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# Developing Students' Science Literacy Skills Through Science Literacy Learning Environment

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**Abstract:** The ability of science literacy needs to be developed because it is a competency required as a 21st-century life skill. The ability of science literacy can be developed through a science literacy learning environment applied in school learning activities. The purpose of this research is to identify the dimensions that support the development of students' science literacy skills through a science literacy learning environment. This research uses the literature review method, which is a method of synthesizing, identifying, and evaluating the works or research results and thoughts produced by other researchers in a specific context. The science literacy learning environment can develop students' science literacy skills through the application of several psychosocial aspects, which consist of personal growth, relationship, and system maintenance and change aspects. In the aspect of personal growth, it consists of the dimensions of communication, representation, investigation, and cooperation. In the aspect of relationship, it consists of the dimensions of teacher support and involvement. In the aspect of system maintenance and change, it consists of the dimension of equity. The development of the science literacy learning environment dimension can have a very significant impact on students' understanding of science literacy concepts.

**Keywords:** Science Literacy; Learning Environment.

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## A. INTRODUCTION

21st-century education plays a very important role in preparing future generations to face increasingly complex global challenges. 21st-century education must be able to develop competencies such as critical thinking, creativity, collaboration, and communication. 21st-century education is key to creating competent, adaptive individuals who are ready to face a future full of challenges (Irawan et al., 2022; Zubaidah, 2019; Herianingtyas, 2022). Science literacy plays an important role in improving the quality of human life, providing benefits in various fields such as health, transportation, energy, and helping to solve problems through major discoveries like electricity and mobile phones. Science literacy education enables individuals to understand natural phenomena and develop critical thinking skills, which are essential for evaluating information in this digital era. Science literacy also gives students the ability to apply knowledge in everyday life and engage in science inquiry to tackle the challenges of the modern world (Gupta, 2020; Hallez, 2008). In an increasingly complex world, science literacy helps students develop into knowledgeable citizens capable of participating in public discussions related to science and technology issues. When students are able to understand science methods and basic science concepts, it will be easier to analyze problems and formulate logical and measurable solutions (Robbia & Fuadi, 2020).

Students' skill in science literacy prepares them to face the challenges of today's world, understand science theories and facts, think critically, solve problems, and apply science

knowledge in everyday life (Fakhriyah et al., 2017). Science literacy enables students to think critically and analytically, allowing them to analyze problems and formulate logical and measurable solutions, and to study issues such as health and climate change (Pertiwi et al., 2018).

Science literacy competencies in PISA are as follows: explaining phenomena scientifically, evaluating and designing science investigations, and interpreting data and evidence with a science approach (OECD, 2019). PISA results for science literacy show that Indonesian students' performance is relatively low compared to OECD countries and even some neighboring Southeast Asian countries. From 2006 to 2022, the trend of Indonesia's science literacy scores tended to stagnate below average, reflecting the challenges in improving the quality of science education at the school level. In PISA 2006, the average science literacy score of Indonesian students was around 393, and although it experienced a slight increase in 2015 to 403, this score is still far from the international standards expected by the OECD (Yusmar & Fadilah, 2023). The need for development to improve science literacy competence (Hardinata et al., 2019; Nugraeni & Paidi, 2021).

The learning environment greatly influences the overall educational experience and students' academic achievements. This includes various elements, such as physical, social, and cultural elements, which collectively influence how students learn. A supportive and engaging learning environment encourages collaboration, motivation, and a sense of belonging among students, which in turn leads to better academic performance (Arianti, 2017; Latief, 2023; Mariyana & Setiasih, 2018).

It is important to create a learning environment that supports equality, values cultural diversity, and involves all students in the learning process. It's not just about uniting students, but also creating meaningful and inclusive learning experiences (Zaturrahmi, 2019). Dweck (2006) states that a learning environment is one that promotes a growth mindset. Piaget (1997) mentioned that social interaction allows students to explore their peers' perspectives. An effective and supportive learning environment is one of the important factors in the development of science literacy.

Social interaction between individuals and their social environment is very important during the process of knowledge formation and cognitive development. Students who collaborate with their classmates help each other learn more effectively and efficiently (Moeed, 2015). Furthermore, a supportive learning environment is important, where students collaborate to gain significant benefits from their learning and development process. These skills are crucial for helping to interact with others when facing social and emotional (Khine et al., 2020; Hussain Malik & Abbas Rizvi, 2018).

Previous research related to methods for improving science literacy skills (Wulandari et al., 2021; Nugraeni & Paidi, 2021; Kang, 2022) . Meanwhile, research related to the CLES learning environment (Sharkey & Gash, 2020); the OSLEI instrument (Che Lah *et al*., 2022); and the WIHIC instrument (Bizimana *et al*., 2022). No research has yet been found on the development of science literacy skills through a science literacy learning environment. This is a novelty in this research.

## B. METHOD

This research uses the literature review method, which is a method of synthesizing, identifying, and evaluating works or research results and thoughts produced by other researchers in a specific context. The sources of literature used are those derived from various journal articles, both national and international.

## C. RESULTS AND DISCUSSION

### 1. Science Literacy

Science literacy encompasses three fundamental questions, namely: first, what someone knows, which requires competencies in science epistemology and science teaching materials. Second, what someone can do, which requires competencies in learning, social, procedural, and communication. Third, what someone values in relation to the values and wisdom present in their surroundings. From this pattern, it can be understood that the general aim of science literacy focuses on societal needs, namely to learn how to address social problems and make decisions based on proper investigative methods and thinking (Yuliati, 2017).

Science literacy not only involves understanding science concepts and theories but also knowledge of the procedures and practices commonly used in science investigations and how these drive the advancement of science. Therefore, someone who possesses science literacy understands the main ideas and concepts that form the basis of science and technological thinking, how that knowledge is obtained, and to what extent that knowledge is supported by evidence or theoretical explanations. For these reasons, science literacy is considered a very important skill (Sutrisna, 2021).

Science literacy develops through comprehensive learning and its application. Therefore, science literacy refers to the understanding of science and technology based on science principles. However, science and technology differ in terms of goals, processes, and outcomes. Technology aims to find the best solutions for human problems, with the possibility of more than one optimal solution. Meanwhile, science focuses on finding answers to specific questions related to natural phenomena (Khery *et al*., 2022).

In PISA, science literacy is understood as an individual's science knowledge and the application of that knowledge to identify questions, acquire new knowledge, explain science phenomena, and draw evidence-based conclusions about science-related issues. This includes an understanding of the characteristics of science as a form of human knowledge and inquiry, as well as an awareness of how science and technology influence our material, intellectual, and cultural environments. Furthermore, science literacy includes the readiness to engage with science issues and ideas as reflective citizens (OECD, 2013).

Understanding science as a practice requires a set of conceptual proofs and epistemic knowledge, which refers to the understanding of the role of certain constructions and the identification of important features in the process of science knowledge development. Epistemic knowledge includes an understanding of the functions of questions, observations, theories, hypotheses, models, and arguments in science, recognition of various types of science inquiries, and an understanding of the role of peer review in building reliable knowledge (Norambuena Melendez et al., 2023).

Science literacy consists of three main competencies, namely: 1) explaining phenomena scientifically, 2) evaluating and designing science investigations, and 3) interpreting data and evidence scientifically. All of these competencies require knowledge. Students with good science literacy will be able to show interest in science topics and ideas, as well as explain science phenomena by evaluating and designing science methods, and interpreting data and evidence scientifically. Explaining science and technological phenomena, for example, requires knowledge of the content of science or content knowledge. The second and third competencies require more than just content knowledge, namely an understanding of how science knowledge is constructed and the extent to which that knowledge can be trusted. Recognizing and identifying the characteristics of science inquiry requires knowledge of the standard procedures underlying various methods and practices used to build science knowledge, known as procedural knowledge. In addition, these three competencies also require epistemic knowledge, which is an understanding of the reasons behind science inquiry, the level of confidence in the conclusions drawn, and the meaning of basic terms such as theory, hypothesis, and data (OECD, 2019).

So, science literacy is an individual's skill to understand, apply, and analyze science information in the context of everyday life. This includes understanding basic science concepts, skills to think critically and analytically about science issues, as well as the ability to evaluate science information found in various sources.

**2. Science Literacy Learning Environment**

The learning environment is a place or atmosphere that influences the process of individual behavior change. In this case, the individuals referred to are students as the main subjects who are in that environment. Based on that explanation, it can be concluded that changes influenced by the environment are real and tend to be permanent. The greater the influence of the environment, the more significant the changes that may occur in the research subjects. This shows the extent of the environmental impact on students' learning behavior (Mariyana & Setiasih, 2018). The learning process always occurs within an environment, namely the educational environment. This environment includes several aspects, such as the physical, intellectual, and social environments (Sukmadinata, 2009).

The learning environment plays a very important role in influencing students' development and learning. The aspects present in that environment, such as the physical environment which includes facilities and classroom comfort, the intellectual environment which involves the methods of delivering material and the approaches used by the teacher, and the social environment which involves interactions between students, teachers, and classmates, all contribute to creating an atmosphere that supports the learning process. A conducive environment can motivate students to participate more actively, explore knowledge, and collaborate in groups, thereby accelerating the understanding and application of the concepts taught. Conversely, an unsupportive environment can hinder students' learning processes, reduce their interest, and slow down their intellectual and social development. Therefore, it is important to pay attention to and design learning environments that are not only physically comfortable but also stimulate positive

interactions and enrich students' learning experiences (Yandi et al., 2023; Higgins et al., 2005; Szpytma & Szpytma, 2019). So, a science literacy learning environment is a learning environment that supports science literacy learning.

In this study, the science literacy learning environment connects learning aspects with the psychosocial dimensions proposed by Moos, namely the dimensions of personal growth, relationship, and the maintenance and change system dimensions (Moos, 1974). The dimension of personal growth in the science literacy learning environment refers to the development of students' understanding and skills in science literacy to comprehend science concepts for solving problems in everyday life contexts. Student personal growth in the science literacy learning environment is carried out through the development of science literacy skills such as communication, representation, investigation, and cooperation.

The process of disseminating science information to the general public is known as science communication. This helps improve the public's understanding of science. According to S. R. Davies (2021), science communication plays many roles in social life and is considered important for modern society. This research examines the role of science communication in modern society. It is defined as an effort to convey science information in an effective and meaningful way to the public (Fischhoff, 2013). Science communication describes PISA competence in the ability to explain phenomena scientifically.

Science communication also serves as a bridge between the science world and the general public, making information that previously seemed complex or difficult to understand more accessible and comprehensible to the public. Science communication is not just about conveying science facts, but also involves understanding how that information can influence behavior, policies, and public opinion. In this context, science communication becomes an important tool for educating the public about relevant science issues, such as climate change, technology, health, and sustainability, which have the potential to affect their daily lives (Evagorou et al., 2015). The dimension of communication can develop students' science literacy skills because communication involves the skills to convey information effectively and make informed decisions based on available science knowledge.

The way a system or certain phenomenon is depicted or explained through the use of models, symbols, or responses in a science context is called science representation. This includes the interaction between the user, model or graphics, and the system or target being represented (Ruyant, 2024). Science representations are very important for helping students understand science concepts. The multi-representation method, which includes the use of various forms of representation, has proven effective in enhancing students' understanding of science processes and their ability to perform them (Rizal, 2014). Science representation illustrates PISA competencies in interpreting data and evidence scientifically.

The use of various forms of representation helps students or other users to see the relationships between existing concepts, thereby enhancing their ability to think critically and analytically in understanding science problems. Furthermore, science representations are not only used to help understand teaching materials but also to facilitate communication between researchers and the general public, where data and science findings are conveyed in an easily understandable manner. By using the multi-representation method, abstract science

concepts can be represented in various formats, allowing for deeper understanding and facilitating more effective learning (Olander et al., 2017; Sukaria, 2024).

The dimension of representation can develop students' science literacy skills because within representation lies the ability of students to play an important role in transforming complex science concepts into more easily understandable forms, whether through visualization, graphs, models, or symbols that represent science phenomena.

Conducting science investigations involves the processes of tracing, data collection, analysis, and synthesis of information to understand natural or technological phenomena. This includes processes such as formulating research questions, developing methods to investigate phenomena, and evaluating the results obtained from the investigation. Teachers can provide support in interpreting experimental results and help students connect their findings with broader theoretical concepts. In many cases, teachers also provide opportunities for students to raise questions that arise during the investigation, encouraging curiosity, and introducing students to new approaches in science research (Khine et al., 2020). Science investigations illustrate PISA competencies in evaluating and designing science inquiries.

In the investigation, students are invited to design valid experiments, collect relevant data, and analyze the obtained results in an objective and precise manner. As part of the learning process, science investigation provides students with the opportunity to understand how science theories are applied in practice and how they can identify patterns or relationships in data. Furthermore, through science investigations, students are also trained to understand that science knowledge continues to evolve, with revisions or developments of theories that can occur based on new investigative results (Mohammed & Kinyo, 2022). The dimension of investigation can develop students' science literacy skills because within investigation, there is the ability for students to develop critical thinking skills to understand and evaluate evidence systematically.

A supportive environment is very important to encourage cooperation in learning, as cooperation provides significant benefits for the learning process and student development. Through cooperation, students actively engage in problem-solving, discussions, and the application of concepts in real-life situations, which deepens their understanding of the material. Interaction with peers who have diverse backgrounds, skills, and experiences enriches discussions and teaches students to appreciate differences. In addition, cooperation helps students develop social and emotional skills, such as empathy, patience, and emotional management. Understanding the individual characteristics within a team, including the strengths, weaknesses, and contribution styles of each member, is also crucial for the success of cooperation, as each individual brings unique value to the shared task (Khine et al., 2020).

Cooperation in learning not only strengthens the understanding of science concepts but also facilitates the development of essential social skills for students. Cooperation allows students to leverage the expertise of each team member, which in turn enhances the quality of discussions and collective work outcomes (Sangkala & Doorman, 2019). The ability to cooperate in science literacy helps students develop skills in collectively solving problems, strategizing, and making decisions based on consensus. The dimension of cooperation can

develop students' science literacy skills because within cooperation, there is the ability for students to develop skills in sharing ideas, listening to different perspectives, and resolving disagreements in a constructive manner.

The next dimension of Moos, which is the relational aspect, emphasizes classroom learning activities in the form of interactions between students as individuals and other individuals, both peers and teachers as educators, in an effort to develop students' science literacy. Classroom activities can include teacher support and involvement.

The findings show that science teaching supervised by teachers has a significant impact on student achievement. The results of the study by Hanfstingl et al. (2024) indicate that science literacy and students' enjoyment of science increase with the number of specialized science teachers in schools. Lee (2023) findings support the argument that environmental issues should be incorporated into traditional science classes and that environmental educators should collaborate with other experts in developing an interdisciplinary environmental science curriculum. Teachers can enhance students' digital literacy with support, which in turn will improve their online learning capabilities (Zheng et al., 2024).

Teachers also play the role of mentors who guide students in developing critical and analytical thinking skills. The support of teachers in technology-based learning, such as online learning, can help students overcome digital challenges and optimize their potential in utilizing technology for learning (Eser & Aktan, 2021). The role of teachers is not only limited to academic instruction but also includes fostering a positive attitude towards science and developing the skills needed for students' future. The dimension of teacher support can develop students' science literacy skills because teacher support is crucial in creating effective learning experiences, especially in the context of complex science education.

Student involvement also affects not only academic achievement but also their social and emotional development. Research shows that students who are actively engaged in learning have better social skills and are able to work more effectively in groups. Furthermore, with adequate teacher support, student involvement can be enhanced through a more personal and adaptive approach to individual needs (Fraser, 2023).

The research by Klosterman & Stein (2023) shows higher scores for the dimensions of involvement, teacher support, and student cohesion. Bizimana et al. (2022) research shows that conventional teaching methods can enhance student involvement in biology learning. Research by Oo et al. (2022) shows that involvement has a significant impact on the total scale and subscales of WIHIC. Therefore, strengthening student involvement in various aspects of learning, whether through traditional or innovative methods, is an important element in creating an effective and profound learning environment. The dimension of involvement can develop students' science literacy skills because within involvement, students become more motivated, feel more valued, and connect with the subject matter as well as their classmates.

The final aspect, system maintenance and change, emphasizes the extent to which the learning environment is student-centered and provides opportunities for all students to have equal chances in learning. Activities conducted in this aspect may include providing equal

opportunities for all students to develop science literacy skills, regardless of their background, abilities, or other personal characteristics.

Equity in education plays an important role in creating an inclusive learning environment and supporting the development of all students. In addition, equity also serves as an important factor in determining the learning strategies used by students. Creating equity in the educational process is not just about providing equal opportunities, but also involves creating conditions that support each student to develop according to their potential (A. Gupta & Sharma, 2023).

As shown by the research conducted by Chang et al. (2018) on equity, almost all students in Korea believe that they participate equally in science classes; the study conducted by Cai et al. (2022) found that equity has a positive impact on students' learning outcomes. Additionally, it was found that equity is an important predictor of learning strategies (Brandisauskiene et al., 2023). The dimension of equity can develop students' science literacy skills because within equity, students feel treated fairly, they tend to be more engaged in learning, and are more motivated to achieve their academic goals.

## D. CONCLUSIONS AND SUGGESTIONS

The science literacy learning environment is a learning environment where there are psychosocial aspects that can develop students' science literacy skills. These aspects are the personal growth aspect, which involves the personal efforts of students to develop their science literacy skills; the relational aspect, which emphasizes classroom learning activities through interactions between students as individuals and other individuals, both peers and teachers as educators, in an effort to develop science literacy skills; and the system maintenance and change aspect, which emphasizes the extent to which the learning environment focuses on students and provides equal opportunities for all students to learn.

Student personal growth in the science literacy learning environment is carried out through the development of science literacy skills such as communication, representation, investigation, and cooperation. Meanwhile, in the relational aspect, classroom activities are conducted in the form of teacher support and student involvement. In the final aspect, which is the aspect of system maintenance and change, activities are conducted that can provide equal opportunities for all students to develop their science literacy skills, regardless of their background.

The development of the science literacy learning environment dimension can have a very significant impact on students' understanding of science concepts. A learning environment rich in information resources will encourage students to be more active in seeking knowledge, experimenting, and developing critical and analytical thinking skills. Thus, the development of this environmental dimension can enrich students' learning experiences, making them more meaningful and profound in understanding science. Further research can explore the long-term impact of increased science literacy on problem-solving in everyday life, as well as its influence on students' attitudes towards science and technology. Thus, further research can enrich the understanding of how learning environments can effectively develop science literacy in various educational contexts.

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