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Digital-Based Science Learning Innovation in Improving Generation Z Science Literacy

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ABSTRAK

Penelitian ini bertujuan untuk mendeskripsikan bentuk inovasi pembelajaran IPA berbasis digital serta menganalisis perannya dalam meningkatkan literasi sains generasi Z. Metode penelitian yang digunakan adalah kualitatif deskriptif dengan teknik pengumpulan data melalui wawancara mendalam, observasi, dan dokumentasi. Informan penelitian terdiri dari guru IPA, siswa generasi Z, dan kepala sekolah yang dipilih secara purposive. Hasil penelitian menunjukkan bahwa inovasi pembelajaran IPA berbasis digital diwujudkan melalui penggunaan platform e-learning, simulasi virtual, video interaktif, dan project-based learning digital. Penerapan pembelajaran ini mampu meningkatkan literasi sains siswa, khususnya dalam hal pemahaman konsep, keterampilan berpikir kritis, pemecahan masalah, serta literasi informasi. Faktor pendukung keberhasilan mencakup infrastruktur digital yang memadai, kesiapan guru, dan keterlibatan aktif siswa, sedangkan hambatan meliputi keterbatasan fasilitas, kesenjangan kompetensi guru dalam teknologi, dan potensi distraksi siswa saat menggunakan gadget. Penelitian ini menegaskan bahwa inovasi pembelajaran IPA berbasis digital memiliki kontribusi signifikan dalam memperkuat literasi sains generasi Z di era digital.
Kata Kunci: inovasi pembelajaran, IPA berbasis digital, literasi sains, generasi Z

ABSTRACT

This research aims to describe the form of digital-based science learning innovation and analyze its role in improving Generation Z's science literacy. The research method used is descriptive qualitative with data collection techniques through in-depth interviews, observation, and documentation. The research informants consisted of science teachers, generation Z students, and school principals who were purposively selected. The results showed that digital-based science learning innovation was realized through the use of e-learning platforms, virtual simulations, interactive videos, and digital project-based learning. The implementation of this learning is able to improve students' science literacy, especially in terms of concept understanding, critical thinking skills, problem solving, and information literacy. Supporting factors for success include adequate digital infrastructure, teacher readiness, and active student involvement, while barriers include limited facilities, gaps in teacher competence in technology, and potential student distraction when using gadgets. This research confirms that digital-based science learning innovation has a significant contribution in strengthening Generation Z's science literacy in the digital era.
Keywords: *learning innovation, digital science, science literacy, generation Z*

INTRODUCTION

The development of digital technology has brought significant changes to the learning styles of Generation Z, who grew up in a fast-paced, information-rich, and connected environment. This generation tends to prefer visual, interactive, and device-based learning because it is considered more practical, engaging, and in line with their

habits of accessing knowledge through the internet, social media, and digital learning apps (Kustini & Wicaksono, 2025).

This encourages a paradigm shift in education, where conventional methods that only focus on lectures need to be transformed into more innovative learning, utilizing multimedia, simulations, and digital platforms to suit the learning characteristics of Generation Z who are active, collaborative, and accustomed to moving quickly from one source of information to another.

Scientific literacy is one of the important competencies of the 21st century that is needed to face global challenges, such as technological developments, social change, and increasingly complex environmental issues (Rakhmah, 2020). However, the level of scientific literacy of students in Indonesia is still relatively low, as reflected in the results of international studies such as PISA, where students' abilities to understand scientific concepts, apply knowledge in everyday life, and think critically about scientific issues are still below the average of other countries.

This condition shows the need for strategic efforts in the world of education, especially through learning innovations that are able to improve conceptual understanding, critical thinking skills, and students' problem-solving abilities in the context of science (Zahro et al., 2019).

Conventional science learning is often considered boring because it tends to be teacher-centered, emphasizes memorization of concepts, and provides minimal space for students to experiment and think critically (Dumaini et al., 2019). This method is also still limited in utilizing the potential of digital media, which can actually enrich the learning process through visualization of abstract concepts, interactive simulations, and data-driven exploration.

As a result, students' interest and motivation in science often declines, even though by utilizing digital technology, learning can be made more contextual, interesting, and relevant to students' daily lives, especially for generation Z who are accustomed to digital interactions (Hartati et al., 2025).

Digital-based learning innovations, such as the use of virtual simulations, e-learning, interactive videos, and science applications, have great potential in improving the quality of science learning (Rahmawati et al., 2024). Utilizing this technology not only captures students' attention and fosters learning motivation, but also helps them understand abstract concepts more concretely through visualizations and interactive learning experiences.

Furthermore, digital learning can foster critical thinking, collaboration, and problem-solving skills, thus directly contributing to strengthening students' scientific literacy. With a more flexible and adaptive approach, this innovation also allows students to learn at their own pace and style, resulting in more optimal learning outcomes (Aini, 2024).

Research is needed to explore in depth how digital-based science learning innovations can be implemented effectively to improve the science literacy of Generation Z (Budianti et al., 2024). This research is important because Generation Z has different learning characteristics than previous generations, namely being more familiar with technology, preferring visual interactions, and tending to actively seek information through digital platforms. Therefore, scientific studies are needed to understand the extent to which the use of digital media such as virtual simulations, interactive videos, e-learning, and science applications can truly improve students' motivation, conceptual understanding, and critical thinking skills. The research results are expected to provide practical recommendations for teachers, schools, and

policymakers in designing science learning strategies that are more relevant to the needs and challenges of the 21st century (Nursaya'bani et al., 2025).

The research gap lies in the limitations of previous studies that generally only focus on the effectiveness of using certain media, such as e-learning, applications, or interactive videos, without a comprehensive look at how digital learning innovations in science affect the scientific literacy of generation Z. In addition, previous studies have focused more on cognitive learning outcomes alone, while aspects of scientific literacy that include critical thinking skills, problem solving, and the application of science in real life are still rarely explored. On the other hand, studies on the typical characteristics of generation Z in the context of digital-based science learning are also still limited, so research is needed that can address this gap.

The novelty of this research lies in the integration of a digital innovation approach with science learning, aimed at improving science literacy, not just academic achievement. This research also focuses on Generation Z, considering their characteristics as digital natives who are familiar with technology and have a learning style based on digital interactions. Furthermore, this study offers an in-depth qualitative perspective on the experiences of teachers and students in implementing digital-based science learning, thus providing a more comprehensive understanding of the effectiveness of this learning innovation in real-world contexts.

The purpose of this study is to describe the forms of digital-based science learning innovations applied in the learning process, analyze the role of these innovations in improving the science literacy of Generation Z, and identify supporting and inhibiting factors in their implementation. Furthermore, this study also aims to provide recommendations for digital-based science learning models that are relevant and adaptive to the needs of Generation Z, thereby supporting the improvement of science literacy in the digital era.

METHOD

This research method uses a descriptive qualitative approach that aims to understand in depth the process of implementing digital-based science learning innovations and their impact on the science literacy of generation Z. The research was conducted in secondary schools (SMP/SMA) that have integrated digital technology in science learning with locations selected purposively according to research needs (Syamsuni Hr et al., 2024). The research subjects included science teachers who implement digital-based learning, Generation Z students (grades VIII–XI), and principals or educational staff as data sources, with approximately 8–12 primary informants (teachers and students) and 2–3 additional informants (principals/educational staff). Informants were selected using purposive sampling based on certain criteria, such as active use of digital media in learning and involvement in scientific literacy (Sudarsih, 2025).

Data collection techniques include in-depth interviews to explore teacher and student experiences, participatory observation in learning activities, and documentation in the form of digital modules, learning platforms, student work, and activity notes (Sri Hanipah, 2023). The research instruments used included interview guidelines, observation sheets, and field notes. Data analysis was conducted using the Miles & Huberman model through the stages of data reduction, data presentation, and conclusion drawing/verification. Data validity was tested using source triangulation (teachers, students, documents), technical triangulation (interviews, observations, documentation), and member checking to validate the interview results. In terms of research ethics, the researcher maintained the confidentiality of informants' identities,

requested permission from the school and participants, and respected the principle of informed consent.

RESULTS AND DISCUSSION

The results of the study show that the form of digital-based science learning innovation is realized through the use of various e-learning platforms such as Google Classroom, Moodle, and Edmodo for material distribution, the use of interactive media such as PhET simulations, experimental videos, and 3D animations, and the integration of smartphone-based science learning applications that make it easier for students to learn independently (Sarwa et al., 2021) In addition, teachers also implement a digital project-based learning model by involving students in content creation, such as digital posters, experimental videos, or interactive presentations. This innovation can improve the scientific literacy of Generation Z, where students more easily understand abstract concepts through digital simulations, develop critical thinking and problem-solving skills in virtual experiment-based tasks, and strengthen information literacy through the ability to search, evaluate, and process scientific information from various digital sources. The implementation of this digital learning also fosters students' interest in learning science because it is more in line with the characteristics of Generation Z who are visual, fast, and collaborative.

Supporting factors for the implementation of this learning innovation include digital infrastructure support in the form of Wi-Fi, computer labs, and student smartphone ownership, teacher readiness in mastering learning technology, and the active involvement of Generation Z students who are accustomed to using digital media. However, the study also found several inhibiting factors, such as the uneven distribution of digital facilities in schools, gaps in teacher skills in utilizing digital media, and the potential for student distraction when using gadgets, for example due to access to social media and online games that can reduce focus on learning.

Relevance to Generation Z: Digital-based learning innovations

Digital-based learning innovations have proven to be in line with the characteristics of Generation Z, who tend to adapt quickly to technological developments, are accustomed to using gadgets, and enjoy learning through visual and interactive media (Roza et al., 2022). The application of various digital media, such as virtual simulations, experimental videos, learning applications, and e-learning platforms, not only makes the learning process more engaging but also encourages active student participation in learning activities.

Students can more easily understand abstract concepts through visualization, collaborate on digital projects, and develop critical thinking and problem-solving skills in real-world contexts (Mutia, 2025). Thus, digital-based learning not only adapts to Generation Z's learning styles but also significantly increases their motivation, engagement, and learning outcomes.

Scientific Literacy Increases

Research findings show that the use of digital media in learning not only plays an important role in helping students understand abstract science concepts, but also contributes significantly to improving science literacy skills (Taroreh, 2024). Through interactive media such as virtual simulations, animations, and learning applications, students are encouraged to think more critically in analyzing scientific phenomena, be analytical in evaluating information obtained from various digital sources, and be able to apply scientific knowledge to everyday life contexts. Thus, digital-based learning has

proven effective not only as a means of knowledge transfer but also as a medium for developing essential scientific competencies in the 21st century.

Relation to Previous Research

The results of this study are in line with the findings of previous studies which show that the use of digital technology can improve student learning outcomes, especially in understanding material and increasing learning motivation (Rahman et al., 2024). However, this study makes an additional contribution by highlighting aspects of scientific literacy more comprehensively, encompassing critical thinking and analytical skills, as well as the application of scientific concepts in real life. Thus, this study not only strengthens the evidence for the effectiveness of digital technology in education but also broadens understanding of the role of digital innovation in shaping scientific competencies relevant to the needs of the 21st century (Dianto et al., 2025).

Implementation Constraints

Barriers related to infrastructure and teacher readiness are crucial considerations in implementing digital-based science learning. Limited facilities such as internet access, computer labs, or uneven distribution of digital devices can limit the effectiveness of learning innovations, while variations in teacher technology skills impact the quality of material delivery and student learning experiences (Prasetyo & Rosita, 2025). These findings demonstrate the need for ongoing training for educators to become more competent in utilizing digital media, as well as efforts to ensure equitable access to technology across schools to ensure all students have equal opportunities to participate in effective and meaningful digital learning.

The implications of the findings of this study indicate that digital learning innovations in science have the potential to be used as a learning model that can be applied in other schools to improve students' scientific literacy (Saputra & Noor, 2025). However, the successful implementation of this model depends heavily on the availability of adequate technological support, a curriculum that adapts to the use of digital media, and the active role of teachers in designing, facilitating, and guiding the learning process. By fulfilling these three factors, digital-based learning will not only improve understanding of science concepts but also develop critical, analytical, and applicable science literacy skills for Generation Z.

CONCLUSION

Digital-based science learning innovations have been successfully implemented through the use of e-learning platforms, virtual simulations, interactive videos, and digital project-based learning, which have been proven to improve Generation Z's science literacy, including conceptual understanding, critical thinking skills, problem-solving, and information literacy. Generation Z responded positively to digital-based learning because it aligns with their technologically inclined, visual, interactive, and collaborative nature. The success of this innovation is supported by factors such as the availability of digital infrastructure, teacher readiness, and active student involvement, but still faces obstacles such as limited digital facilities, varying teacher abilities in mastering technology, and potential student distractions when using gadgets. Overall, digital-based science learning innovations have great potential as a learning model that can be improved and replicated in other schools to strengthen science literacy in the digital era.

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