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RESEARCH PAPER

Systematic Review: Generative Artificial Intelligence (GAI) and Artificial Intelligence (AI) and Learning in Elementary and Secondary Schools

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ABSTRACT

This study examines the role of Generative Artificial Intelligence (GAI) in school education and its advantages for learning in elementary and secondary school contexts. Education is an important activity for individuals, communities, and societies, while learning is recognizing patterns in the information we receive. The GAI enables a tailored approach to learning, enhancing engagement and motivation. Some previous studies have examined the usage of GAI in academic establishments and its impact on students and teachers. This study used the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) methodology. Journals and conference papers were determined to be the most popular types of manuscripts utilized to report results in response to our established research questions. The study shows that GAI is an effective tool, for improving educational practices and learning outcomes but does not improve skills. The findings indicate that additional research is required to achieve more conclusive results and completely comprehend its impact on teaching and learning processes. Additional research helps highlight the potential benefits and limitations of schools.

| **KEYWORDS** | School education, Learning, Artificial Intelligence, Generative AI, |

Introduction

Learning is a process of identifying patterns in the information that we receive. Educators use different methods to teach students how to recognize and learn from patterns. Primary education is focused on helping students correctly identify existing knowledge and acquire new information. Knowledge management is concerned with the aspects of learning (Muzaffar, 2020; Sisson & Mazzuchi, 2019). In school education, it is common practice to tailor teaching methods to students; learning styles, are often categorized as auditory, visual, and kinesthetic. The idea behind this approach is that it leads to better learning outcomes. for instance, learners are believed to retain information better when it is presented visually. However, while this approach is widely accepted and effective, studies have questioned its validity, and empirical evidence is lacking. Despite this, a learning style suggests that students learn better when taught in a way that suits their learning style (Ali et al., 2022).

Education is a vital activity for people, communities, and societies. It faces possibilities and challenges, including frequent disruptions (Muzaffar, 2016). The growth of digitalization has opened up numerous opportunities. The internet provides a vast amount of information and knowledge for students and teachers with internet access, who can comprehend and use it. However, despite decreasing digital divides, as of 2023,

35.4% of the global population still lacked internet access. By 2023, Generative Artificial Intelligence (GAI) had become widespread and garnered significant media attention, as evidenced by inquiries on major search engines worldwide. GAI has been developed for decades with Machine Learning (ML) techniques as its foundation. In November 2022, OpenAI released ChatGPT-3.5, a generative pre-trained transformer (GPT) AI chatbot, making it accessible to a wider audience with internet connectivity and a smartphone or PC. This chatbot powered by Artificial Intelligence (AI) can respond to user input in a way, that feels natural and informative (Jauhiainen & Guerra, 2023).

GAI provides several benefits, depending on the students' ages. Primary school education can help students learn reading, vocabulary, writing, and counting skills from an early age—advanced themes, such as writing styles, grammar, and text analysis. Large Language Models (LLMs) can help make a difficult, lengthy language easier and more concise. For instance, the app can provide personalized feedback, analyze user needs, and evaluate outcomes. This was discovered through a test in which primary school students polished their language. The LLMs can produce questions and prompts that urge students to think critically about what they read and write. Additionally, they can analyze and comprehend offered information, which enhances students' skills. GAI in secondary school education enables personalized content for students in natural sciences, humanities, and languages, tailored to their abilities and interests. The GAI enables a tailored approach to learning, increasing engagement and motivation. LLMs might create practical challenges and quizzes to help students grasp and contextualize study content. GAI enables thorough performance tracking and tailored programming based on individual student capabilities. This individualized approach reduces anxiety and boredom in class, which can lead to dissatisfaction and dropout rates within the educational system (Kasneci et al., 2023).

With the increasing use of AI technologies, the world is experiencing technological advancement. It has expanded beyond its roots in computer science and is now utilized in various fields such as engineering, commerce, art, and science. As a result, it has started to impact many aspects of human life. To thrive in the digital age, individuals must enhance their AI literacy by acquiring new skills (Yue et al., 2022). It intensely impacts our daily lives, and it is also widely acknowledged that AI is among the most disruptive technologies in history. Contrary to popular belief, AI has raised expectations instead of decreasing them. Although general-purpose AI is still a distant reality, it is currently utilized to solve real-world problems in various applications. Young people must comprehend how AI functions to effectively use new technologies in their daily lives, including learning and social interaction (Casal-Otero et al., 2023).

Integrating ChatGPT-3 into the educational environment can significantly boost students' engagement levels and enhance their ability to make connections between various subjects. ChatGPT-3 can offer personalized explanations, answer questions in real-time, and present complex concepts in related terms. This dynamic interaction encourages students to actively participate in learning, fostering a deeper understanding of the material. Additionally, the tool can help bridge different topics, allowing learners to see how concepts intersect and relate, thus promoting critical thinking and a more holistic approach to education

Literature Review

Several studies highlighted AI's potential to support teachers by automating administrative tasks and providing real-time insights into student performance, thus

allowing educators to focus more on instruction. However, the literature also reveals significant challenges, such as ethical concerns regarding data privacy, the need for teacher training AI tools, and the risk of over-reliance on technology that could reduce critical human interaction in learning. As Educational Robotics (ER) and virtual tutors grew in popularity, scholars noted both the advantages and limitations of these tools in fostering engagement and promoting STEM skills (Bano et al., 2023), emphasizing that careful implementation and teacher support are essential for effectively integrating AI in classrooms (Rizvi et al., 2023). This contrast reflects the broader debate regarding integrated AI technologies in the educational sectors, as stakeholders attempt to weigh the potential benefits and hazards. Existing research on GAI such as ChatGPT has proved its ability to promote learning outcomes comparable to those attained by human instructors, by delivering personalized feedback and instructions. Teachers have been shown to utilize ChatGPT more frequently than students for different purposes, including creating lesson plans, examinations, and example solutions (Elkhodr et al., 2023).

Methodology and Material

We used the Preferred Reporting Items Systematic Reviews and Meta-analysis (PRISMA) (Moher et al., 2009) methodology for this study and this systematic approach provide a robust framework for comprehensively understanding the topic and drawing meaningful conclusions. This methodology ensures that the study adheres to established standards for a quality review. To gather relevant literature, we utilized three online databases, enriching the breadth and depth of our literature search. Our study was meticulously structured around two specific research questions.

Research Questions:

Question 1: Is Generative Artificial Intelligence (GAI) a new assistive tool or does it enhance learning skills in school education?
Question 2: What is the effectiveness of Artificial Intelligence (AI) in elementary and secondary school students' learning?

Search Strategy

Initially, we tried searching articles using keywords ("Learning GAI" OR "School education") AND ("Learning" OR Artificial Intelligence") AND ("primary OR elementary") AND ("secondary school" OR "middle school") from November 2022 to October 2024, displayed in Table 1.

Table 1
Search Articles Using the Keywords

Database	Keywords
IEEE Xplore	("Learning GAI" OR "School education") AND ("Learning" OR Artificial Intelligence") AND ("primary OR elementary") AND ("secondary school" OR "middle school")
ACM Digital Library	("Learning GAI" OR "School education") AND ("Learning" OR Artificial Intelligence") AND ("primary OR elementary") AND ("secondary school" OR "middle school")
Google Scholar	("Learning GAI" OR "School education") AND ("Learning" OR Artificial Intelligence") AND ("primary OR elementary") AND ("secondary school" OR "middle school")

Finally, we obtained 232 articles from these 3 databases, IEEE (Institute of Electrical and Electronics Engineering) Xplore, ACM (Association for Computing Machinery) Digital Library, and Google Scholar database. 17 articles were repeated. 42 articles had no full-text availability. There were 173 articles screened by title and abstract and 57 were unrelated to our topic. 109 articles were removed due to other reasons (including books, chapters, dissertations, and reviews), such as higher education, undergraduate and college students learning high school education, the industry needs and involvement analysis, reports, and learning related to disability, gesture, teaching approach, space engineering industrial impact for digitalization, design, and challenges and digital education. Therefore only 7 articles were suitable for demonstrating the effectiveness of digital learning, as shown in Figure 1.

Inclusive and Exclusive Criteria

We have incorporated articles that cover various aspects, of AI and GAI in school settings. We have excluded books, chapters, dissertations, reviews, and reports on industrial and related to other fields of AI and GAI, particularly those related to high schools and higher education or intended for professional purposes.
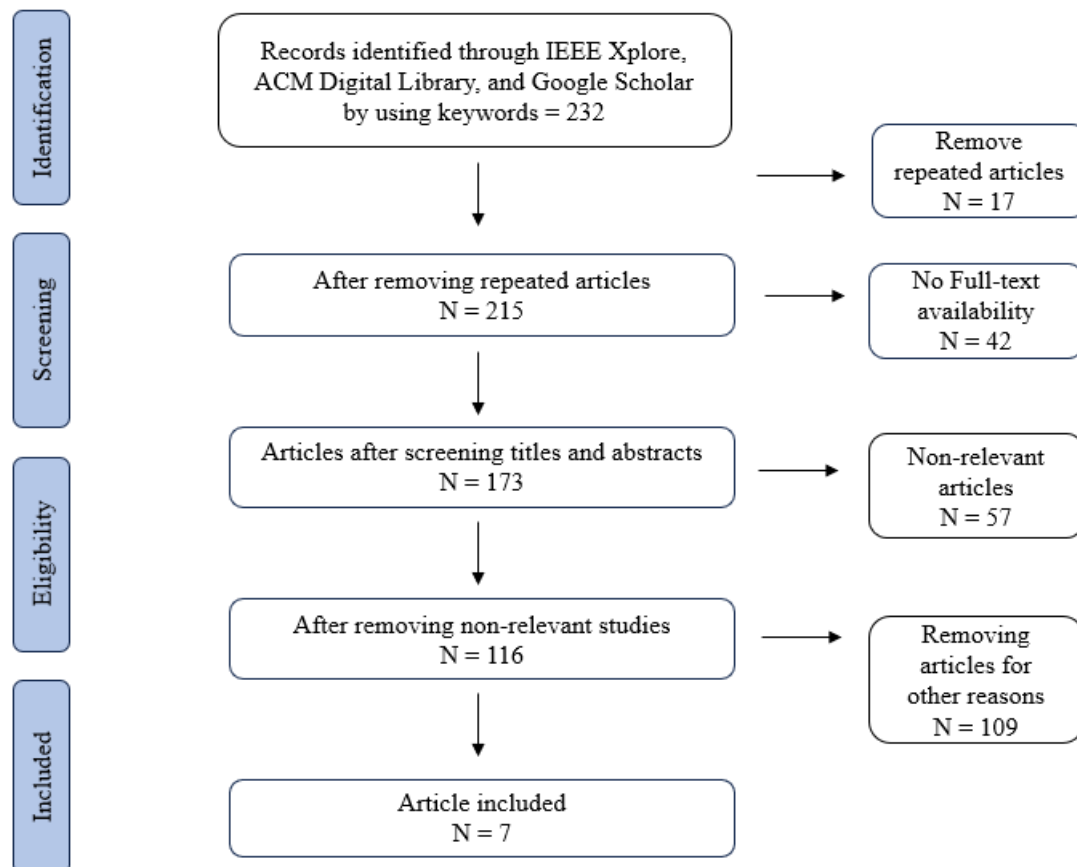

Figure 1
The Flowchart of the PRISMA Methodology

Results and Discussion

This section will discuss the results and answer the two research questions: Is GAI a new assistive tool or does it enhance learning skills in school education? And, what is

the effectiveness of AI in elementary and secondary student learning? We also provide additional relevant information.

Artificial Intelligence (AI) and GAI in School Education

Artificial Intelligence (AI) is a computer science field that seeks to create intelligent machines capable of mimicking human behavior and mental processes. Algorithms assist machines learn from data, intelligent judgments, and solve problems. AI can be divided into two categories: narrow AI and GAI. Narrow AI focuses on specific tasks that a human can do. Narrow AI focuses on specific tasks, such as facial recognition. GAI algorithms create new content based on real-world data patterns. These models have significant applications in natural language processing, computer vision, and brain imaging. GAI techniques have contributed to the production of high-quality creative work. Visual arts, music, literature, films, and animation are all examples of media. AI technology is transferred to inventive processes, especially in education. The collaboration, analogies, and scaffolding can help 5th graders understand AI concepts without programming skills. Educational theories like constructivism can provide an optimal learning environment (Relmasira et al., 2023).

Despite their potential, ChatGPT and other GAI are rapidly transforming education. Some schools have advocated banning ChatGPT in school settings, while others are developing software to detect AI-generated text. Teachers use strategies to discourage students from using ChatGPT to write essays and assignments. The New York (NYC) Education Department prohibited ChatGPT on school devices and networks, preventing students and teachers from depending on it. Advanced GAI, such as GTP-5, may outperform current techniques shortly (Baidoo-anu & Ansah, Owusu, 2023). LLMs, such as ChatGPT, have the potential to revolutionize teaching and the learning approach. For example, it aids personalized learning, lesson planning, language acquisition, research, and writing. It also helps professional growth, assessment evaluation, and students' familiarity with AI issues. LLMs in education are a promising study field that can improve students' learning and support teachers utilizing these models in education, it's important to exercise caution and understand their limitations and biases. Integrating LLMs into education requires strict privacy, security, environmental, and ethical considerations, as well as continual human supervision and direction (Kasneci et al., 2023).

The 21st century has seen a significant shift in educational techniques, driven by technological advancements like AI. Advancements in ML have enabled advanced digital content generation. GAI is an unsupervised or partially supervised ML system that generates man-made relics using statistics and probabilities. GAI uses Deep Learning (DP) to build artificial relics from digital content, including, image/graphics, text, audio, and video. Training examples are analyzed to understand patterns and distribution. The literature identifies two important GAI models: Generative Adversarial Network (GAN) and Generative Pre-trained Transformer (GPT). GAN is now the most prevalent GAI technique employed. GAN employs two neural networks, a generator, and a discriminator network (Baidoo-anu & Ansah, Owusu, 2023).

Children's ability to ask curiosity-driven inquiries enhances their learning. curiosity is defined, as the desire to know or experience something that drives exploratory activity in pursuing new knowledge. It is an important aspect that positively affects the individuals' learning experiences and consequences. It indicates that classrooms can foster curiosity by teaching students to be comfortable with ambiguity and ask questions to answer it (Abdelghani et al., 2024).

AI education interventions teach students in grades K-12 AI concepts and applications. It is important to note that ML is just one aspect of AI. ML refers to algorithms that can recognize patterns from vast amounts of data and develop models to forecast (Rizvi et al., 2023). AI has brought about a significant change in various aspects of human life, through its rapid technological advancement. GAI is taking place in many educational fields, particularly, medical and engineering education. GAI has various educational applications, including individualized learning support, evaluation, and intelligent tutoring systems. However, the GAI in education has sparked debates on ethical concerns, academic integrity, and the potential to transform teaching and learning. As GAI continues to evolve, it is crucial to study its effects, benefits, and limitations to determine its future in education (Bahroun et al., 2023).

By 2023, it will have been three years since the release of the GPT-3 large language model, less than two years since the Codex model, less than a year since the Copilot plug-in for generating code directly within an IDE, five months since the ChatGPT chatbot interface, and one month since their release. A working group was formed when the computing education community was still adjusting to the widespread use of GAI technologies by students and the general public. New models and techniques bring challenges and opportunities, raising important questions about adaptation. How will students' motivation to learn and retention be affected if they can create solutions to programming coursework? (Prather et al., 2023).

GAI a New Assistive Tool or Does it Enhance Learning Skills in School Education

The ChatGPT is a large language model that has the potential to make a significant impact in the field of education. There are several specific ways in which ChatGPT can be used to improve learning and resources that support it. However, it also has some deficiencies, such as lack of personal interaction, limited understanding, bias in training data, lack of creativity, dependency on data, limited ability to personalize instruction and privacy concerns. Overall, it can be powerful for enhancing teaching and learning. It's important to know its limitations and use it with other teaching methods prioritizing human interaction and understanding (Baidoo-anu & Ansah, Owusu, 2023).

Despite the benefits of GAI technologies such as ChatGPT in an educational context, educators, researchers, and policymakers continue to argue their potential benefits and downsides. This is primarily because, as some teachers have stated, these GAI tools might be exploited by students who want to cheat. Other instructors have expressed worry that AI technologies could misinform students by giving them inaccurate information, prompting calls to ban and restrict their use in school education. ChatGPT supports, on the other hand, believe it provides an opportunity to teach students how to use AI tools with caution and interact with these GAI technologies (Elkhodr et al., 2023).

Education stakeholders share their perspectives on the advantages of using GAI systems for teaching literacy in elementary schools, GAI systems can create customized lesson plans, including mentor texts, that teachers can adjust to each student's needs and skill level. These systems provide relevant and timely feedback for writing assignments and encourage new ideas (Han et al., 2024).

Numerous studies have investigated the potential and challenges of GAI tools in many settings, including education. Several studies have looked into the broader application of AI, highlighting the benefits, drawbacks, and ethical implications of

implementing GAI technology in various scenarios. GAI in scientific writing necessitates careful consideration and comprehension. ChatGPT's effectiveness is also being evaluated in other areas (Elkhodr et al., 2023).

The Effectiveness of AI in Elementary and Secondary Students' Learning

AI-powered chatbots like ChatGPT and Bing Chat are increasingly valuable in education and provide unique opportunities for students to address learning challenges. Computing education's future involves the use and impact of GAI and LLM-based tools, adapting teaching methods, and updates to academic integrity policies. It also calls for collaboration to shape computing education for the common good amidst its rapid evolution (Prather et al., 2023). The focus of education has shifted to preparing students for industries that use AI. Research in Science, Technology, Engineering, Arts, and Mathematics (STEAM) education should investigate the impact of thinking. This approach prepares them to adapt to changing job requirements and real-life situations (How & Hung, 2019).

AI supports advanced technologies such as ML and neural networks for solving problems. It can combine knowledge from various fields, providing an opportunity to enhance children's learning experiences by using multiple technologies simultaneously. Computers interact with children through gesture, touch, and speech, AI enables young learners to access digital content and services. However, there is limited research on how preschool teachers can intentionally improve children's learning using AI technologies. Moreover, there is a lack of studies on teaching AI to young children who don't have prior knowledge of computer programming and robotics. Teaching AI to young learners poses several challenges for early childhood educators. There is a need to figure out how AI is relevant to early childhood learning, identify concepts children can grasp, and engage children in meaningful experiences that help them acquire these core concepts (Yang, 2022).

Technologies are becoming more common and are impacting our daily lives. Educators are realizing the importance of AI education, as it can help students improve literacy, apply knowledge to solve real-life problems, and develop fundamental skills, along with critical and ethical reflection on the role and use of AI in society. It can positively affect the learning outcomes of young learners, motivating them and building positive attitudes. Effective teaching methods, hands-on activities, investigation with other subjects, and addressing misconceptions are ways to promote successful AI education (S. J. Lee & Kwon, 2024). It is critical to create an AI curriculum that appeals to all age groups providing comprehensive information, and develop dynamic and engaging learning materials aligned with K-12 educational objectives. Although difficult it is critical to combine AI academic knowledge with practical experience. Relatively sophisticated topics, such as reinforcement learning, were deemed both difficult and interesting. Similarly, students' interest and perception of AI-powered agents improved after they created them during one of the AI training sessions (Rizvi et al., 2023).

ChatGPT garnered over one million users within just one week of its official launch on November 30, 2022. This GAI tool surprised the global community with its remarkable ability to execute complex tasks. However, the paper also identified some flaws in ChatGPT, such as inaccurate information. This contrasting situation suggested that policymakers, educators, and technology professionals collaborate and engage in discussions to address these issues (Baidoo-anu & Ansah, Owusu, 2023). The following point indicates that ChatGPT is a tool, but technically it does not support skill enhancement. In the future, it may be possible to enhance skills by adding some new

features, creating a few solutions with options, and combining them to solve problems, but currently, it is just a tool. It's important to use it carefully, particularly in scientific fields.

There is a lot of potential to improve how we develop and encourage children's interest in AI. Every topic in AI can be taught at different levels of complexity. One possible solution is to simplify the process by hiding certain actions within a "black box." Previous studies have shown that children can comprehend ML processes with multiple steps, such as data labeling and evaluation. However, learning about just one building block of ML doesn't lead to a complete understanding. Despite the potential of IoT and Robotics to enhance student engagement and teach AI concepts, there remains a dearth of research on technologies in AI educational programs. We must explore and develop strategies for integrating AI education programs that effectively incorporate cutting-edge technologies (Rizvi et al., 2023). It is essential to prepare young learners to become aware citizens and competent workers in the era of AI. To achieve this, workshops can be helpful for middle school students and are crucial for shaping their interest and perspectives on AI and its related careers (I. Lee et al., 2021).

GAI has ethical and societal implications. It can create Deepfakes and spread misinformation. It is challenging our understanding of AI systems as socio-technical systems. GAI-generated media is easily available on social media platforms, especially among children who may not be aware of its presence. Previous research has demonstrated the significance of digital media and AI literacy in young learners. Therefore, GAI methodologies introducing secondary school students to and encouraging critical discussions about their societal and ethical implications are crucial (S. Ali et al., 2021). Teachers' negative attitude towards GAI contradicts the current literature on technology integration in instruction. Teachers often hesitate to integrate emerging technologies due to their complexity and breadth and may lack certain competencies such as comfort and open-mindedness (Kaplan-Rakowski et al., 2023).

Conclusion

This study presents a comprehensive review of the latest literature on GAI, focusing on its impact on educational territory. The study delved into the context: of GAI, as a cutting-edge trend in school education. We used the PRISMA methodology to conduct this literature review.

The review included an analysis of 232 articles that discussed the role of GAI as a tool in elementary and secondary education, especially in grades 5 to 8. However, the study emphasized that only a limited number (7 studies) provided an evaluation, which hindered a more comprehensive analysis. The investigation revealed a lack of empirical evidence concerning the use of GAI in elementary and secondary education, and further research is needed in this area.

In this literature review, the defined two research questions were thoroughly addressed with detailed analysis and insight. ChatGPT model that has the potential to impact education. There are several specific ways that ChatGPT can be used to improve learning and the resources that support it. AI-powered chatbots like ChatGPT and Bing Chat are increasingly useful in education and provide special opportunities for students to address learning challenges. These chatbots offer benefits like interactivity, personalization, and a better understanding of topics and create a comprehension of the principles and concepts of robotics and automation.

It's important to acknowledge that the study was based on 7 articles identified using specific research criteria in three databases. It was noted that using alternative databases may have yielded additional relevant articles. Therefore, the study is best viewed as an initial exploration rather than a comprehensive overview.

Recommendations

The review brought attention to several other significant points. AI is a field of computer science that aims to create intelligent machines that can change human behavior and thinking processes. GAI algorithms generate new content based on real-world data patterns. Its technique has helped produce high-quality creative work. The study also provided insight into the role of GAI as a supportive learning tool, highlighting that its current impact on enhancing skills is limited. It is anticipated that GAI may contribute to skill development in the future. The study showed that at present, it primarily serves as a tool. Educators and stakeholders are actively considering its potential and further investigation is necessary to understand its impact. The study aims to offer valuable guidance to educators and researchers in the field of education.

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