

Opportunities, Challenges, and Suggestions for Generative AI in Education

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Abstract

Though generative artificial intelligence (GenAI) has achieved remarkable success across diverse fields (such as chatbots, image generation, and speech recognition), its applications in education remain limited due to the complexity of the educational system. In this paper, we analyze the opportunities and challenges of GenAI-based education for different participants, including teachers, students, and other relevant stakeholders. Based on recent research, we further propose four actionable recommendations to address existing issues, contributing to the continuous development of GenAI-based education.

Keywords

Education; GenAI; Survey

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1. Introduction

Generative artificial intelligence (GenAI) technologies can automatically generate content in response to prompts through natural-language conversational interfaces and have exhibited great potential in various fields. Despite the remarkable effects brought by GenAI-based applications, such as ChatGPT, Cursor, and Sora, their application in the field of education is still limited^[1]. However, GenAI-based education offers substantial improvements compared to traditional education, creating an urgent need for AI-driven evolution in the education sector. For instance, traditional education is universal but lacks adaptability for students with different backgrounds. Another case is that GenAI-based tools can quickly generate effective and accurate content for teachers and

students, which significantly improves teaching and learning efficiency.

Recent research^[2-5] has not only demonstrated the efficacy of solidifying the theoretical underpinnings of GenAI in education but also opened up viable paths for more in-depth collaborative research between educators and artificial intelligence technicians. In our study, we further explore the potential of GenAI in education based on existing technologies and works. Additionally, we analyze the challenges and propose innovative solutions, contributing to the continuous development of GenAI-based education.

The main contributions of this paper can be described as follows:

(1) We discuss the opportunities and challenges that

GenAI brings to several roles (teachers, students, and other stakeholders) in education based on recent studies;

- (2) We propose guidelines to promote the development of GenAI for educational purposes.

The remaining paper is organized as follows. Section 2 introduces related works, including popular GenAI applications and GenAI for educational scenarios. Section 3 describes the opportunities and challenges of GenAI in education. Furthermore, we provide some effective suggestions in Section 4. Finally, conclusions are drawn in Section 5.

2. Recent research

2.1. Generative artificial intelligence applications

Generative artificial intelligence models have achieved great success in various fields, such as speech, image, and video. Different from traditional AI models, GenAI models usually contain more parameters and are trained using a huge amount of unstructured data. The development of GenAI models typically involves multiple key stages, such as pre-training, fine-tuning, and deployment. The applications of GenAI are more

interactive, facilitating conversational exchanges and enabling more personalized responses based on user prompts. Excellent applications are as follows:

- (1) ChatGPT ^[6], launched by OpenAI, is an intelligent chatbot that serves hundreds of millions of users worldwide.
- (2) Cursor ^[7], an AI-coding software, can significantly improve the efficiency of developers and programming learners.
- (3) Sora has significantly influenced the text-to-video (T2V) domain, culminating in remarkable capabilities.
- (4) The AQ application, developed by Ant Group using a large medical model, promotes evolution in the medical field.
- (5) Gamma AI is a platform specifically designed for educators to streamline the process of creating lessons and presentations.

2.2. GenAI for education

In recent years, GenAI has been considered an outstanding means to improve the efficiency, adaptability, etc. of education. As shown in **Figure 1**, GenAI can provide different benefits for various relevant roles.

Firstly, GenAI can be regarded as an assistant for

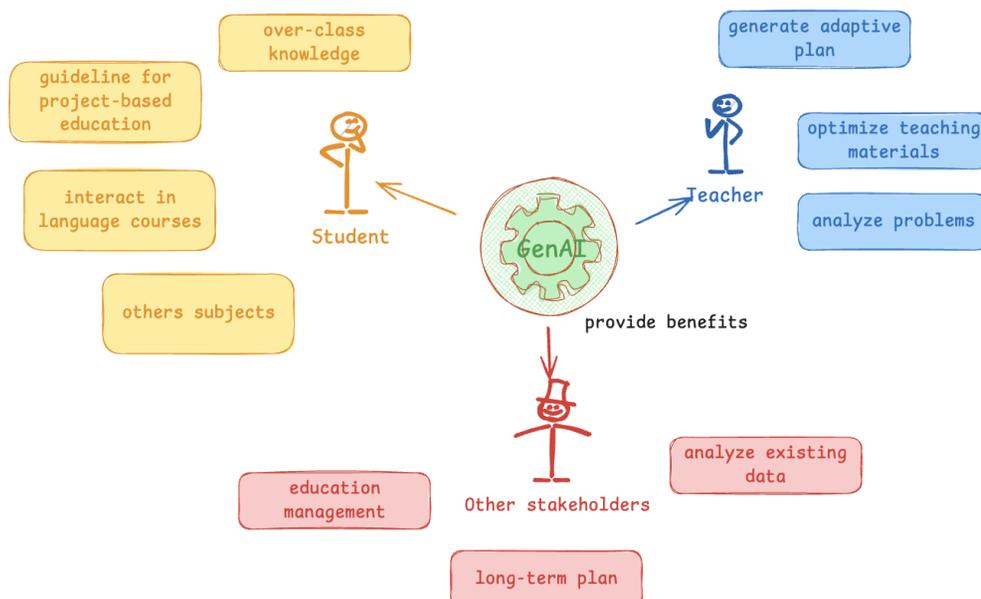


Figure 1. The benefits of using GenAI in education for various roles

teachers^[8]. In the academic field, Wang^[9] surveyed how GenAI can assist educators in collecting relevant assessment materials, automating exercise creation. Kehoe^[10] explored the potential of GenAI to revolutionize lesson planning in initial teacher education. Additionally, there are several industry GenAI-based applications for teachers, such as Gamma AI (a platform designed specifically for educators to streamline the process of creating courses and presentations), Coursebox (which allows educators to easily create digital courses), etc. For students, GenAI tools are co-tutors and learning assistants. Notably, research^[11] surveyed 1,041 full-time undergraduate students and concluded that students favor AI tools—consistent with the interactive and efficiency-driven advantages of GenAI highlighted above—because these tools save them time and help them perceive improvements in their academic work.

Though the advantages of the GenAI-based education mentioned above, we cannot ignore that concerns brought by GenAI technologies. Data security is one of the most notable problem because education data leaks are unacceptable. Furthermore, the competence limit and using threshold of GenAI model brought the huge challenge to the implementation of AI in the field of education. Besides, many education participants do not make enough readiness for AI due to underdeveloped infrastructure, distrust or others.

3. Details for analysis

3.1. Opportunities of GenAI for education

Section 2 describes some classical works of GenAI for education. In this section, we introduce the opportunities of GenAI in education. **Figure 1** demonstrates the advantages of GenAI-based education compared to traditional education generally. And the remainder of this section discusses these contents in detail.

3.1.1. Teacher

GenAI tools are effective assistants for teachers, as they save inefficient working time and reduce unnecessary effort. We discuss four advantages of GenAI-based education in this section:

Firstly, GenAI-based education provides more adaptive methods than traditional education. Students in

schools are diverse: some may like learning historical knowledge, while others are enthusiastic about math. In traditional education, it is difficult for teachers to attend to every student, so they usually adopt more generalized teaching methods. However, GenAI can help teachers design personalized plans for each student based on their learning needs. For example, Duolingo^[12] offers users individualized learning plans, real-time feedback, and relevant guidance and support to help them better understand their learning problems and progress.

Besides, teachers can generate or optimize teaching materials using GenAI tools—such as presentation slides, engaging videos, or teaching plans—which previously needed to be completed manually in traditional education. To illustrate, recent studies provide specific commands that teachers can use to interact with ChatGPT, enabling the generation of questions and answers, quizzes, and assignments.

Furthermore, in traditional education, teachers usually analyze problems based on their own knowledge, which may be limited in many scenarios. GenAI models (such as ChatGPT, DeepSeek, and Qwen) are trained on huge amounts of high-quality data, so they possess rich prior knowledge. This allows them to help teachers gain more insights and diverse perspectives when addressing teaching-related questions. As an illustration, educators^[13] have attempted to use GenAI to explore narratives from various perspectives and generate more systematic surveys.

3.1.2. Student

GenAI can function as an intelligent tutor or assistant to deliver personalized academic guidance for students. By leveraging such technologies, students are enabled to explore knowledge beyond traditional classroom instruction and even take an active role in their own learning process. The specific benefits for students can be summarized as follows:

First of all, students can learn more knowledge in the traditional class using tools effectively. In traditional education, learning content is inherent and limited, and is far behind the most advanced knowledge. Thus, students usually lack of necessary professional competence after graduating. GenAI is the most effective manner to deal with this problem because tools are trained using massive

data and even fine-tuned for a special scene. For example, there are many code generation tools to generate advanced code structure not exhibited in class for students in computer science, such as Cursor (Bytedance), Codefuse (Ant Group).

Besides, GenAI can be an expert for students' project-based classes. Project-based learning (PBL) stems from the learning theory of active construction. However, students often lack real practical experiments in the project-based subject, which brings a lot of distress. In contrast, GenAI tools can provide effective instruction and help students implement high-level work. Recent research^[14] explored the AI for PBL and regarded AI as an important tool for PBL.

In language courses, GenAI also takes advantage in contrast to traditional classes. Recently, students usually receive complex syntax and try to remember a large number of words, but not a real environment. GenAI can be seen as a co-worker to provide reality scenarios for learners. To illustrate, Duolingo is a free language learning program based on a GenAI model, where students obtain real-time feedback with a chatbot in simulation environments. In addition to language learning, other fields also benefit from GenAI simulating competence, such as medical^[15], chemistry^[16], etc.

3.1.3. Other stakeholders

Beyond teachers and students, other stakeholders—such as school leaders—can also leverage GenAI technology to enhance both the efficiency and effectiveness of their work. For instance, school leaders can utilize GenAI to analyze existing educational data (e.g., student performance trends, resource allocation metrics) to formulate more scientific long-term development plans. Additionally, they can streamline key education management tasks—including curriculum oversight, faculty evaluation, and administrative coordination—with the support of GenAI tools, thereby reducing manual workload and improving decision-making accuracy^[17].

3.2. Challenges of GenAI for education

Despite the effectiveness brought by GenAI for education, it is crucial to acknowledge the concerns of GenAI technology. We split the challenge into four categories as follows:

- (1) Data privacy and security
- (2) Threshold of GenAI
- (3) Readiness of roles
- (4) Model limits

3.2.1. Data privacy and security

Research should pay more attention to data privacy and security in GenAI fields. In the development stage, workers usually fine-tune the existing LLM model using private data in order to reduce model biases and make the model more compatible with a specific scene. In the product stage, users should offer an accurate prompt to the model. For example, if a teacher would like to explore diverse perspectives for exam questions, they need to provide original question content and existing answers to model.

All of the actions mentioned above bring the risk of user data, which is a huge obstacle for promoting GenAI in education, because private data of teachers or students is precious and should not be leaked.

3.2.2. Threshold of GenAI

During the pre-training or fine-tuning stages, GenAI models are resource-hungry and computation-intensive—characteristics that make them difficult to deploy on resource-constrained devices. For instance, the Qwen^[18] model (with 14 billion parameters) requires a training dataset of up to 3 trillion tokens, along with multiple high-performance GPU devices. Such resource demands are prohibitive for most institutions. While numerous technologies have been proposed to lower the deployment threshold of AI models—including knowledge distillation, model pruning, and quantization—barriers to GenAI application persist.

Although the computational requirements during the inference stage are significantly lower than those of pre-training and fine-tuning, many institutions still face challenges related to high computing resource demands and technical barriers.

3.2.3. Readiness of roles

The readiness of roles plays an important role in promoting GenAI-based education.

- (1) Teacher: Teacher readiness is significant to the promotion of GenAI in education. However,

one challenge teachers may face is a lack of professional development programs and training, but the generative results obtained by AI tools are often dependent on high-quality prompts. Another mainstream problem is that some teachers do not trust AI and think AI tools lack innovation. This problem will be described in detail in Section 4.

- (2) Student: Students may tend to directly copy results generated by AI tools, neglecting critical thinking and independent learning. This practice runs counter to the fundamental goals of education. Additionally, many students struggle to formulate reasonable and effective inputs when using AI tools, limiting the tools' practical value in their learning process.
- (3) School: Firstly, AI infrastructure plays a crucial role in AI applications. However, many schools cannot provide outstanding infrastructure. Besides, the absence of clear policies and guidelines can also bring uncertainty and challenges for the promotion of GenAI.

3.2.4. Model limits

The experience of AI applications depends largely on the capabilities of the model. There are three main challenges that should be of concern:

- (1) Model generalization: AI models are always dependent on existing data, so they have rich prior knowledge, but overfitting often occurs. However, the innovation and creativity are necessary for some fields, such as computer science, chip research, e.t, rather than too much prior knowledge.
- (2) Real-time: More and more institutes and companies provide high-performance basic models, such as Qwen (Alibaba), GPT-4^[19] (OpenAI), Deepseek-V3^[20] (DeepSeek). However, basic models cannot guarantee the real-time of data, which is an important attribute of education.
- (3) Application limit: LLMs have shown remarkable capabilities in reasoning, which could be seen as the brain. AI applications need not only the "smart brain," but also the "limbs." Thus, more

and more proprietary AI agents are proposed to solve various problems, which require a lot of manpower for maintenance.

4. Proposed suggestions

The GenAI technologies have brought about a massive evolution in education, yet they currently face challenges (as discussed in Section 3.2). Motivated by these insights, we propose four actionable suggestions that can facilitate the integration of GenAI in educational contexts. The relationships between the challenges and suggestions are shown in **Figure 2**.

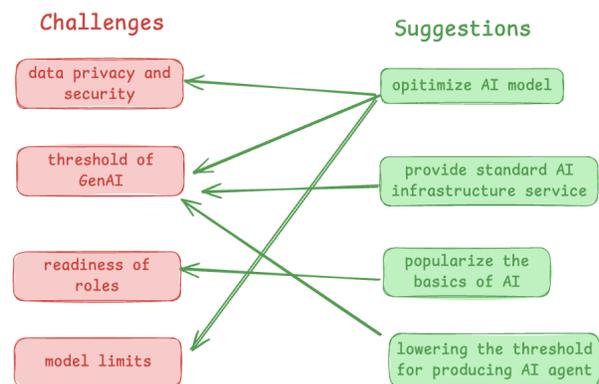


Figure 2. The relationships between the challenges and suggestions

4.1. Optimizing AI model

As mentioned in Sections 3.2.1, 3.2.2, and 3.2.4, AI models play crucial roles in the end-to-end process, so we are eager to improve the model performance, reduce the computation and memory resource requirements, and avoid privacy leakage for the existing model.

Firstly, future works should improve the generalization further and avoid overfitting. Besides, we can pay more attention to reinforcement learning models, which can learn effective knowledge from the real environment rather than collected data (for example, Deepseek-r1^[21]). Furthermore, model compression and acceleration technologies cannot be ignored, such as model pruning, knowledge distillation, etc., which can significantly reduce the threshold of model usage. For the data privacy problem, validation methods should be valued, such as federated learning technologies^[22].

4.2. Providing standard AI infrastructure (AI-Infra) service

As described in Section 3.2.2, AI infrastructure, encompassing GPU devices, cluster management systems, and other components, remains cost-prohibitive for many organizations. A viable solution to this challenge is the provision of standardized AI infrastructure services by central institutions on a pay-as-you-go model, which enables users to circumvent the need to build infrastructure from scratch. For instance, numerous cloud service providers have already launched analogous services, such as Volcano Engine MLP and Aliyun PAI. Moreover, many organizations can develop in-house GenAI models using standardized AI infrastructure, a solution that effectively tackles data privacy issues.

4.3. Popularizing the basics of AI

As described in Section 3.2.3, Teachers, students, and stakeholders should master basic AI knowledge in GenAI-based education.

Teachers should develop trust in validated AI models while mastering the basic principles of AI technologies, enabling them to integrate these tools effectively into instructional design.

Students, conversely, should view AI as a cognitive assistant rather than a direct source of answers, fostering critical thinking and independent problem-solving skills.

Stakeholders should offer robust support throughout the end-to-end teaching process, including the formulation of policies and guidelines, as well as the provision of AI infrastructure.

4.4. Lowering the threshold for producing AI agents

AI agents leveraging GenAI models can execute specialized tasks, making it crucial to establish simple and effective methodologies for AI agent development. Open-source is an important way to share existing technology, such as dify (the agentic platform). Through open-source, developers can develop and use new agent tools. Another manner is that cloud service providers can offer standardized AI agent production workflows alongside detailed implementation guidelines, such as Agentforce.

5. Conclusion and future work

This paper systematically explores the landscape of GenAI-based education through a structured analytical framework. Starting with an in-depth examination of its opportunities, it is evident that GenAI tools serve as invaluable assets for educators: they can generate customized teaching plans tailored to diverse classroom needs and provide multifaceted instructional insights, thereby enhancing the quality of curriculum design. For students, GenAI functions as both a collaborative tutor and a specialized knowledge resource, enabling them to transcend the boundaries of traditional classroom learning—particularly in project-based learning contexts and language courses. Additionally, other stakeholders such as school leaders can leverage GenAI technologies to streamline administrative operations, optimize resource allocation, and facilitate evidence-based decision-making.

Nevertheless, the widespread adoption of GenAI in educational settings is not without obstacles. This study categorizes the existing challenges into four distinct dimensions: (1) Data privacy and security risks, which arise from the sensitive nature of educational data and potential vulnerabilities in GenAI systems; (2) Prohibitive adoption thresholds for most educational institutions, including inadequate infrastructure and technical capacity; (3) Role readiness gaps, referring to the need for educators, students, and other stakeholders to adapt their roles and skill sets to effectively integrate GenAI into educational practices; (4) Inherent model limitations, such as inadequate generalization capabilities, delayed information updates, and constrained application scenarios. Corresponding to these challenges, the paper proposes four targeted strategic recommendations aimed at mitigating the identified issues and promoting the sustainable integration of GenAI in education.

It is important to acknowledge the limitations of this research. The current study primarily relies on existing literature reviews and theoretical analysis, lacking in-depth empirical data from direct educational participants. To enhance the comprehensiveness, validity, and practical relevance of future research, we intend to conduct extensive questionnaire surveys and in-depth interviews with educators, students, and relevant stakeholders. This approach will enable us to gather authentic user experiences and perspectives, further

analyze the multifaceted impacts of GenAI in real educational contexts, and refine our understanding of its potential and constraints. Ultimately, such empirical

investigations will contribute to the development of more actionable strategies for harnessing GenAI to advance the modernization of education.

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