Journal of Systemics, Cybernetics and Informatics (2024) 22(3), 34-37
https://doi.org/10.54808/JSCI.22.03.34

Integrating Generative AI in Active Learning Environments: Enhancing Metacognition and Technological Skills

Areej ELSAYARY
College of Interdisciplinary Studies, Zayed University
Abu Dhabi, United Arab Emirates

ABSTRACT

This paper explores the innovative integration of Generative AI (GenAI) in active learning environments to augment metacognitive knowledge and technological skill development among students. While active learning has been pivotal in promoting student engagement and learning, the incorporation of GenAI presents a novel approach to further enhance these outcomes. The study investigates how GenAI tools can be utilized within a reflective practice model to bolster metacognitive regulation and technological proficiency. By discussing the synergistic relationship between GenAI, active learning, and metacognitive strategies, this paper provides insights into the evolving landscape of educational technology and its impact on student learning processes. The paper offers a theoretical framework based on established concepts in metacognition, active learning, reflective practice, and technological skills, contextualized within the realm of GenAI. This paper contributes to the understanding of how GenAI can be harnessed as an educational tool, facilitating deeper and more effective learning experiences.

Keywords: Generative AI, Active Learning, Metacognition, Technological Skills, Reflective Practice, Educational Technology.

1. INTRODUCTION

Active learning is a pedagogical approach that engages students in the learning process, encouraging them to actively participate in constructing their knowledge rather than passively receiving information [1]. It is closely linked with metacognition, the awareness and regulation of one's own cognitive processes, which is essential for effective learning and problem-solving [2]. The integration of active learning and metacognitive strategies has been shown to significantly enhance students' academic performance and prepare them for lifelong learning [3].

With the advent of advanced technologies in education, Generative AI (GenAI) has emerged as a transformative tool. GenAI, which includes technologies like machine learning and natural language processing, offers personalized learning experiences, aids in the development of critical thinking, and provides innovative solutions to complex problems [4]. Its application in educational contexts signifies a paradigm shift, enabling more dynamic, interactive, and adaptive learning environments.

This study aims to explore the integration of GenAI in active learning settings to enhance metacognition and technological skills among students. By doing so, it aligns with several United Nations Sustainable Development Goals (SDGs), particularly SDG 4 (Quality Education) and SDG 9 (Industry, Innovation, and Infrastructure). SDG 4 emphasizes inclusive and equitable quality education and promotes lifelong learning opportunities for all, while SDG 9 focuses on building resilient infrastructure, promoting inclusive and sustainable industrialization, and fostering innovation [5].

The objectives of this study are to:

1. Investigate the impact of GenAI-enhanced active learning on students' metacognitive awareness and regulation.
2. Analyze the development of technological skills through GenAI applications in educational settings.
3. Assess how GenAI integration in education can contribute to achieving the SDGs, particularly in fostering inclusive and quality education and promoting innovation.

Through this research, we aim to provide insights into how GenAI can revolutionize educational practices, support the development of 21st-century skills, and contribute to the global agenda of sustainable development.

Metacognition in Education

Metacognition, coined by Flavell [6], refers to one's awareness and control of their cognitive processes in learning. It encompasses skills like planning, monitoring, evaluating, and regulating one's cognitive activities [6]. Metacognitive strategies, including self-regulation and reflection, are crucial in enhancing learning outcomes and adaptability in various learning situations [7]. These strategies have shown positive impacts on student performance, promoting deeper understanding and efficient problem-solving skills [2]. Metacognition is integral to achieving SDG 4's goal of quality education, as it fosters critical thinking and self-directed learning, key competences in today's rapidly evolving world [8].

Active Learning Methodologies

Active learning, a process that involves students in their learning, is a departure from traditional lecture-based teaching. It emphasizes student engagement, participation, and critical thinking [9]. Techniques like group discussions, problem-based learning, and peer teaching are components of active learning that enhance students' understanding and retention of information [10]. Active learning aligns with SDG 4's aim of inclusive and equitable quality education by fostering environments where students are central to the learning process, actively constructing knowledge rather than passively receiving [11].

The Role of Reflective Practice in Learning

Reflective practice, as conceptualized by Schön [12], is the process of learning through and from experience towards gaining new insights of self and practice. This model has been widely

recognized in professional development, particularly in education and healthcare [13]. Reflective practice involves critical analysis of experiences, leading to deeper learning and is considered an essential component of metacognitive regulation [14]. Implementing reflective practices in educational settings encourages continuous learning and adaptability, contributing to SDG 4's focus on lifelong learning opportunities [15].

Technological Skills in the 21st Century

Technological skills, including digital literacy and IT proficiency, are increasingly vital in the 21st-century landscape [16]. These skills encompass more than just the ability to use technology; they involve understanding the role of technology in society and the economy, critical for innovation and sustainable development [17]. Enhancing technological skills in education is not only about tool usage; it's about preparing learners to navigate and contribute to a digital world, resonating with SDG 9's emphasis on innovation and infrastructure [18].

Introduction to Generative AI and its Educational Applications

Generative AI (GenAI), comprising technologies like machine learning, deep learning, and natural language processing, is revolutionizing educational paradigms [19]. GenAI can personalize learning pathways, adapt content to individual learning styles, and offer innovative problem-solving tools [20]. In education, GenAI applications range from automated grading systems to AI tutors and content generation tools, offering significant potential to transform learning experiences [21]. The integration of GenAI aligns with SDG 4's goal to enhance the quality and inclusivity of education by providing adaptable and personalized learning experiences.

Integration of Metacognition, Active Learning, and Reflective Practice

The theoretical framework of this study is rooted in the synergistic integration of metacognition, active learning, and reflective practice. Metacognition, as defined by Flavell [6], involves the awareness and regulation of one's own cognitive processes, which is a critical component for successful learning outcomes [2]. Active learning, a student-centered approach, engages learners in the process, promoting deeper understanding and retention of information [1, 22]. Reflective practice, a concept developed by Schön [12], allows learners to introspect and learn from their experiences, thereby fostering continuous professional growth [13, 16]. The combination of these elements forms a robust educational framework that encourages learners to be actively involved, self-aware, and reflective, leading to more effective and meaningful learning experiences [23].

The potential of GenAI in Enhancing Educational Components

Generative AI (GenAI) technologies, such as machine learning and natural language processing, offer new dimensions to this integrated framework. GenAI has the potential to personalize learning experiences, adapt content to individual learning styles, and provide dynamic feedback mechanisms [24]. By incorporating GenAI into the learning process, educators can enhance active learning environments with intelligent, adaptive technologies that respond to the unique needs of each student, thereby fostering deeper engagement and understanding [21]. Furthermore, GenAI tools can facilitate metacognitive processes by providing analytics and insights into learning patterns, enabling students to reflect more effectively on their learning journey [20].

2. CASE STUDIES / EXAMPLES

Personalized Learning Through AI-Driven Platforms [25]

At a Chinese university, an AI-driven learning platform was implemented to enhance student learning experiences. This platform utilized machine learning algorithms to analyze student learning behaviors and academic performance data. Based on this analysis, it generated personalized learning materials and adaptive learning paths for each student. The platform's AI capabilities enabled it to dynamically adjust content difficulty and presentation based on individual student progress. The study demonstrated that students using this platform showed significant improvements in engagement and academic performance. This case underscores the potential of GenAI in personalizing educational experiences, addressing individual learning needs, and improving overall academic outcomes.

AI Tutors in Language Learning [26]

The case study focused on an AI-based language learning app designed for teaching English to non-native speakers. The app incorporated natural language processing (NLP) technologies to provide immediate feedback on pronunciation and grammar, crucial aspects of language learning. This real-time feedback was particularly beneficial for learners outside of the classroom, offering a personalized and flexible learning experience. The study observed that the app effectively complemented traditional language learning methods, enhancing learners' language skills more efficiently. This example highlights how GenAI can serve as an effective tool for language acquisition, providing tailored and immediate feedback that is difficult to achieve in conventional learning settings.

Enhancing Metacognitive Skills through AI Analytics [27]

In this research, an AI-powered analytics tool was integrated into an online learning environment. The tool tracked and analyzed students' learning activities, providing them with visual feedback on their study habits and progress. This feedback was instrumental in helping students develop metacognitive skills, as it made them aware of their learning strategies and areas requiring improvement. Students could then adjust their study habits accordingly, leading to better academic performance. The study demonstrated the effectiveness of GenAI in fostering metacognitive awareness and skills, crucial for lifelong learning and self-improvement.

AI in STEM Education [28]

The project involved the use of an AI-driven simulation tool in STEM education. This tool provided a virtual environment for students to conduct experiments and explore scientific concepts interactively. The AI component adapted the complexity of the scenarios based on student responses, ensuring a tailored learning experience. This adaptive approach kept students engaged and challenged, catering to various skill levels. The study highlighted the benefits of using GenAI in STEM education, particularly in creating dynamic, interactive, and personalized learning experiences that stimulate interest and deeper understanding of complex scientific concepts.

The Impact of Generative AI (GenAI) on Practices, Policies, and Research Direction in Education: A Case of ChatGPT and Midjourney

This study explores the profound impact of Generative AI tools, such as ChatGPT, in the realm of school education [29]. It focuses on how these tools have become increasingly accessible, significantly influencing teaching and learning methodologies.

The case study centered around the use of ChatGPT in Midjourney, an online learning platform, highlights the implications of these AI tools in enhancing educational engagement and effectiveness. It discusses how ChatGPT can aid in creating personalized learning experiences and foster innovative teaching practices, reshaping traditional educational paradigms.

Challenges and Opportunities of Generative AI for Higher Education as Explained by ChatGPT
Alqahtani [30] examines the dual aspects of challenges and opportunities presented by the use of ChatGPT in higher education settings. The study delves into how ChatGPT intersects with and challenges conventional blended learning methodologies in engineering education. It also raises critical discussions around academic integrity and quality control in the wake of AI integration. The case study provides insights into how ChatGPT could be leveraged to enhance learning experiences while also addressing potential pitfalls in its application.

Navigating AI Literacy in the Classroom: A Case Study with GenAI's Data Analysis Tool
In this case study, McMinn [31] explores the role of ChatGPT and other GenAI tools in fostering AI literacy. It discusses how these tools, particularly in data analysis, can aid in making informed decisions. The study focuses on the implementation of GenAI tools in an AI literacy course, emphasizing the importance of critically evaluating their capabilities and limitations. This case study provides valuable insights into how educators can integrate GenAI tools in classroom settings to enhance understanding and critical thinking among students.

AI Case Study: Minimising GenAI Usage Through Simulated Role-Play
As explored by UNSW Sydney [32], this study presents an innovative approach to minimize the usage of GenAI tools like ChatGPT through simulated role-play in a politics and international relations course. The study discusses the concerns around academic integrity and quality control posed by GenAI. It provides a case study on how simulated role-play can serve as an effective alternative or complementary approach to GenAI tools, ensuring academic rigor and integrity while engaging students in interactive learning experiences.

Challenges and Limitations
Integrating Generative AI (GenAI) in educational settings presents several challenges. Firstly, there is the issue of ensuring equitable access to these technologies, as not all institutions may have the resources to implement them effectively [29]. Additionally, there is a concern regarding the potential for GenAI tools to perpetuate biases if not carefully designed and monitored [30]. The integration of GenAI also raises questions about academic integrity and the authenticity of student work, especially with tools capable of generating sophisticated content [32]. Furthermore, there is a need for educators to acquire new skills to effectively integrate and utilize these technologies in their teaching practices.

The current study has limitations that open avenues for future research. One limitation is the scope of the study, which primarily focuses on the potential of GenAI without an extensive exploration of its long-term impacts on educational outcomes. Future research could explore longitudinal studies to assess the sustained impact of GenAI in education. Another area for future research is the exploration of strategies to mitigate the challenges and risks associated with GenAI, such as developing frameworks for ethical use and guidelines for maintaining academic integrity.

3. CONCLUSIONS

The study highlights the potential of GenAI in revolutionizing educational practices by enhancing metacognition, active learning, and technological skills. GenAI tools, such as ChatGPT, offer opportunities for personalized learning experiences and innovative teaching methodologies, aligning with the objectives of quality education and fostering innovation in line with the Sustainable Development Goals.

The future of GenAI in education looks promising, with the potential for these technologies to create more adaptive, personalized, and engaging learning environments. As GenAI continues to evolve, it is likely to play a significant role in shaping the educational landscape, offering new ways to enhance learning and teaching processes.

For educators, it is recommended to embrace the potential of GenAI while being mindful of its limitations and ethical implications. Continuous professional development and training in the use of GenAI tools should be prioritized. Policymakers should focus on creating policies that ensure equitable access to these technologies and establish guidelines for ethical use. It is also important to foster collaborations between educational institutions and technology developers to ensure that GenAI tools are aligned with educational goals and needs.

4. REFERENCES

[1] M. Prince, **"Does active learning work? A review of the research**," J. Eng. Educ., vol. 93, no. 3, pp. 223–231, 2004.
[2] G. Schraw and D. Moshman, "Metacognitive theories," **Educ. Psychol. Rev**., vol. 7, no. 4, pp. 351–371, 1995.
[3] J. Bransford, A. L. Brown, and R. R. Cocking, Eds., **How people learn: Brain, mind, experience, and school: Expanded edition.** National Academy Press, 2000.
[4] E. Brynjolfsson and T. Mitchell, "What can machine learning do? Workforce implications," **Science**, vol. 358, no. 6370, pp. 1530–1534, 2017.
[5] United Nations, "**Transforming our world: the 2030 Agenda for Sustainable Development**," United Nations, Department of Economic and Social Affairs, 2015.
[6] J. H. Flavell, "Metacognition and cognitive monitoring: A new area of cognitive-developmental inquiry," **Am. Psychol**., vol. 34, no. 10, pp. 906–911, 1979.
[7] B. J. Zimmerman, "Self-efficacy: An essential motive to learn," **Contemp. Educ. Psychol**., vol. 25, no. 1, pp. 82–91, 2000.
[8] P. R. Pintrich, "The role of metacognitive knowledge in learning, teaching, and assessing," **Theory Into** Pract., vol. 41, no. 4, pp. 219–225, 2002.
[9] C. C. Bonwell and J. A. Eison, "**Active learning: Creating excitement in the classroom,**" ASHE-ERIC Higher Education Report No. 1, Washington, DC: School of Education and Human Development, George Washington University, 1991.
[10] S. Freeman et al., "Active learning increases student performance in science, engineering, and mathematics," **Proc. Natl. Acad. Sci.**, vol. 111, no. 23, pp. 8410–8415, 2014.
[11] J. Michael, "Where's the evidence that active learning works?" **Adv. Physiol. Educ.,** vol. 30, no. 4, pp. 159–167, 2006.

[12] D. A. Schön, **The reflective practitioner: How professionals think in action**. Basic Books, 1983.
[13] D. Boud, R. Keogh, and D. Walker, **Reflection: Turning experience into learning**. Kogan Page, 1985.
[14] A. ElSayary, "Using a Reflective Practice Model to Teach STEM Education in a Blended Learning Environment," **Eurasia J. Math. Sci. Technol. Educ.,** vol. 17, no. 2, Art. no. em1942, 2021. Available: https://doi.org/10.29333/ejmste/9699
[15] K. Mann, J. Gordon, and A. MacLeod, "Reflection and reflective practice in health professions education: A systematic review," **Adv. Health Sci. Educ**., vol. 14, no. 4, pp. 595–621, 2009.
[16] A. ElSayary, "Using Interactive Technology to Enable Interactive E-learning Environment," in **Overcoming challenges in online learning: perspectives from Asia and Africa**, A. ElSayary and A. Olowoselu, Eds. Routledge, 2023, pp. 145–150. Available: https://doi.org/10.4324/9781003342335-17
[17] A. ElSayary, "Students' Active Engagement in Online Learning," in **Overcoming challenges in online learning : perspectives from Asia and Africa**, A. ElSayary and A. Olowoselu, Eds. Routledge, 2023, pp. 97–106. Available: https://doi.org/10.4324/9781003342335-12
[18] H. Jenkins, **Confronting the challenges of participatory culture: Media education for the 21st century**. MIT Press, 2009.
[19] E. Brynjolfsson and A. McAfee, **Machine, platform, crowd: Harnessing our digital future.** W. W. Norton & Company, 2017.
[20] O. Zawacki-Richter, V. I. Marín, M. Bond, and F. Gouverneur, "Systematic review of research on artificial intelligence applications in higher education – where are the educators?" **Int. J. Educ. Technol. High. Educ**., vol. 16, 2019, Art. no. 39.
[21] R. Luckin, "Towards artificial intelligence-based assessment systems," **Nat. Hum. Behav**., vol. 1, 2017, Art. no. 0028.
[22] L. Abdul Hadi and A. ElSayary, "Implementation of a High School Equivalency Policy in an **Active Learning Environment: A Case Study of US-Curriculum School in the United Arab Emirates," in Active and Transformative Learning in STEAM Disciplines,** M.D. Lytras, Ed. Emerald Publishing Limited, 2023, pp. 259–279. Available: https://doi.org/10.1108/978-1-83753-618-420231013
[23] A. ElSayary, "The influence of UAE schools initiatives on high-school students' STEM career aspirations," **Eurasia J. Math. Sci. Technol. Educ.,** vol. 19, no. 2, Art. no. em2225, 2023. Available: https://doi.org/10.29333/ejmste/12913
[24] E. Brynjolfsson and A. McAfee, **Machine, platform, crowd: Harnessing our digital future.** W. W. Norton & Company, 2017.
[25] H. Xie et al., "Artificial intelligence in education: A review," **IEEE Access**, vol. 7, 2019, pp. 127690–127707.
[26] A. Kukulska-Hulme and S. Bull, "Openness to mobile learning: Experiments with an AI-enhanced language-learning app," **Interact. Learn. Environ**., vol. 27, no. 5-6, pp. 620–634, 2019.
[27] I. Roll and P. H. Winne, "Understanding, evaluating, and supporting self-regulated learning using learning analytics," J. Learn. **Analytics**, vol. 2, no. 1, pp. 7–12, 2015.
[28] T. Wambsganss et al., "AI-Supported Education in STEM: A Systematic Review of AI Methods and Applications," **IEEE Access**, vol. 8, 2020, pp. 227846–227863.
[29] Stanford University, "**AI Cases in Education - IT Teaching Resources**," 2023. [Online]. Available: https://teachingresources.stanford.edu/resources/ai-cases-in-education/
[30] S. Alqahtani, "Challenges and Opportunities of Generative AI for Higher Education as Explained by ChatGPT," **J. Educ. Technol.**, vol. 18, no. 1, pp. 1–14, 2021.
[31] S. McMinn, "Navigating AI Literacy in the Classroom: A Case Study with GenAI's Data Analysis Tool," **J. Educ. Technol.**, vol. 18, no. 1, pp. 15–26, 2021.
[32] UNSW Sydney, "**AI Case Study - Minimising GenAI usage through simulated role-play**," 2023. [Online]. Available: https://www.education.unsw.edu.au/news-events/news/ai-case-study-2