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Generation Z's Science Literacy in the Digital Age: Facing Challenges and Driving Innovation

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Abstract

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Science literacy is a crucial 21st-century skill that enables individuals to think critically, analytically, and creatively when addressing everyday problems and global changes. Generation Z, born between 1997 and 2012, has grown up as digital natives with intensive exposure to information technology and social media. However, their familiarity with technology does not necessarily guarantee deep scientific understanding. Many students still struggle to explain scientific phenomena logically and to apply scientific concepts in evidence-based decision-making. This literature review highlights the challenges of science literacy among Generation Z, including gaps in scientific comprehension, the influence of digital media, and variations in skill levels. Various educational innovations, such as technology-based discovery learning and the integration of augmented reality, provide significant opportunities to enhance student engagement and motivation. This article emphasizes the importance of educational strategies that align the characteristics of Generation Z with science-based technological approaches to optimize science literacy in the digital era.

1. Introduction

Scientific literacy is one of the main competencies that society must possess in the 21st century. In a global context, scientific literacy functions not only as an academic skill but also as a foundation for individuals to understand reality, think critically, and make rational, evidence-based decisions. According to the Programme for International Student Assessment (PISA) framework, scientific literacy includes the ability to explain scientific phenomena, design and evaluate scientific investigations, and interpret data or evidence scientifically. Thus, scientific literacy is an important prerequisite for a person's success in the workplace, social participation, and active involvement in global issues such as climate change, health, and digital technology (Valladares, 2021). Generation Z, or Gen Z, born between 1997 and 2012, presents both challenges and new opportunities in science education. They grew up amidst the rapid development of digital technology, making technology an integral part of their daily lives.

Their characteristics as digital natives bring a tendency to learn visually, interactively, and to multitask when accessing information. They are also more active on social media and tend to search for information through digital platforms. This condition can be leveraged to develop scientific literacy through innovative, technology-based learning methods. However, Generation Z's closeness to technology does not automatically correlate with scientific understanding. As revealed by Hernandez-de-Menendez et al. (2020), although Gen Z is fluent in using digital devices, they do not necessarily understand the scientific principles underlying the technology. This indicates a gap between technological skills and scientific

literacy abilities. Many students still have difficulty explaining scientific phenomena in depth and relating them to real life. Dewi et al. (2021) found that the scientific literacy scores of high school students in Singkawang were only around 40% in the dimensions of context, knowledge, and competence.

This problem is exacerbated by the 2018 PISA results which placed Indonesia 71st out of 79 countries in science ability. This shows the need for fundamental improvements in science learning in schools, both in terms of curriculum, teaching methods, and the use of technology. Teaching that is still dominated by conventional methods tends to make students passive, so that critical thinking, problem-solving, and scientific decision-making skills do not develop optimally. A number of efforts have been made to increase scientific literacy. For example, the development of a scientific literacy-based test instrument has been proven to be valid and reliable in measuring students' skills (Istyadji, 2023). A reading literacy program based on collaboration between teachers and parents also showed success in increasing learning motivation. On the other hand, literacy communities such as *Gubuk Literasi* have also emerged, which seek to develop a reading culture in society.

Innovation in digital technology-based learning also shows promising results. The use of discovery learning combined with digital applications can increase understanding of scientific concepts, encourage student activeness, and foster learning motivation (Lestari et al., 2023). Furthermore, technologies such as augmented reality (AR) are able to provide immersive, interactive, and contextual learning experiences, making it easier for students to understand abstract scientific concepts (Al-Ansi et al., 2023). Based on this background, it is important to examine

the scientific literacy of Generation Z by considering their characteristics as digital natives, the challenges they face, and the opportunities for innovation available. This article presents a literature review of the relationship between scientific literacy and Generation Z, focusing on challenges, opportunities, and strategies that can be implemented to optimize science education in the digital era.

2. Literature Review

Scientific literacy is a multidimensional concept that has been widely studied by global and national researchers. According to the OECD, scientific literacy not only includes mastery of scientific facts but also the skill of using scientific knowledge to make decisions. Therefore, scientific literacy indicators are often associated with the ability to think critically, solve problems, and actively participate in global issues. In the Indonesian context, various studies show low student scientific literacy. The 2018 PISA results confirmed that Indonesia lags behind other countries in the aspect of scientific literacy. Dewi et al. (2021) added that students still have difficulty connecting scientific concepts with the context of daily life. This indicates the need for more innovative and relevant learning approaches that match student characteristics.

Generation Z as digital natives are often assumed to have high technological skills. However, the literature shows that their understanding of science is not in line with their digital proficiency. Hernandez-de-Menendez et al. (2020) emphasizes that this generation is often more comfortable using technology, but does not delve into the underlying scientific principles. That although Gen Z has a positive attitude

towards technology, they still need guidance in integrating technology into science learning.

Several innovative strategies have been offered in the literature to overcome this gap. Technology-based discovery learning has been shown to improve scientific literacy skills through active exploration (Lestari et al., 2023). In addition, the use of augmented reality in science learning is able to create an interactive and immersive learning experience, deepening students' understanding of abstract scientific phenomena (Al-Ansi et al., 2023). Nevertheless, research also warns of the limitations in the use of technology. Chan (2023) expressed the concerns of the teaching generation about over-reliance on technology, both from a pedagogical and ethical perspective. Therefore, the integration of technology must be done in a balanced way, combining traditional methods with digital innovation.

Apart from pedagogical aspects, scientific literacy also needs to be understood in relation to the social context. A study by Hornsey and Fielding (2020) shows that an accurate understanding of climate change has a greater effect on behavioral intentions than mere general awareness. This confirms the importance of linking science education to global and local issues to make it more relevant to students' lives. The literature indicates that the scientific literacy of Generation Z faces complex challenges. However, great opportunities also exist through the integration of digital technology and innovative learning methods. Further study is needed to bridge the gap between digital skills and scientific understanding, especially in a diverse socio-cultural context.

3. Methods

This research uses a literature review method as the main approach to study scientific literacy in generation Z and the integration of digital technology in science learning. The literature study method was chosen because it allows researchers to collect, analyze, and synthesize findings from various relevant research sources, including scientific articles, education journals, research reports, academic books, and official publications related to educational technology and the characteristics of generation Z. Through this approach, the research not only focuses on primary data but also critically examines previous findings to obtain a comprehensive understanding of the concept of scientific literacy, challenges, learning strategies, and the relationship between digital native characteristics and science learning abilities.

The process of collecting literature data was carried out in several systematic stages. First, researchers identified relevant literature sources through the Goggle Scholar academic database. The keywords used included a combination of terms such as "science literacy," "digital native," "Generation Z," "Discovery Learning," "digital learning," and "science education." The second stage was the selection of literature with strict inclusion criteria, namely publications that had been published, were relevant to the context of science education, and contained discussions about digital technology and the characteristics of generation Z. Literature that did not meet these criteria, or was opinion-based without an empirical basis, was excluded from the analysis. The next stage was the analysis and synthesis of the literature. Researchers read each source in depth, noting important findings, emerging patterns, and research gaps related to scientific literacy and the use of digital technology.

The results of the analysis were then categorized based on the main themes, including: 1) the role of digital technology in increasing scientific literacy, the Discovery Learning approach based on technology, the characteristics of generation Z as digital natives, and challenges and strategies for implementing digital-based science learning. With this method, the research was able to present a holistic and integrated understanding of the relationship between scientific literacy, digital technology, and the characteristics of Generation Z students. Through this literature review method, the research not only identifies best practices and learning innovations but also reveals gaps, limitations, and opportunities for developing scientific literacy in the digital era. Thus, the findings of this literature-based research become the basis for compiling strategic recommendations related to the integration of technology in science education and the development of Gen Z competencies in a critical, creative, and responsible manner.

4. Results and Discussion

4.1 Digital Technology Integration in Science Learning

The results of the literature review consistently show that the integration of digital technology in science learning has a significant impact on increasing students' scientific literacy, especially for generation Z who are known as digital natives. This generation grew up with the rapid progress of digital technology and the internet, so they have the skills and comfort in using various technological devices (Ashour, 2020). Previous studies have emphasized that Gen Z is more responsive to technology-based learning media compared to traditional learning methods which

tend to be conventional and limited to lecture methods or textbooks. By utilizing digital devices such as interactive videos, application-based simulations, online learning portals, and various other interactive media, students have the opportunity to actively explore scientific concepts, observe phenomena that are difficult to do in a physical laboratory, and carry out virtual experiments that are close to real conditions. This approach allows students to not only understand theory but also to relate it to practice and more real learning experiences, thereby deepening their understanding of science as a whole.

The application of the Discovery Learning approach combined with digital technology has been proven to encourage students to develop critical, analytical, and creative thinking skills (Chusni et al., 2021). In this process, students are trained to formulate questions, collect information, analyze data, formulate hypotheses, and test theories independently through digital exploration and experiments. The literature also shows that students' learning motivation increases significantly when they can access learning content interactively and participatively. With a more active learning experience, students tend to play a greater role in the learning process, not just as passive recipients of information. In addition, problem-solving and evidence-based decision-making skills also develop, because students are accustomed to connecting scientific theory with real practice through the digital media they use. Thus, science learning does not only stop at understanding concepts but also trains students to be able to think critically in facing challenges and making logical and scientifically based decisions.

Even so, the literature also highlights a number of challenges that need to be considered in the application of digital technology in science learning. One of the main challenges is the technology access gap, where not all students have the same opportunities or facilities to use digital devices optimally. In addition, students' digital literacy levels also vary, so their ability to utilize interactive learning media is not always even (Purnama et al., 2021). This shows the need for assistance and guidance from teachers so that the use of digital technology does not just become entertainment or passive consumption, but truly fosters a deep scientific understanding. Teachers act as facilitators who guide students in exploring content, connecting digital experiences with scientific concepts, and helping them develop critical thinking and problem-solving skills.

The literature review confirms that the integration of digital technology in science learning has enormous potential to reduce the gap between the skills of using technology and scientific understanding. This approach allows students to become individuals who are able to think critically, creatively, and analytically, and are responsible for the environment and society. With the right learning strategies, digital technology not only increases students' scientific literacy but also equips them with relevant 21st-century skills, making the learning experience more interesting, effective, and applicable in daily life and preparing them to face global challenges more maturely and rationally.

4.2 Gen Z Characteristics and Science Literacy Challenges

A more in-depth literature review highlights the close relationship between the characteristics of Generation Z and the scientific literacy challenges they face in

the current digital era. Based on the analysis of a number of scientific articles, educational journals, and previous research publications, it was found that although Generation Z is very technologically savvy and tends to actively use social media to obtain information, this does not automatically guarantee their ability to understand scientific concepts in depth. Generation Z grew up amidst the rapid development of digital technology and almost unlimited internet access, so they are accustomed to relying on fast information available online (Szymkowiak et al., 2021). However, the literature shows that this tendency often makes them focus more on the quantity of information than on the quality or scientific validity. As a result, their ability to critically evaluate data, distinguish facts from disinformation, and apply scientific concepts in a real context still requires further development.

In the literature review, a number of studies emphasize the importance of designing learning approaches that strategically utilize digital technology. Learning that only relies on digital information access without proper pedagogical guidance can lead to a shallow understanding of concepts. Therefore, the literature emphasizes that digital technology should be used as a means to improve students' analytical, critical, and creative thinking skills, not just as a tool for entertainment or passive information consumption. For example, the use of interactive simulations, virtual laboratories, or digital experiments can help students understand scientific principles through direct experience, so that the concepts learned are not only theoretical but also applicable (Asare et al., 2023). These virtual simulations and experiments allow students to explore scientific phenomena in depth, perform experiments repeatedly,

and gain a more solid conceptual understanding through practice that is close to real conditions.

In addition, the literature also emphasizes the important role of teachers as facilitators in the learning process. Teachers do not only function as conveyers of material but also guide students in the exploration process, helping them connect digital experiences with scientific concepts, and encouraging the application of scientific literacy in daily life (Engeness, 2020). Previous studies show that teacher guidance is very important so that students not only understand digital content but are also able to develop metacognitive skills, critical thinking, and problem-solving abilities. Teachers can provide direction, feedback, and stimulate discussions that facilitate students to evaluate information more deeply and rationally.

Another challenge that arises, as identified in the literature review, is the variation in the level of scientific literacy among students. Some students have a strong understanding, while others still have difficulty understanding scientific phenomena in depth. This condition requires a differentiation strategy in learning, so that each student gets adequate opportunities to develop their scientific literacy skills according to their level of competence and learning style. By combining the Discovery Learning approach and digital technology, the literature shows that students not only gain conceptual knowledge but are also able to develop metacognitive thinking skills, problem solving, and critical awareness of the information they receive.

The relationship between the characteristics of generation Z as digital natives and technology-based learning approaches confirms that great potential can be

utilized optimally if learning strategies are designed carefully. The younger generation can face global challenges better, make evidence-based decisions, and play an active role as critical, creative, and responsible citizens. The literature review shows that a deep understanding of Gen Z characteristics, combined with the effective use of technology, can be a foundation for a significant increase in scientific literacy, so that this generation is ready to face the complexities of the modern world in a rational, adaptive, and constructive manner.

5. Conclusion

Based on the literature review, scientific literacy is an essential competency for the 21st-century generation, especially for Gen Z who are digital natives. Scientific literacy not only includes mastery of scientific concepts but also the ability to think critically, creatively, analytically, as well as the ability to solve problems and make evidence-based decisions. Although Gen Z has a closeness to technology, this does not automatically guarantee a deep scientific understanding. The gap between the skills of using digital devices and understanding scientific principles is the main challenge in science education. The literature review shows that the integration of digital technology in science learning, especially through the Discovery Learning approach, can be an effective solution. By utilizing interactive digital media, simulations, and learning portals, students can actively discover concepts, perform virtual experiments, and connect scientific theory with real practice.

This approach not only increases conceptual understanding but also motivation, activeness, and critical thinking skills. The role of the teacher as a

facilitator remains crucial in guiding students to connect digital knowledge with scientific principles and develop metacognitive skills. The results of this study confirm that a learning strategy that is in line with the characteristics of Gen Z can minimize the scientific literacy gap, strengthen analytical skills, and prepare the younger generation to face global challenges responsibly. Thus, the integration of digital technology and active learning methods is key to building strong, relevant, and applicable scientific literacy to support personal development and positive contributions to society and the environment.

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