Proceeding of the International Conference on Global Education and Learning
Volume. 1, Number. 2, Year 2024
e-ISSN : 3089-8072, Page 72-82
Available online at: https://prosiding.aripi.or.id/index.php/ICGEL

To What Extent is GenAI Relevant to Empowering Students' Critical Thinking and Creative Thinking Skills?

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Abstract: *Advances in technology, particularly Generative AI (GenAI), have opened up great opportunities in improving critical and creative thinking skills in education. It offers the potential for personalizing learning, strengthening collaboration, and creating innovative environments that support the development of essential 21st century skills. This article discusses the relevance and implementation of GenAI in learning, examining the benefits it brings, such as increased student analysis and innovation, as well as the challenges faced, including technology dependency, accessibility gaps, and teacher training needs. With thoughtful implementation strategies, GenAI can be a catalyst for empowering students in an inclusive manner, although it requires regulations and policies that support its sustainability and equitable distribution of benefits. The results of this discussion confirm that the integration of GenAI in education requires a holistic approach to ensure its significant impact on student learning and skill development.*

Keywords: *Generative AI, Critical Thinking Skills, Creative Thinking Skills, Education, Technology*.

1. INTRODUCTION

The 21st century is characterized by rapid technological development and global transformation that affects almost all aspects of life, including education (Kain et al., 2024). In this era, critical and creative thinking skills are key competencies that young people must possess (Kennedy & Sundberg, 2020; Novia et al., 2024). Both skills are needed to solve complex problems, innovate and adapt in an ever-changing environment (Tang et al., 2020). 21st century education emphasizes learning that is not only oriented towards knowledge transfer, but also on developing higher-order thinking skills as the foundation for future success (Thornhill et al., 2023).

Critical thinking skills enable students to analyze information in depth, evaluate multiple perspectives, and make decisions based on valid data (Jamil et al., 2024). On the other hand, creative thinking skills focus on the ability to generate new ideas, explore innovative solutions, and apply an out-of-the-box approach to challenges (Peterson & Pattie, 2024). The combination of these two skills is an important asset for students to contribute effectively in various fields, such as science, technology, and arts, which are increasingly influenced by digital transformation (Putri et al., 2023).

However, with the advancement of technology, especially in the field of artificial intelligence (AI), new challenges arise in the education process. GenAI, which can generate text, images and data-driven solutions, presents great potential to support learning (Borah et al., 2024). On the one hand, this technology opens up opportunities for students to deepen their

Received: October30, 2024; Revised: November 30, 2024; Accepted: December 18,2024; Published: December 30, 2024

understanding through simulations, data analysis and personalized feedback (Reethika & Kanaga, 2024). On the other hand, reliance on these technologies can hinder students' ability to think independently if their use is not managed wisely.

Another significant challenge is the disparity in access to these technologies. Not all students have the same opportunities to access the technological devices and internet needed to utilize AI in learning (Gill et al., 2024). This gap can exacerbate educational inequality, especially in less developed regions. There are also concerns about potential unethical uses of AI, such as automated plagiarism and academic fraud, which could undermine the integrity of the learning process (Mulenga & Shilongo, 2024).

Therefore, the presence of AI in education requires a strategic approach that not only focuses on implementing the technology, but also on developing a framework that ensures its benefits are accessible to all students (Adel et al., 2024). Education should keep humans at the center of the learning process, with AI as a supporting tool to strengthen, not replace, students' critical and creative thinking skills. Only in this way can 21st century education achieve its primary goal: creating a generation that is competent, innovative and ready to face global challenges.

2. LITERATURE REVIEW

Critical and creative thinking skills are at the core of 21st century education, which aims to prepare students for global challenges and the evolving demands of future jobs (González et al., 2020; Thornhill et al., 2023). Critical thinking involves the ability to analyze information, evaluate arguments and make decisions based on valid evidence. Meanwhile, creative thinking emphasizes innovation and the ability to generate relevant new ideas. These two skills become an important foundation for the development of life skills, as students not only learn to understand concepts, but also to apply the knowledge creatively in various situations (Forte-Celaya et al., 2021; Putri et al., 2023).

GenAI has emerged as one of the enabling technologies in education, offering various advantages in student skill development (Law, 2024). This technology allows students to interact with AI-based systems that can process information, provide personalized feedback, and simulate learning scenarios. Research shows that the use of GenAI in project-based learning strategies helps students deepen their understanding through independent and interactive exploration (Zheng et al., 2024). Thus, GenAI acts as a catalyst to encourage students' creativity and critical thinking.

The benefits of GenAI in the world of learning are not only limited to students, but also to teachers. For teachers, this technology provides tools to design more engaging and adaptive learning (Martin et al., 2020). For example, GenAI can be used to create learning modules based on student needs, so that teachers can focus more on assisting the learning process. Studies show that AI-based learning strategies are able to increase student participation and provide better learning outcomes than conventional approaches (Mutambik, 2024).

However, the successful implementation of GenAI in learning is highly dependent on the attitude and readiness of all parties involved. Students need to be trained to use this technology wisely, not as a substitute for the thinking process, but as a tool to support their exploration. Teachers also need to improve their technological literacy to be able to utilize GenAI effectively in learning. Studies show that training teachers in using educational technologies such as AI greatly influences their successful implementation in the classroom (Dimitriadou & Lanitis, 2023).

Stakeholders, including governments and educational institutions, have a great responsibility in creating policies that support the ethical and inclusive integration of GenAI (Knight et al., 2023). Gaps in access to these technologies should be minimized through investments in educational infrastructure, such as hardware, software, and educator training (Dimitriadou & Lanitis, 2023; Zebua, 2024). In addition, policy makers should ensure that AI integration does not replace human interaction, but strengthens collaboration between students and teachers.

Thus, GenAI can be an effective tool in supporting 21st century learning, provided that its use is designed to reinforce, not replace, the human learning process. Collaboration between learners, teachers, stakeholders and related parties is key to success in creating a learning environment that supports the development of students' critical and creative thinking skills. Further research is also needed to understand the long-term impact of this technology in education.

3. METHODS

This research uses a qualitative approach to analyze the role of Generative AI (GenAI) in supporting critical and creative thinking skills in 21st century education. This article integrates a literature review of existing research, examining the applications and challenges of GenAI in fostering higher-order thinking skills. Key data sources include peer-reviewed articles, case studies, and theoretical frameworks on educational technology, critical and creative thinking, and AI ethics. This study emphasizes a holistic analysis of GenAI's potential

in facilitating personalized learning experiences, project-based learning models, and innovative problem-solving while addressing risks such as dependency, ethical issues, and gaps in technology access.

4. RESULTS AND DISCUSSION

Gen AI in Education today?

Research on GenAI and its assessment emerged after ChatGPT focused on its ability to solve student tasks such as exams with test questions and multiple choice questions (Lam et al., 2024). However, GenAI's progress is also being watched with the introduction of AI detection tools that allow students' answers to be seen for their originality (Nikolic et al., 2024). Although in reality GenAI has been widely used by students, such as ChatGPT, Gemini and many more.

On the other hand, the tremendous advances in GenAI have also presented significant challenges to the field of assessment. Many people are concerned that academic misconduct is increasing because students can bypass their learning process by submitting AI-generated work as their own for assessment, and there is a lack of reliable AI detection tools (Chan, 2024). Without proper regulation, it is possible for learners to gain an unfair advantage over their peers in assessment.

There are also concerns about fair access to GenAI tools, data security in the use of GenAI, bias in algorithms, lack of AI literacy training for teachers and students in schools, and the spread of fraudulent information generated by AI. Regarding the use of GenAI in assessment, many areas remain unclear and arise in the absence of established guidelines (Giannakos et al., 2024). For example, is it an academic offense if a student independently works on his/her assignment but uses GenAI to improve his/her writing? Can the use of AI improve students' 21st century skills? These questions not only highlight the importance of revisiting key concepts in assessment (e.g. security and validity of assessment) but also point to the need to review and redesign assessment in higher education to better prepare students for a world with AI.

The development of GenAI continues to grow and is often accessed through a chatbot interface. The GenAI chatbot that has been developed today has surpassed the capabilities of its predecessors, where AI tools can offer more dynamic, responsive and intelligent interactions (Feng et al., 2024).The GenaAI application, which has been integrated into a Natural Language Process (NLP) model, can generate text, images, voice, structured data, and even video. Despite continuous improvement, the GenAI chatbot is far from perfect. OpenAI (2022) has

acknowledged ChatGPT's limitations, including generating inaccurate or biased information, responding inconsistently to paraphrasing, guessing in ambiguous situations, and potentially following malicious instructions, on its website.

The Importance of Critical Thinking Skills

As a response to the times, developing learning that emphasizes high-level thinking skills (HOTS) is essential (Mislia et al., 2019). The implementation of this program in character learning aims to equip students with HOTS competencies that are relevant to the needs of the 21st century. One of the important skills in HOTS is critical thinking skills, which is the main key in creating superior products in the modern era (Kennedy & Sundberg, 2020; Thompson, 2002).

Critical thinking is defined as the ability to think reflectively, rationally, and focus on making decisions. Critical thinking skills involve using a variety of knowledge and skills to solve problems, analyze assumptions, and conduct data-based investigations to come up with valid conclusions (Tang et al., 2020). Critical thinking also includes being skeptical without being cynical, open-minded, analytical, decisive, evaluative, and strong without bias. It involves abilities such as interpretation, analysis, evaluation, and self-regulation, with problem-solving stages including identification, determination, enumeration, assessment, and in-depth observation (Toheri et al., 2020).

One study explains that critical thinking requires cognitive analysis and evaluation to reduce misconceptions. In the context of 21st century learning, this skill is crucial as it helps students sort out valid information amidst an abundance of information (Trilling & Fadel, 2009). The development of critical thinking can be done through inquiry-based learning and problem solving, as well as meaningful learning projects involving real questions and problems.

In science education, critical thinking is an important dimension as it helps students take responsibility in utilizing science and technology. Processes such as exploration, investigation and problem solving in science require critical thinking skills to achieve maximum application. Science learning that focuses on tasks and issues in its curriculum is closely related to the development of critical thinking (Ahmad, 2021).

Critical thinking is considered important in preparing students for future career challenges, especially in science fields such as biology. This skill can be measured through essay tests designed to encourage students to analyze, evaluate, and process information based on observation and experience (Thornhill et al., 2023). Other studies have also mentioned that

essay tests have the advantage of capturing students' ability to reason, analyze, and evaluate in accordance with assessment guidelines and taxonomies such as Bloom's Taxonomy.

Students' Creative Thinking Skills

In addition to critical thinking skills, creative thinking skills are related to the ability to generate new ideas. This skill involves the ability to identify gaps, paradoxes, opportunities, challenges, problems, and new relationships by creating various possibilities from different points of view, generating unique or original ideas, and enriching existing ideas (Forte-Celaya et al., 2021; Handayani et al., 2021). The creative thinking process provides a new perspective and generates ideas by combining pre-existing concepts.

Creative thinking also hones students' ability to look at a problem from various points of view and develop many ideas (Gube & Lajoie, 2020). It involves problem-sensitivity, open-mindedness to new and unusual information and ideas, and the ability to connect various elements to solve problems. In cognitive taxonomy, creative thinking belongs to the highest level (C6 - create), which demands the ability to create something new to help students develop their ideas (Affandy et al., 2024; Samala et al., 2024).

In biology learning, creative thinking skills are important because in addition to understanding declarative knowledge such as facts and concepts, students also need to learn procedural knowledge, such as how to obtain information, understand how science and technology work, and develop scientific thinking habits (Komalasari et al., 2024). Project-based learning models can encourage the creation of new ideas and works in biology learning.

The importance of creative thinking skills in education can be seen from its ability to help students make the right decisions in various situations. With these skills, students can see the world from different perspectives and find new solutions to real problems. Creative thinking skills have great benefits, such as helping individuals self-actualize, solve problems in different ways, engage in rewarding activities, achieve personal satisfaction, and improve quality of life (Affandy et al., 2024).

GenAI Opportunities in Supporting Critical Thinking and Creative Thinking Skills

GenAI provides significant opportunities to support critical and creative thinking skills (Lee & Low, 2024; Palani & Ramos, 2024). The technology leverages the ability to generate content based on input data so that it can be used in a variety of contexts, from education to the creative industries (Rashid et al., 2024). In the development of critical thinking, GenAI allows users to analyze information in depth and systematically. For example, tools such as GPT can present summaries of academic data, facilitate the identification of patterns and relationships between concepts, and validate arguments with a broader perspective. This creates

opportunities for individuals to make decisions, however, verified through reliable scientific sources (Ghallab, 2019; Varona et al., 2021).

On the other hand, creative thinking skills can also be encouraged through GenAI's ability to generate new ideas, refine concepts, or even create solutions that have never been imagined before (Palani & Ramos, 2024). In the field of art and design, this technology enables experimentation with prototypes quickly and efficiently, making the innovation process more inclusive and adaptive. In this way, GenAI is not only a tool for getting work done, but also a source of inspiration for new innovations (Zhang & Zhang, 2024).

However, this great potential of GenAI must also be balanced with an awareness of the challenges and risks that come with it (Huang et al., 2024; Zebua, 2024). Over-reliance on this technology can reduce the ability of human original thinking, especially if users are not made aware of the importance of manual processes in generating ideas (Handayani et al., 2021; Mittal et al., 2024). Additionally, the risk of bias in the results provided by GenAI is also a challenge, as the model relies on available data, which may not always reflect diversity or accuracy. Therefore, the implementation of GenAI in supporting critical and creative thinking skills must be done wisely, by placing technology as a complement to human abilities, not as a replacement.

5. CONCLUSION

GenAI has the potential to strengthen students' critical and creative thinking skills through learning personalization and solution innovation. Successful implementation requires student, teacher, and stakeholder collaboration, supported by digital literacy, training, and inclusive policies, to ensure its ethical and equitable use in education.

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