated the relevance of the content, the clarity of the language, and the alignment with PISA indicators. Aiken's V was calculated as 0.83, indicating high validity. The internal reliability test yielded a Cronbach's α of 0.935 (very high internal consistency).

Procedure

Both groups participated in three learning sessions (2 x 40 minutes each) covering Earth's Structure and Plate Tectonics, Earthquakes, and Volcanoes. The same teaching materials (textbooks, worksheets, and media) were used in both groups; the only difference was the learning model. In the experimental group, was taught using SQ3R, while in the control group was taught using the discovery learning model.

In the experimental group, during the Survey stage, the teacher asks students to read the material text in the Student Worksheet (LKPD) independently to gain an initial overview. Students then observe and note down important words, sentences, or things from the text. In the Question stage, the teacher guides students to create questions or formulate problems based on their observations, for example, "Why does the earth have different layers?" or "How does plate movement affect life on earth?" Students then formulate questions or formulate problems related to the structure of the Earth and plate tectonics. In the Read stage, students form groups of 4-5 people. In groups, students reread the entire LKPD text and seek information from other sources. Students also carefully watch a learning video about plate movement simulations. After that, students answer the questions they have created based on the information they have obtained. In the Recite stage, students create a summary based on the questions they have created and the information they have obtained. Students then convey their understanding orally in group discussions or class discussions using their own words. In the Review stage, students compare the information they obtained independently with that from texts or other sources. Next, students and teacher discuss the information obtained at each stage.

The control group (Discovery Learning) followed the discovery learning stages: Stimulation (observing diagrams and videos of earthquakes), Problem Identification, Data Collection (reading texts and analyzing figures), Data Processing, Verification, and Drawing Conclusions. To ensure fidelity, classroom implementation was monitored using an observation checklist filled out by the researcher and another observer during all sessions.

Data Analysis

Data analysis was conducted using SPSS version 30. Normality (Shapiro–Wilk) and homogeneity (Levene's test) were confirmed before the main test. An independent sample t-test compared mean scores, and normalized gain (N-Gain) was used to assess learning improvement.

▪ **RESULT AND DISSCUSSION**

The data from this study were analyzed using pretest and posttest scores from the experimental and control classes. Before treatment, the pretest scores of both classes were comparable. The average pretest score of the experimental class was 38, while the control class was 36. After the learning process, there was a quite striking improvement in both classes, but the increase was greater in the experimental class. The average posttest score in the experimental class increased to 83, while the control class reached 70. When this increase was calculated using the N-Gain value, the experimental class obtained a score of 0.72, which is in the high category. In contrast, the control class obtained a score of 0.52, which is in the medium category. These findings indicate that learning with the SQ3R model resulted in a greater increase in scientific literacy skills than Discovery Learning.

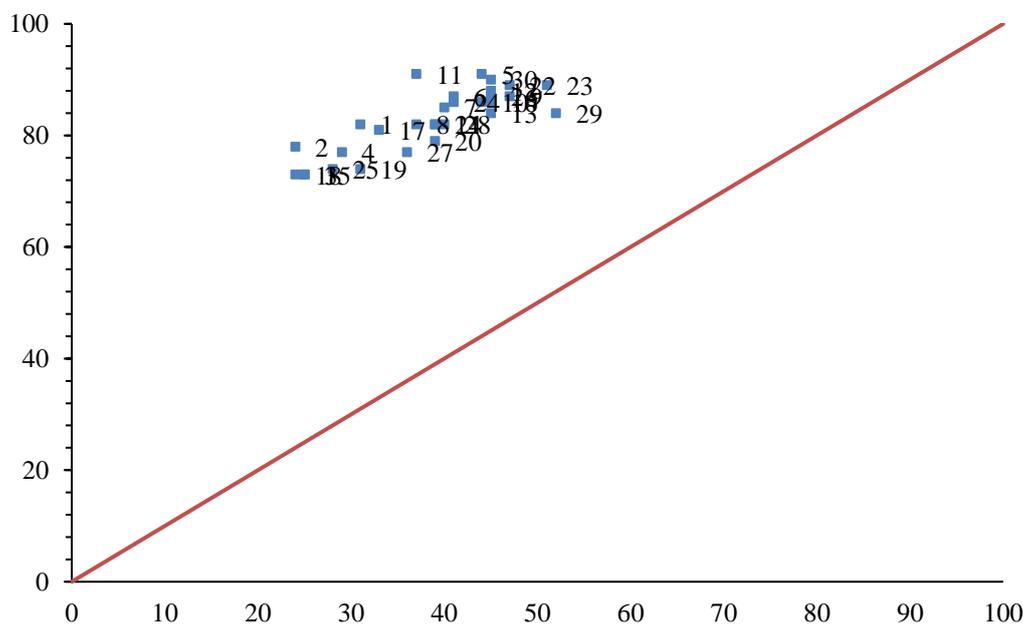


Figure 1. Scatter plot of the distribution of pretest–posttest scores of experimental class students

The figure above shows that all students increased their scores, as indicated by all points above the diagonal line $y = x$. The further a point is from the diagonal line, the greater the increase in the student's score. This pattern confirms that the SQ3R learning model consistently improves student performance. The Independent-Samples T-test was conducted using SPSS 30. The results of the Independent Sample T-test are shown in Table 2.

Table 1. T-test result

Data Tested	Sig.(2-tailed)	Alpha Value	Description
Experimental and Control Pretest	0.149	0.05	No difference
Experimental and Control Posttest	0.000	0.05	There is a difference

The results of the Independent Sample T-test revealed a difference between the average pretest and posttest scores of the experimental and control classes, with a 2-tailed significance value of <0.05 . The resulting 2-tailed p-value of 0.000 indicates a significant difference in the scientific literacy test scores between the control and experimental classes.

Based on the results of the scientific literacy skills test for grade VIII students on Earth Structure & Plate Tectonics, Earthquakes, and Volcanoes at SMPN 1 Mertoyudan, the SQ3R learning model can improve students' scientific literacy. This is evident from students' scientific literacy scores in the experimental class, which tended to be higher than in the control class. This evidence was obtained from a t-test analysis, where the Sig. (2-tailed) <0.001 , indicating a significant difference in the increase in scientific literacy between students in classes that implement the SQ3R learning model and those using the commonly used school learning model, namely Discovery Learning. As for the magnitude of the increase in scientific literacy from the N-Gain calculations, both classes show increased scientific literacy. The N-Gain value in the experimental class reached 0.72 (high), while the N-Gain value in the control class was 0.52 (moderate).

Scientific literacy emphasizes the ability to utilize scientific knowledge to identify questions, gain new insights, explain scientific phenomena, and draw conclusions based on scientific evidence (Bybee, 2016). The SQ3R model facilitates students' knowledge construction rather than simply recording information. Students reconstruct their knowledge through surveys, questioning, reading, memorization, and review (McNamara, 2007). The scientific literacy test instrument used is based on the PISA 2025 Science Framework. The scientific literacy dimension used is the scientific competency dimension, divided into three indicators: the ability to explain phenomena scientifically (as listed in questions 1-5 (5 items)); devise and evaluate designs for scientific investigations and critically interpret scientific data and evidence (as listed in questions 6-9 (4 items)); and conduct research, evaluate, and use scientific information for decision-making (as listed in questions 10-13 (4 items)).

During the learning process, the SQ3R model was implemented in the experimental class according to the existing syntax. This was evident in the student worksheets (LKPD). In the Survey phase, students were asked to read the text for 5 minutes and note important points. Student notes showed that they wrote down key points in their own language, rather than copying or summarizing the text directly. This activity helped them develop an initial understanding of the material. This aligns with Jannah (2018), who stated that implementing the SQ3R model aims to maximize students' reasoning about the text's content and maintain that understanding continuously. In the Question phase, students were asked to create three questions they wanted to know about the material being studied. However, the questions students formulated in the LKPD tended to focus on surface-level information and were general, such as "Why is the structure of the Earth important to study?" "What causes earthquakes?", and "How are volcanoes formed?" At this phase, most students had not yet conducted an in-depth analysis of the text, so their ability to formulate critical questions was still limited to identifying basic concepts.

The ability to explain phenomena scientifically is an indicator of the skill to do so, allowing students to recall relevant knowledge in specific situations and apply it to construct explanations of the phenomena being studied. Explanations in science require various forms of representation, such as reading texts, diagrams, charts, and graphs

(PISA, 2025). This index in the experimental group increased because students were essentially asked only to remember and identify a scientific phenomenon. At the same time, most school teachers generally conduct instruction that focuses on theory and memorization (Yuli & Bayram-Jacobs, 2020). Students' intelligence influences the improvement of scientific literacy skills in understanding the material and the skills learned (Bybee, 2015). One of the questions given to students in this indicator is "The movement of tectonic plates causes various natural phenomena, such as earthquakes and volcanic eruptions. Explain what causes the movement of tectonic plates!". In the Read and Recite phase of the lesson, students, divided into groups, thoroughly reread the material and are able to orally convey a summary based on the questions they formulated in the previous phase. Because at this stage students are given the freedom to seek additional sources of information beyond the main text, not only is the reading text presented, but also supporting data in the form of visuals, such as maps of tectonic plate distribution and diagrams of relationships between regions and earthquake frequencies. This deepens students' understanding and retention of the text material and data presented. The resulting summaries tend to be more exploratory and demonstrate a deeper understanding of the material. The Survey and Read phase helps students reactivate prior knowledge before encountering the text. When this initial schema is connected to new information, students more easily grasp concepts and construct more accurate explanations (Kintsch, 2013). Reading activities accompanied by diagrams, illustrations of geological processes, or plate maps also encourage the integration of various forms of representation (Ainsworth, 2006). This combination of text and visuals helps students construct more coherent, factual scientific explanations. The survey and reading process greatly supports the improvement of scientific literacy skills, especially the ability to explain phenomena scientifically, because students are trained to search for information critically and internalize concepts before expressing them orally or in writing (DeBoer, 2019).

The Devise and evaluate designs for scientific investigations and critically interpret scientific data and evidence indicator relies on the ability to distinguish questions that can be answered appropriately through scientific inquiry (PISA, 2025). This indicator showed a larger increase in the experimental class because the question, read, and recite stages of the SQ3R model help students analyze information effectively, such as by formulating questions and repeating them. This process helps students plan and evaluate scientific investigations, while supporting them in critically interpreting data, resulting in significantly improved scientific literacy skills in the scientific competency dimension (Abrahams & Millar, 2008). This process is not simply repetition; it requires them to select important information, connect text to diagrams or visual examples, and ensure their explanations remain consistent with the data. Activities like this involve retrieval practice and deeper processing, thereby fostering their ability to interpret data and scientific evidence (Karpicke & Blunt, 2011). In this indicator, students appear to be beginning to explain the relationship between variables, although some still provide descriptive answers. One question given to students in this indicator is, "Plate movement can cause volcanic eruptions. If you want to research this, create two research questions that can help understand the relationship between the two!" The formulation of the questions given by students varies, such as "How does the movement of tectonic plates affect the pressure within the earth that causes volcanoes?" and "Do certain types of plate

movements cause volcanic eruptions more often?" Some students do not answer or give irrelevant answers, such as "Because the plates are not connected properly" and "Tectonic plate movement is one of the main causes of volcanic eruptions." The ability to design and evaluate scientific investigations falls into the category of higher-order thinking skills that require complex mental processes (Zohar & Dori, 2003). Students struggle due to a lack of experience conducting real-world scientific investigations (Moeed, 2013). Science learning in Indonesia still emphasizes theory and memorization over in-depth investigative practice (Kind, 2015). In practice, students are presented with information about simple experiments on how tectonic plates move during earthquakes in the form of visual texts, and they analyze the information in depth through question, reading, and reciting activities in the SQ3R learning method. Students are allowed to ask questions and find their own answers, fostering scientific literacy, active learning, and long-term retention of the information they acquire (DeBoer, 2019). However, some students appear less enthusiastic about asking questions or recounting their reading, requiring more intensive guidance using various methods.

The indicator "research, evaluate, and use scientific information for decision-making" refers to the ability to study, evaluate, and apply scientific information to inform decision-making. One of the questions given to students in this indicator is "The government applies strict regulations on development in earthquake-prone zones to minimize the risk of damage due to earthquakes, such as the use of earthquake-resistant buildings and prohibitions on construction in vulnerable zones. These regulations involve various aspects, including the implementation of building standards, spatial planning, and public education. How can these government regulations protect the community?". In the Review phase of the learning activity, students are asked to compare the information they independently obtained with scientific information from texts or other sources, which is then discussed with the teacher. Based on the results of the Student Worksheet (LKPD), it appears that students can re-identify their prior knowledge, including the definition of tectonic plates, the number of Earth structures, and the types of plate boundaries. This prior knowledge is then supplemented with more accurate information from other scientific sources obtained by the students. This comparative process helps students identify parts of their prior knowledge that are still general or incomplete, and revise their understanding based on more valid data. The Review phase encourages students to re-evaluate their prior understanding and compare it with the scientific information they have just read. When students must check whether their prior knowledge is "still appropriate," they engage in metacognitive monitoring (Efklides, 2014). Through this process, students learn to evaluate the credibility of sources, weigh the relevance of data, and draw practical implications, skills crucial to evidence-based decision-making. This is why this indicator developed quite strongly in the experimental class. This indicator shows the most consistent development in students' argumentation because, in the application of SQ3R learning, the survey and question-and-answer process makes it easier for students to identify important information presented and to formulate critical questions relevant to scientific phenomena. At the same time, the reading and reciting stage helps students understand and analyze information in depth, as they reread the text as a whole and summarize what they have learned. The review stage strengthens students' ability to reflect on and critically evaluate the information obtained, enabling them to use scientific data appropriately in decision-making. Factors such as a systematic approach,

metacognitive awareness, information literacy skills, and transferability of skills contribute to this significant increase (Lopatovska, 2007). This aligns with McNamara's (2007) explanation that, in implementing the SQ3R model, students are helped to construct knowledge, not simply record information. During the question, recite, and review stages, students often experience limited classroom learning time. Implementing these stages requires a longer time allocation.

SQ3R learning can significantly improve students' scientific literacy skills as a learning method. The SQ3R model can be implemented by presenting students with problems to solve at the beginning of the learning process. Through this model, students are required to actively solve problems, explore information, exchange ideas, and collaborate, thereby providing a meaningful learning experience. However, teachers must pay attention to the learning material and select topics that demonstrate the contextuality of the problems and align with real-world situations. Thus, the problems students solve are everyday problems. The SQ3R model requires teachers and students to be active and innovative during learning. This means that teachers and students need to optimize their potential and efforts and play their full roles in accordance with their respective tasks in the learning process. In addition, both are challenged to be creative in designing contextual problems, finding information sources, and seeking solutions to the problems they face (Tarchi, 2010).

Research Limitations

Although this study demonstrates that the SQ3R learning model can significantly improve students' scientific literacy, several limitations should be noted. The short duration (3 meetings) may limit the development of broader inquiry skills. First, the quasi-experimental design used does not allow for full control over all external variables, unlike a pure experiment. Second, this study involved only a sample from one school, so the results cannot be generalized to the population of junior high school students in Indonesia. Third, potential teacher effects, or recency effects, may also influence the results. If the same teacher taught both groups, there is still the possibility of bias in the application of the two models. Meanwhile, if the teachers were different, differences in results could be influenced by their teaching styles, experience, or enthusiasm.

CONCLUSION

This study shows that the SQ3R learning model is more effective than the Discovery Learning model in improving junior high school students' scientific literacy. The use of SQ3R resulted in a higher normalized gain (0.72, high category) compared to the control group (0.52, medium category), demonstrating the model's superiority in fostering students' proficiency in using scientific texts.

Among the three competencies assessed, the most significant improvement was observed in researching, evaluating, and using scientific information for decision-making (N-Gain = 0.52). This finding highlights the potential of SQ3R to foster critical decision-making skills, a crucial component of scientific literacy in the 21st century.

The contribution of this study lies in demonstrating that reading-based strategies, often associated with language learning, can be successfully adapted for use in science classrooms to develop deeper reasoning and metacognition. However, implementing SQ3R also presents challenges. This model requires more classroom time than

conventional methods and requires teachers to guide in formulating meaningful questions and practicing effective summarization. To address this challenge, teachers are encouraged to gradually integrate SQ3R, starting with simpler texts and developing students' questioning and reading skills before applying it to more complex science materials.

In Indonesia, where scientific literacy outcomes consistently fall below the OECD average, this study underscores the importance of integrating metacognitive reading strategies into science learning. Thus, SQ3R can serve as a practical and impactful approach to equip students with the skills to analyze, evaluate, and apply scientific information in both academic and real-life contexts.

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