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Research Article

The Role of Generative AI in Supporting Science and Numeracy Literacy Among Elementary School Students

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Abstract
The development of Generative Artificial Intelligence (GenAI) in primary education opens up new opportunities in improving the quality of learning, especially in the aspects of science literacy and numeracy of elementary school students which are still challenges in 21st century education. This study aims to analyze the role of GenAI in supporting science literacy and numeracy of elementary school students based on a literature review. The research method used is a non-systematic literature review with a thematic analysis approach to various scientific studies relevant to GenAI, science literacy, and numeracy literacy. The results of the study show that GenAI plays an important role in improving understanding of science concepts through visualization, simulation, and contextual explanation, as well as supporting numeracy literacy through adaptive exercises, context-based questions, and instant feedback according to students' abilities. In addition, GenAI also contributes to creating more personalized and interactive learning. However, its implementation still faces challenges such as the risk of misinformation (hallucination), algorithm bias, limited access to technology, and teachers' readiness to integrate technology. In conclusion, GenAI has great potential in supporting the improvement of science literacy and numeracy of elementary school students, but its success is highly dependent on teacher roles, learning design, and appropriate educational policies. Unlike prior studies, which largely address GenAI in higher education or general digital learning contexts, this review contributes novelty by specifically connecting GenAI to science literacy and numeracy simultaneously within the elementary school context, an area that remains limited in the existing literature.

Keywords: Elementary School, Generative AI, Literature Review, Numeracy, Science Literacy

1. Introduction

The development of Generative Artificial Intelligence (GenAI) has brought major changes in the world of education, including in elementary schools. GenAI is a technology capable of generating text, images, and other content based on data learned through large models such as Large Language Models (LLMs) (Hadi et al., 2023; Raiaan et al., 2023). In education, GenAI can help learning to be more personalized, adaptive, and interactive (Kang & Ahn, 2025; Rashid et al., 2024). This is important because science literacy and numeracy in elementary schools are the basis for students' thinking skills. However, the use of GenAI still needs to be studied more deeply because it has a positive impact and risks that need to be understood.

Technologically, GenAI evolved from a transformer architecture capable of processing language in a complex way through self-attention mechanisms (Chen et al., 2025; Hadi et al., 2023). This development has given birth to increasingly sophisticated AI models, including multimodal models that can process text and visuals (Raiaan et al., 2023; Rashid et al., 2024). This technology has great potential for elementary school learning because students still need concrete media. However, the literature also

shows that there are risks such as misinformation or hallucinations (Tang et al., 2023; Testolin, 2024). Therefore, an understanding of this technology is essential before it is applied in learning.

Science and numeracy literacy are basic skills that are important in education. Science literacy includes not only mastery of concepts, but also the ability to interpret scientific phenomena, use evidence, and apply knowledge in daily life. Meanwhile, numeracy literacy includes the ability to use number concepts, mathematical reasoning, and contextual problem solving as a basis for decision-making (Adamson, 2025; Joachin-Arizmendi et al., 2024; Rashid et al., 2024; Rusydiana et al., 2023; Head, 2023; Widyasari & Haryanto, 2022).

In this context, GenAI offers several concrete benefits for science and numeracy learning. It can help students understand abstract concepts through examples, simple explanations, and interactive simulations (Kang & Ahn, 2025; Rashid et al., 2024). It supports personalized learning and provides quick feedback to students, helping teachers create more engaging material suited to student needs (Kang & Ahn, 2025; Rashid et al., 2024). More specifically, GenAI can compile adaptive exercises, deliver real-time feedback, generate questions calibrated to students' ability levels, and support more efficient formative assessments, freeing teachers to focus more on assisting the learning process itself (Bernal, 2024; Dai et al., 2023; Kasneci et al., 2023). In science literacy and numeracy specifically, this translates into simple contextual and simulation-based problems that can increase student engagement. However, the effectiveness of these benefits remains highly dependent on the teacher's ability to manage the technology (Gerdes et al., 2024; Henriksen et al., 2024).

Alongside these benefits, GenAI's use in elementary education carries several risks that require careful management. Chief among these is the possibility of inaccurate or misleading answers, including outright hallucinations (Tang et al., 2023; Testolin, 2024), which is particularly consequential given that elementary students still need concrete, reliable media to build accurate scientific and mathematical understanding. Beyond accuracy, ethical issues such as algorithmic bias and student data privacy also arise, underscoring the need for governance frameworks covering algorithm transparency, student data protection, AI use accountability, and the development of AI literacy among both teachers and students (Black et al., 2024; Kotiyal et al., 2025; Yan & Chau, 2025). A further practical challenge is the gap in access to technology across different regions. Left unaddressed, these risks can undermine, rather than support, students' understanding of science literacy and numeracy, making appropriate teacher training and clear policy guidance essential for GenAI's use in schools (Gerdes et al., 2024; Kang & Ahn, 2025).

Teachers have an important role in the use of GenAI in the classroom. Teachers are not only teachers, but also directors of the use of technology. GenAI should be used to help students think critically, not just give answers. Research shows that the use of GenAI needs to be designed with clear learning objectives (Adamson, 2025; Henriksen et al., 2024). In science literacy and numeracy, teachers can use GenAI to create problem-based learning. However, without good pedagogical skills, this technology can be less effective.

There is still a research gap on the use of GenAI in science literacy and numeracy in elementary schools. Many studies still focus on higher education or the general context of digital learning. Research that combines GenAI with basic literacy is still limited. Therefore, this study is important to fill the gap. The novelty of this research lies in its focus on connecting GenAI with science literacy and numeracy in elementary schools simultaneously.

Overall, GenAI has great potential in supporting the science literacy and numeracy of elementary school students through adaptive and personalized learning. However, its use needs to be studied carefully so as not to cause negative impacts. This study aims to analyze the role of GenAI based on the existing literature. The formulation of the problem in this study is: what is the role of Generative

Artificial Intelligence in supporting the science literacy and numeracy of elementary school students based on the existing literature review? This study is expected to make a theoretical contribution to the development of AI-based learning models in primary education as well as become the basis for more empirical follow-up research.

2. Literature Review

2.1. Generative Artificial Intelligence

Generative Artificial Intelligence (GenAI) is a branch of artificial intelligence that is able to generate various forms of content such as text, images, audio, video, and program code based on data learned from Large Language Models (Hadi et al., 2023; Raiaan et al., 2023). This technology is built using a transformer architecture that allows the system to understand the context of language in a more complex way through a self-attention mechanism. In the field of education, GenAI is used to support adaptive learning, create teaching materials, prepare evaluation questions, and provide automatic feedback to students. The presence of GenAI is considered an important innovation in the transformation of 21st-century education because it is able to improve personalization and interactivity of learning (Kang & Ahn, 2025; Rashid et al., 2024). However, this technology also has challenges such as algorithmic bias, information accuracy, and ethical issues of using student data.

2.2. Science Literacy

Science literacy is the ability of individuals to understand scientific concepts, use scientific evidence, and make decisions based on logical reasoning in daily life. At the elementary school level, science literacy is an important foundation in building critical thinking skills and understanding of natural phenomena. Science literacy learning not only emphasizes mastery of concepts, but also scientific processes such as observing, classifying, and inferring. Various studies show that the use of interactive learning media and inquiry-based approaches can significantly improve students' science literacy skills (Rusydiana et al., 2023; Widyasari & Haryanto, 2022; Head, 2023; Joachin-Arizmendi et al., 2024).(Hafis et al., 2022; Novianti et al., 2022). Therefore, science literacy is a fundamental competency in basic education.

2.3. Numeracy

Numeracy is the ability to use mathematical concepts in understanding, analyzing, and solving problems in daily life. Numeracy includes not only the ability to calculate, but also data understanding, information interpretation, and mathematical reasoning. In elementary school students, numeracy literacy is very important because it is the basis for the development of logical thinking and problem-solving skills. Research shows that context-based learning, the use of digital media, and technology-based approaches can significantly improve students' numeracy skills (Fatahillah et al., 2023; Yunaya et al., 2023). Thus, numeracy is one of the main competencies in 21st century education.

2.4. The Role of Generative Artificial Intelligence in Supporting Science and Numeracy Literacy

GenAI has a strategic role in supporting the improvement of science literacy and numeracy of elementary school students. In science literacy, GenAI helps students understand abstract concepts through simpler, more interactive visualizations, simulations, and contextual explanations. This helps students connect scientific concepts with real phenomena more easily (Rashid et al., 2024) 2024).

In numeracy literacy, GenAI plays a role in providing adaptive questions, context-based exercises, and instant feedback tailored to students' abilities. Thus, learning mathematics becomes more personal

and meaningful. In addition, GenAI also supports a personalized learning model that allows students to learn according to their own speed and ability. However, the effectiveness of GenAI use is highly dependent on the role of teachers as facilitators who direct the appropriate use of technology (Adamson, 2025; Henriksen et al., 2024). However, challenges such as the risk of misinformation, technology dependence, and teacher readiness still need to be considered in the implementation of GenAI in elementary schools.

3. Methods

3.1. Research Design

This study uses a qualitative approach with a non-systematic literature review design. This design is used to explore, interpret, and synthesize various findings of previous research related to the role of Generative Artificial Intelligence (GenAI) in supporting science literacy and numeracy of elementary school students. This approach does not follow strict SLR protocols, but is more flexible in reviewing the literature conceptually and thematically (Henriksen et al., 2024; Rashid et al., 2024).

3.2. Data Source

The data sources in this study are derived from relevant scientific literature, including international journal articles, conference proceedings, and reputable academic publications. The literature is focused on studies that discuss GenAI in education, science literacy, and numeracy literacy in the context of basic education. The main sources are obtained from academic databases such as Google Scholar, Scopus, and relevant open-access publications (Hadi et al., 2023; Raiaan et al., 2023).

3.3. Literature Selection Criteria

The literature selection is carried out based on the following criteria:

a) The article discusses Generative Artificial Intelligence in the context of education.
b) Articles relevant to science literacy and numeracy.
c) The research subjects focus on primary education or the learning of elementary school-age children.
d) Articles published in reputable scientific journals and conference proceedings.
e) Literature that is not relevant to the primary education context or does not explicitly discuss GenAI is explicitly excluded from the analysis.

These criteria are used to ensure that the literature analyzed has a strong relevance and contribution to the research objectives.

3.4. Data Collection Techniques

The data collection technique was carried out through a limited systematic literature search using keywords such as “Generative AI in education”, “elementary school science literacy”, “student numeracy”, and “AI in primary education”. The literature found was then collected, read in depth, and classified based on the research theme. This process aims to obtain data that is in accordance with the focus of the study, namely the role of GenAI in science literacy and numeracy (Adamson, 2025; Kang & Ahn, 2025).

3.5. Data Analysis Techniques

The data analysis technique used is thematic analysis. The analysis process is carried out through several stages. First is data reduction, which involves filtering out irrelevant literature. This is followed by data encoding, which involves grouping information into themes such as the role of GenAI, science

literacy, numeracy literacy, and implementation challenges. Next is data presentation, which involves compiling findings based on thematic categories. Finally, conclusions are drawn through a process of synthesis to identify patterns of relationships between concepts in the literature. This approach allows researchers to gain a comprehensive understanding of GenAI's contribution in basic learning, particularly in strengthening science literacy and numeracy of elementary school students (Adamson, 2025; Henriksen et al., 2024).

4. Results and Discussion

4.1. Characteristics of the Literature Studied

The literature analyzed in this study shows diverse characteristics but has a consistent focus on the development of Generative Artificial Intelligence (GenAI) in education. Most of the literature uses conceptual approaches and theoretical studies on the application of GenAI based on Large Language Models (LLMs) and transformer architectures (Hadi et al., 2023; Raiaan et al., 2023). The main characteristics of the literature include the dominance of conceptual studies compared to empirical studies in primary education; a focus on the integration of AI technology in adaptive learning and personalization; a tendency to discuss GenAI as a learning support system rather than a substitute for teachers; and an emphasis on ethical issues, information accuracy, and digital readiness of teachers. In addition, the literature shows that most studies still focus on the context of general education, while specific studies on science literacy and numeracy in primary schools are still limited.

4.2. The Role of Generative AI in Supporting Science Literacy

Literature findings show that GenAI has an important contribution to improving the science literacy of elementary school students. GenAI is able to present scientific concepts in a more concrete form through visualization, simulation, and adaptive explanations (Kang & Ahn, 2025; Rashid et al., 2024). In science literacy, GenAI helps students understand abstract concepts through interactive illustrations, connect theory with the phenomena of everyday life, and develop scientific observation and reasoning skills. In addition, GenAI also supports inquiry-based learning by providing virtual experiment scenarios that can improve understanding of basic science concepts (Mangubat & Mangubat, 2025).

4.3. The Role of Generative AI in Supporting Numeracy

In the context of numeracy, the literature shows that GenAI plays a role in improving students' mathematical thinking skills through adaptive exercises and contextual problem-solving. GenAI supports numeracy by providing real-life context-based math problems, adjusting the difficulty level of questions to the student's abilities, and providing instant feedback on student answers. This helps students understand mathematical concepts not only procedurally, but conceptually as well. Numeracy literacy becomes more meaningful because students are invited to understand the logic behind each calculation (Kubsch et al., 2025). However, the literature also emphasizes that without teacher assistance, the use of GenAI can reduce students' critical thinking processes due to the tendency to rely on instant answers.

4.4. Opportunities and Challenges of Implementing Generative AI in Elementary Schools

The literature shows that the implementation of GenAI in elementary schools has great opportunities as well as complex challenges. In terms of opportunities, GenAI supports personalized learning (Rashid et al., 2024), increases student engagement and motivation to learn, makes it easier for teachers to compile learning materials, and provides simulation-based and interactive learning. In terms of challenges, the literature points to the risk of AI-generated hallucinations (Testolin, 2024), algorithmic bias and system transparency issues (Yan & Chau, 2025), the technology access gap between regions, and limitations in teachers' digital competencies. In addition, ethical challenges such as student data privacy are an important concern in the implementation of GenAI in primary education.

4.5. Implications of Generative AI Utilization on Learning in Elementary Schools

The utilization of GenAI in learning has significant implications for changing the paradigm of basic education. Pedagogically, GenAI encourages more adaptive, interactive, and needs-based learning for students, and teachers can develop problem-based learning with the help of AI to improve science and numeracy literacy (Henriksen et al., 2024). In terms of the role of teachers, this role shifts from being the main source of information to facilitators and curators of learning, with teachers responsible for ensuring that the information from GenAI remains valid and in accordance with learning objectives (Gerdes et al., 2024). From a technological standpoint, schools need to provide adequate digital infrastructure so that the use of GenAI can run optimally, since without adequate technological support, AI implementation will be difficult to do evenly. Finally, in terms of policy, clear regulations are needed regarding the use of AI in primary education, especially related to ethics, data privacy, and information validity (Feigerlová, 2026).

Overall, the literature shows that GenAI has great potential in supporting elementary school students' science literacy and numeracy through adaptive and interactive learning. However, the success of its implementation is highly dependent on teacher readiness, education policies, and technological infrastructure. Thus, GenAI must be positioned as a learning support tool, not a substitute for the role of teachers in the educational process.

5. Conclusion

Based on the results of a literature review regarding the role of Generative Artificial Intelligence (GenAI) in supporting science literacy and numeracy of elementary school students, it can be concluded that GenAI has great potential in improving the quality of learning in elementary education. This technology is able to provide adaptive, interactive, and personalized learning to help students understand science and numeracy concepts more easily, concretely, and contextually. In science literacy, GenAI plays a role in helping students understand abstract concepts through simpler visualizations, simulations, and explanations. Meanwhile, in numeracy literacy, GenAI supports the development of mathematical thinking skills through contextual problems, adaptive exercises, and instant feedback according to students' abilities. This shows that GenAI can be an effective tool to strengthen the learning process based on understanding, not just memorization.

However, the implementation of GenAI also faces various challenges, such as the risk of misinformation (hallucination), algorithmic bias, limited access to technology, and teachers' readiness to integrate this technology into learning. Therefore, the role of teachers remains the main factor in ensuring that the use of GenAI runs appropriately, ethically, and in accordance with learning goals. GenAI cannot replace the role of teachers, but serves as a learning support tool. Theoretically, further research needs to expand the study to other contexts such as digital literacy and 21st century skills, as

well as conduct empirical research in the field to test the effectiveness of GenAI directly. Practically, teachers need to improve digital literacy competencies in order to be able to utilize GenAI optimally, especially in encouraging students' critical thinking skills. Schools also need to provide adequate training and technical support. In terms of policy, the government needs to establish clear regulations related to the use of GenAI in elementary education, especially those related to ethics, data privacy, and standards for technology implementation in schools.

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