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Pathways to Early Science Literacy: Investigating the Different Role of Language and Reading Skills in Science Literacy Among Early Primary School Children

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Abstract. The purpose of this study is to examine the distinct roles of language and reading skills in science literacy among primary school students through a qualitative approach. Science literacy, defined as an understanding of scientific concepts and processes, and the capacity to apply them in everyday life, is a crucial competency for students in the modern era. This research employed a case study method, with data collection techniques comprising in-depth interviews, classroom observations and document analysis. The findings indicate that language skills play a pivotal role in assisting students in comprehending and communicating scientific concepts in an effective manner. The aforementioned skills encompass an individual's capacity to comprehend and employ scientific terminology, construct sentences with correct grammatical structures, and convey ideas in a clear and logical manner. In contrast, reading abilities are pivotal for students to obtain, comprehend and integrate information from diverse sources, including scientific texts. Well-developed reading abilities facilitate students to understand intricate scientific texts, construct arguments supported by evidence and draw inferences from available data. This research offers insights into the development of language and reading skills holistically, with the aim of improving science literacy among primary school students. It also emphasises the importance of an integrated and comprehensive teaching approach in science education.

Keywords: Language, science, literacy

I. INTRODUCTION

Literacy is a fundamental competence that must be developed in primary school learners. They are required to possess a range of basic literacy skills, including language literacy, numeracy literacy, science literacy, digital literacy, financial literacy, and civic culture literacy. The Indonesian government is pursuing the development of these literacy skills through the school literacy movement, which is situated within the context of implementing Permendikbud No. 23 of 2015 on Cultivating Budi Pekerti. The School Literacy Movement (GLS) aims to establish an educational ecosystem that familiarizes students with the culture of reading, writing, and calculating.

Literacy is defined as an individual's capacity to read and write, and to apply these abilities to manage information and knowledge effectively (KBBI). It is concerned with enhancing individuals' abilities to comprehend and evaluate information in a critical and creative manner, and to reflect upon and express their insights in writing (Suyono et al., 2017). The term "literacy" is generally associated with the capacity of individuals to process, analyze, and comprehend information through reading and writing activities (Yunianika & ., 2019). Literacy facilitates cognitive engagement for readers, ultimately fostering critical thinking and problem-solving abilities. It is anticipated that through the literacy movement, students' fundamental literacy competencies can be cultivated, particularly language and science literacy for elementary school learners.

The acquisition of proficient literacy skills in reading, writing, and science at the primary school level can facilitate students' future academic and professional pursuits. The term "literacy" is defined by the Ministry of Education and Culture (2017) as the ability to read, write, search, manage, and understand information. The development of reading and writing literacy is crucial, as reading skills serve as the foundation for the acquisition of other skills. Reading skills are fundamental abilities that are inherent to every individual. In the contemporary digital age, information is readily accessible. Effective individual literacy is expected to enable the analysis of information in a discerning manner. Furthermore, it is essential to recognize that individual literacy is not easily influenced by information that may not be entirely factual.

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Science literacy can be understood as a scientific skill, encompassing the identification, acquisition, explanation, and conclusion of scientific information and phenomena based on facts. This understanding is consistent with the definition proposed by the Ministry of Education and Culture (2017). Both basic literacy skills can be developed through the School Literacy Movement (GLS). Teachers, as facilitators of learners, must have strategies for developing literacy and science literacy of learners. Teachers can involve learners in many opportunities, which is one way that literacy can be developed (Babinski et al., 2018).

The acquisition of basic literacy skills can be facilitated by the School Literacy Movement (GLS). In order for learners to develop literacy and science literacy, educators must adopt appropriate pedagogic strategies. Teachers can involve learners in a variety of activities, which represent a potential means of developing literacy. (Babinski et al., 2018) Literacy activities have been demonstrated to maintain brain health and enhance logical and linguistic intelligence, thereby improving the ability of students to understand problems, both those related to learning at school and those encountered in everyday life.

The initial findings from observations in grades VI elementary schools indicate that teachers engage in a wide range of literacy activities. One notable example is reading books in designated reading corners, followed by retelling the content of the story in their native language. This activity aligns with the stages of the School Literacy Movement (GLS), representing a development stage. These initial observations offer a compelling opportunity for further investigation into the types of School Literacy Movement (GLS) activities carried out by teachers. The objective of this study is to describe the implementation of literacy and science literacy in elementary schools, with a particular focus on the strategies employed by other teachers to enhance their students' literacy skills.

II. METHODS

The methodology employed in this study is a qualitative approach, which involves a comprehensive review of the relevant literature in order to inform the research process. The qualitative methodology employed in this study is designed to describe or delineate the phenomenon of implementing literacy and science literacy, respectively. The research methodology employed is phenomenology. The objective of phenomenology is to identify and comprehend the distinctions in language proficiency and reading literacy associated with science literacy among students. The data generated by this research is presented in the form of a descriptive analysis of the variations in language and reading literacy skills associated with science literacy among elementary school students. The research subjects were grade VI primary school teachers. The data collection technique employed involved the utilization of literature pertinent to science, literacy, and also reading and language skills. (Sugiyono, 2019)

Figure 1. Qualitative Research Method

III. RESULTS AND DISCUSSION

Definition of literacy

The term "literacy" is derived from the Latin word "literatus," which means "to read." The term "illiteracy" is derived from the Latin word "illiteratus," which means "to lack knowledge of letters." The term "literacy" is used to describe the eradication of illiteracy. Oktaviani & Faizah (2024) Literacy as "the ability to read and write." The term "science" is derived from the Latin word "scientia," which means "knowledge." Science is the systematic study of nature. Mastery of a body of knowledge is not merely the ability to recall facts, concepts, or principles. It is also a discovery process. (Novita Oktaviani & Ulinnuha Nur Faizah, 2024)

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In accordance with this definition, the National Science Education Standards (NSES) define scientific literacy as the knowledge and comprehension of scientific principles and processes that are necessary for individuals to participate in personal decisionl affairs, and contribute to economic productivity. Scientific literacy is defined as a knowledge and understanding of scientific concepts and processes that enables an individual to make informed decisions based on their scientific knowledge, as well as to engage in matters of state, culture, and economic growth. Science literacy can be interpreted as an understanding of science and its application to the needs of society.

In accordance with PISA, science literacy can be defined as "the capacity to utilize scientific knowledge, to identify questions and to draw evidence-based conclusions in order to understand and assist in decision-making regarding the natural world and the alterations made to it through human activity." This definition elucidates that science literacy is the capacity to employ scientific knowledge, identify inquiries and draw evidence-based conclusions in order to comprehend and facilitate decisions regarding the natural world and the alterations made to it through human activity. In its current definition, science literacy is regarded as a multifaceted concept, extending beyond mere scientific knowledge to encompass a broader understanding of its characteristics. PISA assesses learners' comprehension of scientific inquiry, their awareness of how science and technology influence the material, intellectual and cultural environment, and their inclination to engage with science-related issues as reflective human beings. Science literacy is regarded as a pivotal learning objective for all 15-year-olds, irrespective of whether they intend to pursue science studies beyond this age. Scientific thinking is an essential skill for all citizens, not just for scientists. Reflecting the growing prevalence of scientific and technological questions, the inclusiveness of science literacy as a general competence for life is becoming increasingly evident.

Accordingly, the evaluation of science literacy in PISA is not merely a measurement of the comprehension of scientific knowledge; rather, it also assesses an individual's comprehension of various scientific processes and their ability to apply knowledge and scientific methods to real-world situations. These scenarios are not limited to the individual, but encompass the individual's position within society and their role as citizens of the globe.(Rojas Rojas et al., 2019)

One of the domains of the Programme for International Student Assessment (PISA) is that of science literacy. In PISA, science literacy is defined as the ability to use scientific knowledge, identify questions and draw conclusions based on evidence, with the objective of understanding the natural world and the effects that humans have on it. This definition of science literacy considers science literacy to be multifaceted and encompasses not only an understanding of scientific knowledge but also broader aspects.

In PISA 2000 and 2003, three major dimensions of science literacy were identified, namely science competence/process, science content/knowledge and science application context. In PISA 2006, these dimensions underwent further development into four dimensions in addition to the previously identified aspect of student attitudes to science (OECD, 2007).

PISA assesses the science knowledge that is pertinent to the science education curriculum in countries that participate in the assessment. Unlike many other assessments, PISA does not limit itself to general aspects of a country's national curriculum. Rather, PISA assessments are framed in broader, general life situations that extend beyond school life. The items on the PISA assessment focus on situations related to individuals, families and groups of individuals (personal), related to the community (social), and related to life across countries (global).

The PISA context encompasses the application of science in personal, social, and global settings. These include, but are not limited to, the following areas: (1) health; (2) natural resources; (3) environmental quality; (4) hazards; (5) cutting-edge developments in science and technology.(Yasa et al., 2022)

The term "science content" refers to the fundamental concepts of science that are necessary to comprehend natural phenomena and the alterations to nature that have been caused by human activities. In this context, PISA does not restrict the scope of science content to the knowledge that is typically taught in school science curricula; rather, it encompasses knowledge that has been acquired through other sources of information. The criteria for selecting science content are as follows:

1) The content is relevant to real situations.

2) It is crucial to include this knowledge in the curriculum, as it is important for students to be able to apply it in the long term.

3) Suitable for the developmental level of children aged 15 years.

In accordance with the aforementioned criteria, knowledge that is conducive to comprehending the natural world and interpreting experiences within personal, social, and global contexts is selected. This knowledge is derived from the disciplines of biology, physics, chemistry, and earth and space science.

The Programme for International Student Assessment views science education as an integral component of preparing future citizens who are equipped with the necessary competencies to navigate a society that is increasingly influenced by advances in scientific and technological fields. Consequently, science education must cultivate students' abilities to comprehend the fundamental aspects of scientific inquiry, the methodologies employed by scientists, and the inherent limitations and strengths associated with the scientific enterprise. Students must be able to appreciate how scientists collect data and propose explanations for natural phenomena, recognize the fundamental characteristics of scientific inquiry, and anticipate the types of answers that can be expected from science.

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The Role of Language Skills in Science Literacy

A fundamental aspect of science literacy involves understanding and utilizing scientific vocabulary.

Proficient language skills facilitate comprehension and utilization of specific scientific vocabulary. In the field of science, numerous technical terms and concepts necessitate a profound understanding to be applied correctly. For instance, in a lesson on ecosystems, students must grasp and utilize terms such as "habitat," "niche," "biodiversity," and "trophic interaction." The capacity to comprehend and utilize this vocabulary is crucial for enhancing conceptual understanding by mastering scientific vocabulary to better comprehend scientific texts. The ability to communicate ideas clearly is essential for explaining scientific concepts to others, both orally and in writing. A strong vocabulary is beneficial for understanding experimental instructions and answering exam questions more accurately. (Prain, 2004)

One form of this ability is the construction of sentences with correct structure. The ability to construct complex sentences is an integral component of language skills that support science literacy. Good sentence structure allows students to connect complex scientific ideas. Frequently, this necessitates explanations of several interrelated concepts, and the ability to construct complex sentences helps in conveying these ideas in a logical and coherent manner.

The construction of scientific reports with good sentence structure can assist students in the preparation of such documents, in which they must explain the methodology, findings and conclusions in detail. Correct sentence structure can help to prevent misunderstandings and ensure the conveyed information is accurate and readily comprehensible.

Strong language skills assist students in articulating their ideas in a lucid and coherent manner. This is especially crucial in the context of science literacy because it empowers learners to convey their scientific reasoning in an effective manner, both orally and in written form. Subsequently, they are able to participate in scientific discourse. Expressing ideas in a clear and concise manner enables students to contribute to class discussions, participate in scientific debates, and deliver presentations. Such an ability can enhance classroom comprehension. When students can effectively articulate their ideas, it not only facilitates understanding among their classmates but also fosters deeper comprehension of the same concepts. (Rosida Tiurma Manurung et al., 2023)

In the context of science literacy, the ability to comprehend instructions is a crucial skill. Instructions are frequently presented in various formats, such as the steps involved in an experimental procedure or the criteria for a scientific assignment or project. In order to complete these tasks according to the specified criteria, students must be able to comprehend the instructions.

Good language skills enable students to explain scientific phenomena in a logical and understandable way. This includes the description of scientific processes, where the ability to describe the steps in a scientific process, such as the water cycle or photosynthesis, requires the use of clear and accurate language.

Subsequently, the utilization of analogies and metaphors, whereby students demonstrate proficiency in language and are able to employ these devices to elucidate intricate concepts, rendering them more comprehensible. In the field of science, the capacity to articulate research outcomes in a lucid and reasoned manner is of paramount importance. This encompasses the elucidation of data, the formulation of arguments founded upon evidence, and the synthesis of findings.

The opportunity to engage in scientific discourse within the classroom setting provides an avenue for students to cultivate their critical thinking and argumentation abilities. Proficiency in language enables active involvement in these discussions by facilitating the structuring and articulation of logical, evidence-based arguments, which can then be effectively conveyed to others.

The capacity to evaluate and respond to the ideas of one's peers is contingent upon the possession of effective language skills. These skills empower students to comprehend and critique the perspectives expressed by their fellow learners, while also enabling them to provide constructive feedback. (Wright & Domke, 2019)

An increase in active engagement among students with proficient language skills has been observed, resulting in a greater propensity for active participation in classroom discussions. This, in turn, has been shown to enhance their comprehension of scientific concepts.

The Role of Reading Skills in Science Literacy

The ability to comprehend a variety of written texts, including complex scientific texts, is an essential component of scientific literacy. This understanding is crucial for students to grasp the fundamental concepts and intricate details presented in science textbooks, which often contain a wealth of information on scientific phenomena.

The ability to comprehend instructions and procedures is essential for the successful completion of scientific experiments, tasks, and projects. These instructions frequently take the form of written text, and therefore, the capacity to read effectively is crucial for students to be able to follow instructions precisely. (Handayani et al., 2018)

Students can engage with articles from scientific periodicals, which frequently present crucial information about recent discoveries and theoretical advances in the field of science. Those who are able to comprehend such articles can remain abreast of the latest advancements in their respective disciplines.

The ability to interpret information from scientific texts necessitates the capacity to analyze and evaluate the content of the text, which frequently includes the analysis of data. Students are frequently required to interpret data from tables, graphs, and

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diagrams contained in scientific texts. The development of proficient reading skills enables them to comprehend these visual representations and draw relevant conclusions.

Identifying key information, which is often dispersed throughout the text, is a crucial aspect of comprehension. The ability to recognize and connect relevant key information is a testament to the efficacy of one's reading skills. The evaluation of source credibility is a crucial aspect of the reading process, particularly when perusing scientific articles or online sources. This skill is essential for developing a critical understanding of the material under study.

The integration of knowledge from multiple sources is a skill that can be developed through good reading ability. This is an important aspect of science literacy, as it enables students to combine information from various sources. Students must integrate information from textbooks, scientific articles, and other sources to gain a comprehensive understanding of science concepts. This integration of knowledge from multiple sources is essential for developing interdisciplinary knowledge. Many science concepts are interrelated with other disciplines, such as mathematics and technology. Reading from multiple sources allows students to recognize the connections between different disciplines. (Setiyo wahyuni & Wahyuni, 2023)

Another role is that of developing deep understanding. Integration of knowledge from multiple sources helps students to develop a deeper and more comprehensive understanding of the scientific topics studied. Furthermore, students can access information from multiple sources. Reading skills enable students to access and utilize information from multiple sources.

Textbooks represent an essential source of scientific information in schools. The ability to read proficiently is crucial for students to access and comprehend the material presented in their courses of study. Students who demonstrate proficiency in reading can leverage libraries and online resources to obtain supplementary information that reinforces their understanding. Students may also read scientific magazines, online articles, and other publications that provide information on the latest developments in the field of science. This helps them to remain informed and up-to-date with new discoveries and theories.

The structure of scientific texts is often complex and the language used is often technical. The ability to read and comprehend complex texts is therefore an essential skill for students. In order to understand the structure of a scientific text, students must be able to identify the different sections, such as the introduction, methodology, results and discussion. This enables them to read and interpret the text in a systematic way.

A significant proportion of scientific texts utilise technical language that is specific to a particular field. The ability to read effectively enables students to comprehend and utilise this technical language correctly. Strong reading skills assist students in overcoming difficulties they may encounter while reading complex and challenging texts.

Constructing evidence-based arguments is a fundamental aspect of science literacy. The capacity to identify and utilize relevant evidence, a skill contingent on strong reading abilities, enables students to substantiate their arguments with tangible data. Moreover, students must be able to relate the evidence they have gathered to pertinent scientific theories and concepts. Their reading abilities facilitate comprehension of the manner in which evidence either corroborates or negates a particular theory.

This capacity is instrumental in the construction of logical arguments. Students can construct logical and coherent arguments using the evidence they have read and understood. (Choiriyah et al., 2023)

Good reading skills facilitate the formulation of inferences that are grounded in the available data and information. As in the interpretation of data, proficient readers possess the ability to draw conclusions based on data obtained from various sources. Additionally, reading proficiency enables the utilisation of information to effectively solve complex scientific problems. Subsequently, students should be able to draw conclusions supported by evidence, as a result of careful reading of scientific texts. (Cao et al., 2024)

The Role of Science Literacy for Students

Developed countries have been engaged in the long-term process of building science literacy for a considerable period of time. This process is integrated into the learning experience. The United States, for instance, has implemented a program called "Project 2061," which was designed to enhance science literacy in the United States through research. The results of this research were then used to create "American science education standards." These standards were created with the long-term goal of realizing science literacy in American education. Ultimately, the goal is to ensure that science and technology will continue to flourish in the future. The results of science research in Australia indicate that the primary objective of science education in Australia is to enhance science literacy. (Afnan et al., 2023). China has adopted a parallel strategy: implementing "science literacy" as a state program. China initiated this program five years ago with the launch of the 15-Year Plan, which aims to increase the number of science literate individuals. These individuals will contribute to the social and economic welfare of society. Thus, in developed countries, science literacy constitutes a primary objective within science education (Anonime, 2011). The evaluation of the achievement of science literacy encompasses the process of scientific inquiry, which can be defined as the mental process involved when answering a question or solving a problem, including the identification and interpretation of evidence and the explanation of conclusions drawn (OECD, 2022). PISA (2006) defined five components of the science process in assessing science literacy. The first of these is the recognition of scientific questions, which are questions that can be investigated using scientific methods, such as identifying questions that can be answered by science.

The second is the identification of evidence needed in scientific inquiry. In order to investigate a scientific question, one must first identify the evidence needed to answer the question or propose the procedures needed to obtain that evidence. The

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third is the drawing and evaluation of conclusions. This process involves the ability to relate conclusions to the evidence on which they are based or should be based. This process entails the ability to connect conclusions to the evidence on which they are based or should be based. (Ustun, 2024)

The ability to communicate valid conclusions, or to express precisely the conclusions that can be drawn from the available evidence. The term "science process" encompasses the cognitive processes involved in answering questions or solving problems within the scientific domain, including the identification and interpretation of evidence as well as the formulation and evaluation of conclusions. It entails the capacity to recognize the types of inquiries and questions that science can and cannot address, to distinguish the evidence required for scientific investigations, and to distinguish between conclusions that align with the evidence presented and those that do not. The term "science content," on the other hand, encompasses the fundamental concepts that are required to understand the natural world and the ways in which human activities have influenced the natural environment. In this context, PISA does not restrict the scope of science content to knowledge covered in the school science curriculum alone. Rather, it encompasses additional knowledge that can be obtained through alternative sources. (Hejnová, 2024)

IV. SCONCLUSIONS

Language proficiency and reading skills play a significant role in the development of science literacy. The capacity to comprehend written text, extract information, and synthesize knowledge from diverse sources is crucial for students to excel in scientific disciplines. With proficient reading skills, students can access information from textbooks, academic articles, and other resources, comprehend intricate scientific texts, construct arguments based on evidence, and infer from available data. The findings revealed a discrepancy in language and reading abilities pertaining to science literacy, with each domain making a unique contribution to the overall construct. Nevertheless, the findings indicate that reading skills play a more pivotal role than language skills in science literacy. This underscores the significance of reading as a foundation for comprehending and applying scientific concepts.

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