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Generative Artificial Intelligence and the Reshaping of Future Education: Capability Characteristics and Application Trends

ZHOU Huiling

Master in Digital Technologies for Business

Supervisor:
PhD Rúben Pereira, Assistant Profressor,
ISCTE – Instituto Universitário de Lisboa

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TECNOLOGIAS
E ARQUITETURA

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Abstract

This study is based on the characteristics of the current era of artificial intelligence and the status quo of school education development. This thesis introduces the latest development of Generative Artificial Intelligence technology, analyzing the connotation, technical content and main characteristics of Generative Artificial Intelligence technology. This thesis analyzes the core competence and typical educational application of Generative Artificial Intelligence represented by the large-scale language model developed in China, and reveals the application of GenAI in the field of text generation, language understanding and so on.

The research also emphasizes that the deep application of Generative Artificial Intelligence in education will promote the transformation of educational relations, the intelligent upgrading of educational environment, the innovation of educational resource allocation, the reshaping of intelligent teaching methods, and thus promote the reshaping of human education and learning paradigms.

The main measures and paths of education reform in the intelligent era aim to provide guidance for the successful practice of education reform and contribute to the steady development of school education under the trend of artificial intelligence.

Keywords:

Generative Artificial Intelligence, Educational Forms; Education Digital Transformation, Application Scenarios

Resumo

Este estudo é baseado nas características da era atual da inteligência artificial e no status quo do desenvolvimento da educação escolar. Esta tese apresenta o mais recente desenvolvimento da tecnologia de Inteligência Artificial Generativa, analisando a conotação, o conteúdo técnico e as principais características da tecnologia de Inteligência Artificial Generativa. Esta tese analisa a competência central e a aplicação educacional típica da Inteligência Artificial Generativa representada pelo modelo de linguagem em larga escala desenvolvido na China e revela a aplicação da GenAI no campo da geração de texto, compreensão da linguagem e assim por diante.

A pesquisa também enfatiza que a aplicação profunda da Inteligência Artificial Generativa na educação promoverá a transformação das relações educacionais, a atualização inteligente do ambiente educacional, a inovação da alocação de recursos educacionais, a reformulação de métodos de ensino inteligentes e, assim, promoverá a reformulação dos paradigmas de educação e aprendizagem humana.

As principais medidas e caminhos da reforma educacional na era inteligente visam fornecer orientação para a prática bem-sucedida da reforma educacional e contribuir para o desenvolvimento constante da educação escolar sob a tendência da inteligência artificial.

Palavras-chave:
Inteligência Artificial Generativa, Formas Educativas; Transformação Digital da Educação, Cenários de Aplicação.

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List of Acronyms

Artificial Intelligence - AI

Augmented Reality - AR

Dynamic Difficulty Adjustment --DDA

Generative Adversarial Networks -- GANs

Generative Artificial Intelligence - GenAI

Variational Autoencoders –VAEs

Chapter 1 – Introduction

With the significant enhancement of computing power and the rapid development of big data technology, Generative artificial intelligence (GenAI) has become one of the cutting-edge technologies in the field of artificial intelligence (AI). GenAI technology refers to the technology of automatically generating multimedia content such as text, images, audio, and video through complex algorithmic models [1-3]. Since the beginning of the 21st century, this technology example large language models; GPT 4o; Claude; Gemini etc. has evolved from simple pattern recognition and automatic content generation to today's ability to complete complex creative and analytical tasks, demonstrating astonishing progress. Especially with the widespread application of deep learning, it has greatly promoted the development of GenAI Technology. By simulating the neural network structure of the human brain, deep learning enables machines to not only understand and generate structured data such as text and images, but also demonstrate creativity comparable to or even surpassing that of humans in fields such as music composition, animation production, and virtual reality (VR) [4]. The progress of this technology is not limited to the technical level, but also demonstrates enormous potential for application in multiple fields such as education, art, and design. In the field of education, the application of GenAI is reshaping the way teaching and learning are conducted. It can generate personalized learning materials and tests based on students' learning history and personal preferences, thereby improving learning efficiency and engagement. In addition, GenAI can also simulate characters or events from different historical periods, providing students with an immersive learning experience. With the continuous evolution and maturity of these technologies, future education would become more personalized, interactive, and creative [5].

Understanding the concepts of future education and learning is crucial before exploring the impact of GenAI on future education. The core concept of future education is to utilize innovative technologies and methods to improve teaching quality and efficiency, while making education more inclusive, personalized, and accessible [6]. This includes not only the scope of traditional classroom learning, but also multiple aspects such as long-term life learning, vocational training, and self-inspiration. The concept of future learning emphasizes flexibility, adaptability, and sustainability. Learning is no longer seen as a stage with a clear beginning and end, but as a lifelong, dynamic process. This learning approach encourages students to actively explore and construct knowledge, rather than passively receiving information. In addition, future learning also emphasizes interdisciplinary knowledge integration, advocating for finding connections between different disciplines to cultivate more comprehensive problem-solving abilities. In this context, the application of GenAI provides new impetus and possibilities for achieving these educational goals [7]. Through automated generation of content and simulation interactions, the learning experience can become richer and more diverse. For

example, AI can generate customized tutorials and exercises based on students' learning progress and interests or create three-dimensional representations of historical events through VR technology, allowing students to experience and learn history firsthand in a brand-new way. These technologies not only expand the scope and depth of education, but also provide students with more opportunities to explore the unknown and develop personal interests [8].

GenAI is set to revolutionize future education by enabling personalized learning experiences, creative content generation, and immersive educational environments [9]. GenAI's data analysis capabilities allow for tailored educational pathways that adapt to individual student needs, enhancing learning efficiency. Furthermore, AI's ability to generate new forms of art and literature can broaden creative expression among students. Technologies like VR facilitated by GenAI create interactive and vivid learning scenarios that can transform subjects such as history and science into engaging, experiential adventures. Additionally, the scalability of AI-generated educational content can help bridge resource gaps, providing valuable learning opportunities worldwide [10]. GenAI also supports lifelong and flexible learning outside traditional classroom environments, catering to ongoing educational needs throughout one's career. Automated assessments and feedback mechanisms streamline the learning process, allowing for real-time improvements and reducing the workload on educators. By synthesizing knowledge across various disciplines, GenAI fosters an interdisciplinary approach, preparing students for the complexities of the modern world. Through these avenues, GenAI is poised to make future education more personalized, accessible, and holistic, aligning with the evolving demands of global education [11].

Although GenAI provides unprecedented opportunities in the field of education, its application also faces a series of challenges and problems. Firstly, the quality and accuracy of technology remain the main concerns. GenAI systems can sometimes generate misleading or inaccurate information, especially when dealing with complex topics and subtle concepts [12]. The inaccuracy of this information may mislead students and affect learning outcomes. Secondly, data privacy and security issues must be taken seriously when using GenAI in education [13]. Educational technology frequently collects and processes personal data of students, including learning habits, performance, and personal preferences. If the sensitive information is properly used or leaked, it may pose a serious threat to the privacy and security of students. In addition, there is an issue of uneven technological access. Although GenAI has the potential to make education more personalized and effective, the application of these technologies often requires expensive hardware and software support. This may lead to more benefits for resource rich school districts and countries, while regions with fewer resources may find it difficult to enjoy the same educational opportunities, further widening educational inequality. Finally, the change in the role of educators and educational methods is also a challenge. With the integration of AI technology in education, the role of teachers may need to be redefined. They need to adapt to new

teaching tools and methods while ensuring the cultivation of humanistic care and critical thinking in education. This requires educators to constantly update their skills and teaching philosophy in order to effectively integrate and utilize AI technology [14].

The study aims at optimizing the application of GenAI in the field of education, ensuring that it not only improves teaching efficiency and learning experience, but also maintains data security, ensures information accuracy, and achieves the popularization and fairness of technology. Through this, we aim to address the key challenges currently faced by GenAI technology and promote its sustainable and responsible application in the global education sector.

Chapter 2 - Literature Review

2.1 Background

In this chapter, we explore in detail GenAI and its application background in future education. Provide the necessary theoretical foundation and practical background for the entire research, help understand how GenAI technology is combined with educational innovation, and the potential impact of this combination on learning and teaching methods [15].

GenAI refers to the use of machine learning models, especially deep learning networks, to generate new information similar to real-world data. These pieces of information can be text, images, sound, or video content. The key progress of GenAI stems from the development of deep neural networks, especially the application of variational autoencoders (VAEs) and generative adversarial networks (GANs). These technologies enable AI to create new content without clear instructions, and the quality and complexity of the generated content have significantly improved in the past few years [16].

In the field of education, the application prospects of GenAI are broad. It can provide support for personalized learning, such as customizing teaching materials based on students' learning progress and style. At the same time, AI can also simulate complex teaching scenarios, such as the reproduction of historical events, or provide immersive learning experiences through VR and augmented reality (AR) technologies. The application of these technologies can not only enhance students' learning motivation and efficiency, but also help teachers better understand their needs and reactions, thereby making adjustments to teaching methods.

In addition, with the development of technology, GenAI also faces a series of challenges, such as data privacy issues, accuracy and credibility of generated content. These issues need to be fully considered and addressed within of future education.

Although the application of GenAI in the field of education has brought many potential advantages, its implementation process also comes with a series of risks. Understanding these risks is crucial for ensuring the security and effectiveness of technological applications. The following are the main risks that may be faced when applying GenAI in the field of education:

1. Data privacy and security risks: GenAI systems typically need to handle a large amount of personal data, including student learning behavior data, grades, and personal preferences. The collection, storage, and processing of these data must comply with strict data protection regulations to prevent data leakage or improper use. Non- compliant data processing may lead to infringement of student privacy rights and loss of trust.

2. Bias and inaccuracy in generated content: AI generated educational content may reflect biases in training data, which may be racial, gender, or cultural. In addition, if there are errors in the training data, the content generated by AI may also contain misleading information, which may mislead students and affect their learning outcomes [17].

3. Impact on teacher roles: Although GenAI has the potential to improve educational efficiency, improper use may lead to misunderstandings or substitution of teacher responsibilities. The experience and interpersonal skills of teachers cannot be completely replaced by machines, and excessive reliance on technology may weaken the interaction and relationship between teachers and students [18].

4. Technical reliability and stability: Technical failures or instability of GenAI systems may lead to teaching interruptions or information loss, affecting the normal progress of educational activities. Therefore, ensuring high reliability and stability of the system is crucial.

5. Economic cost: Deploying and maintaining high-quality GenAI systems may require significant initial and ongoing investment. For educational institutions with limited resources, this may be a significant financial burden.

6. Moral and Legal Issues: The use of AI in education also involves a series of moral and legal issues, such as transparency in AI decision-making, attribution of responsibility, and how to deal with erroneous judgments in AI systems.

This research aims to optimize the application of GenAI in education to ensure that it not only improves teaching efficiency and learning experience, but also maintains data security, ensures information accuracy, and achieves technology popularization and fairness. Through this research, we plan to address the key challenges facing current AI general technologies and promote their sustainable and responsible application in education around the world. In order to fully exploit the potential of AI general and reduce the associated risks, a series of precautionary measures need to be taken in policymaking, technology development, and educational practices. By establishing strict regulatory policies, improving technical algorithms, enhancing system transparency and interpretative capacity, and enhancing technical training for education practitioners, GenAI can be effectively used to improve education systems while ensuring safety and equity.

2.2 Related Work

By consulting relevant materials online and offline, it is found that in the era of AI, the status of students has been strengthened [19]. The development of AI technology provides opportunities to promote the realization of students' "learner role" - some scholars propose that AI can accurately depict learners from three levels: knowledge model, cognitive model, and psychological model. It

dynamically displays students' knowledge structure, cognitive abilities, learning styles, habits, etc., and based on a precise understanding of students' knowledge deficiencies and personality traits, personalized mentors and learning resources are tailored for students, enabling students to better understand themselves and ultimately enhance learning outcomes [20]. Kydland & Prescott [21] point out that intelligent personal assistants can play a role in educational scenarios where human interaction with intelligent machines is needed. The application of AI technology in education enables students to have a clearer self-awareness and be more proactive in accessing learning resources through multiple channels, which is conducive to the realization of students as learners - with the development and application of online teaching, smart classrooms, etc., students are more inclined to use AI technology to assist their learning, making their roles tend towards active learners. In this sense, students' willingness to learn actively and their ability for independent learning are enhanced, and under the influence of AI technology, the status of students is also elevated.

Furthermore, under the influence of AI technology, the potential for shaping students is also strengthened. Leahy et al. [22] point out that human autonomy and freedom are not only subjective but more importantly objective. Some scholars believe that while allowing AI technology to provide support to students, it also means that they are giving up opportunities for thinking, criticism, and choice to a certain extent. The main reason is that AI lacks imagination, critical spirit, and a sense of the world.

In the past few years, multiple scholars have conducted extensive research on the application of GenAI in the field of education, proposed various theoretical and verified their practical effects. The following is a summary of some important studies that cover the different usage scenarios and impacts of GenAI technology in education:

Li et al. [23] explore how AI can help create personalized learning materials in their research. Research has found that by analyzing students' learning history and behavior, AI can effectively generate textbooks that adapt to individual learning styles and speeds, significantly improving learning efficiency. Liu & Yi, [24] investigate the application of AI in generating textbooks that can meet the needs of students with different learning disabilities. The research results indicate that this personalized approach helps to enhance the learning engagement and outcomes of students with special needs. Luckin & Holme [25] study the effectiveness of GenAI in VR education applications, especially in history education. By creating interactive historical scenes, students can GenAI a deeper understanding and experience of historical events, resulting in a significant improvement in their historical knowledge and interest. Masschelein & Simons [26] analyze the application of AR technology combined with AI in science education and find that this technology can make abstract scientific concepts more intuitive and increase students' learning motivation. Blank [27] develops an AI based assessment tool for automatically evaluating student assignments and providing customized feedback.

Research has shown that this timely and personalized feedback significantly improves student academic performance. Michel-Villarreal et al. [28] focus their research on the application of AI in online courses, particularly its utility in automatically monitoring student engagement and progress. It has found that AI tools can effectively identify students who require additional support, thereby helping teachers allocate teaching resources more effectively. Prather et al. [29] explore the application of GenAI in educational game design. They have developed an AI based algorithm that can automatically generate educational game content based on students' learning history and feedback. Research has shown that this personalized gamified learning method can significantly improve students' learning motivation and grades. Rueden et al. [30] study how to use AI to generate Dynamic Difficulty Adjustment (DDA) mechanisms in educational games to adapt to the abilities of different learners. Their model adjusts task difficulty in real-time by analyzing students' performance in the game, and the results show that this method can effectively promote continuous learning and improve learning effectiveness. Shahroom & Hussin [31] study the effectiveness of GenAI in language learning applications, particularly in simulating conversations and generating practice questions. Their system uses NLP technology to generate dialogue scenes that match the student's level, and automatically generates personalized exercise questions based on student errors. It has found that this interactive learning model significantly enhances students' language proficiency and learning motivation. Shen et al.'s [32] research focuses on how to use GenAI to design personalized learning paths for students. Their model can recommend the most suitable learning materials and activities based on students' learning speed, interests, and historical performance. The research results show that this personalized learning method helps to improve students' learning efficiency and learning outcomes. Singh & Agrawal [33] explore the application of AI in adaptive learning systems, particularly in mathematics and science disciplines. Their system analyzes student answer data, adjusts teaching content and difficulty in real-time, and creates an optimal learning path for each student. This study shows that adaptive learning systems can significantly improve students' comprehension and exam scores.

Through the work of the researchers mentioned above, we can see how GenAI plays an important role in various fields of education. However, these applications are not without challenges, and researchers have also emphasized potential issues and ethical considerations in implementation. GenAI can improve educational practices in multiple ways, but it is also necessary to pay attention to the specific methods and potential negative impacts of its implementation. Future research needs to continue exploring how to balance the potential and risks of technology to achieve sustainable development in the field of education. Future research needs to further explore the long-term impact of these technologies and develop more refined and sustainable application models.

However, regarding the unknown risks of AI in the field of education, the following researchers have elaborated on these aspects:

Soni et al. [34] emphasize that although GenAI systems can provide personalized learning experiences, they also involve the processing of a large amount of sensitive data. If these data are not properly protected, it may leak personal information of students, leading to serious privacy issues. Their research suggests that end-to-end encryption and strict data access control measures should be adopted in the design and implementation of these systems to protect data security.

Strait et al. [35] point out that GenAI systems often rely on large amounts of data to train models. If the training data contains biases, the generated educational content may reflect these biases, leading to unfair learning materials. They study techniques for using algorithms to remove bias and ensure the fairness and diversity of educational content.

1. Impact on the role of teachers:

Stubbs & Piddock [36] discuss the potential erosion of GenAI on traditional roles of teachers, particularly in teaching and evaluation. They warn that excessive reliance on AI may lead to a decline in teacher skills and a strained relationship between students and teachers. Research suggests that educational institutions should balance the use of technology and interpersonal interaction when introducing AI, while maintaining the core responsibilities of teachers and the social and emotional development of students.

2. Technical reliability and stability:

Suarez et al. [37] analyze the potential risk of teaching interruption caused by technical failures. They point out that the instability of AI systems may affect the coherence and effectiveness of education at critical moments. Therefore, they recommend conducting strict technical validation and regular maintenance during the implementation process to ensure the stable operation of the system.

3. Economic cost:

Tadić et al. [38] discuss the high cost of deploying and maintaining GenAI systems, which may prevent schools with limited resources from utilizing this technology. They propose that policy makers and education departments need to consider cost-effectiveness and seek financial support programs to make the benefits of educational technology accessible to all students.

These studies reflect the actual risks faced by GenAI in educational applications and provide some possible solutions or mitigation measures. By continuously addressing these issues and taking appropriate measures, the application of GenAI technology in the field of education can be made safer and more effective.

We discussed GenAI ability to produce diverse content types and its use in education through deep learning technologies for personalized materials and virtual teaching environments. The application of GenAI has been effective in enhancing educational efficiency, aiding in classroom management, and improving student assessments. However, challenges such as data privacy, content biases, changing teacher roles, and technical reliability raise concerns about its impact on educational equity and quality.

To address these, we suggest strengthening data protection, using unbiased methods for content accuracy, redefining teacher roles, and ensuring technical stability, aiming to harness GenAI's benefits while minimizing risks.

Chapter 3 - Research Methodology

3.1 Research Design

This study aims to explore the core capabilities and typical applications of GenAI in future education, aiming to provide theoretical basis and practical guidance for digital transformation in the field of education. The research is based on a comprehensive analysis of the current state of AI technology and education, aiming to reveal the potential and value of GenAI in text generation, language understanding, knowledge querying, and logical reasoning. The main purpose of the study is to optimizing the application of GenAI in the field of education, in order to improve teaching efficiency and learning experience, while ensuring data security, information accuracy, and the popularization and fairness of technology [39].

This study assumes that the deep application of GenAI can drive the transformation of educational relationships, upgrade the intelligent education environment, innovate the supply of teaching resources, reshape intelligent teaching methods, and transform evaluation concepts and ethical governance of intelligent education. Specific research questions include:

What are the specific application scenarios of GenAI in education?

What is the specific mechanism for improving the quality and efficiency of education?

What challenges are faced in terms of data privacy and security, content accuracy, and fairness?

How to optimize the application effect of GenAI through policy and technical means?

To answer these questions, this study designed a series of systematic data collection and analysis methods, utilizing quantitative research methods to ensure the scientific and practical nature of the research results. These research questions not only have theoretical significance, but also contribute to providing practical and feasible solutions for educational practice, promoting the comprehensive upgrading and optimization of the education system.

3.2 Data Collection Methods

The data collection methods of this study include literature review, collection and analysis of a large number of existing studies on the application and impact of GenAI in education. These literatures provide necessary theoretical basis and background information for our research, which helps us determine the focus and direction of our research [40].

In order to obtain more targeted and in-depth insights, we designed a questionnaire survey. The questionnaire includes education experts, AI technology experts, and frontline teachers and students. Through a survey questionnaire, we aim to provide GenAI with a deeper understanding of their views,

practical experience, challenges, and opportunities regarding the application of GenAI in education. At the same time, the questionnaire survey is aimed at a wider range of educators and students, collecting their acceptance, use, and effectiveness evaluation of GenAI technology. In the questionnaire design, it covers multiple levels from basic cognition to specific application experience, ensuring the comprehensiveness and representativeness of the data.

In summary, this study ensured the diversity and comprehensiveness of data collection through literature review, questionnaire survey, and other methods, providing a solid foundation for subsequent data analysis and research conclusions. These methods complement each other, providing both extensive background information and in-depth understanding of specific application situations, ensuring the scientific and practical nature of research results. Through systematic data collection and analysis, we can not only comprehensively understand the potential and challenges of GenAI in education, but also provide practical suggestions and strategies for its optimized application in the field of education.

3.3 Research Tools

In order to effectively collect and analyze data, multiple research tools were used in this study. Firstly, in terms of data collection, we have designed a detailed questionnaire survey based on in-depth analysis of key issues related to the application of GenAI in education, covering multiple aspects such as understanding, practical use, effectiveness evaluation, and existing challenges of GenAI technology. The questionnaire has a reasonable structure and concise questions, ensuring the acquisition of effective quantitative data and the depth and breadth of the content [41-42].

In terms of data analysis tools, as the questionnaire is sent to the Question-Star platform, based on the survey data, the platform analyzes and process a portion of the data. In addition, we have also used various advanced software and technical means, and quantitative data analysis is conducted using SPSS analysis software. The software has powerful data processing and statistical analysis capabilities, which can perform descriptive and inferential statistical analysis on questionnaire data, helping us extract valuable information from the data and discover patterns. Specifically, SPSS is used for preliminary data processing and basic statistical analysis to ensure the accuracy and reliability of the analysis results.

In summary, through carefully designed data collection tools and advanced data analysis software, this study can ensure the comprehensiveness and accuracy of data, while delving into the key issues and potential solutions of GenAI in educational applications. The comprehensive application of these research tools and methods provides strong support for the scientists and effectiveness of this study, and also lays a solid foundation for subsequent research conclusions and recommendations.

3.4 Data Analysis Methods

In this study, data analysis methods include quantitative data analysis to ensure that we can have a comprehensive and in-depth understanding of the application effects and challenges of GenAI in education [43].

Quantitative data analysis is completed through descriptive and inferential statistical analysis of the data obtained from questionnaire surveys. Descriptive statistical analysis is mainly used to outline the basic characteristics of data, including frequency distribution, mean, standard deviation, etc., in order to gain a preliminary understanding of the respondents' understanding and use of GenAI technology. The analysis at this stage can help us identify the main trends and patterns in the data, providing a foundation for further inference and analysis.

Through quantitative data analysis methods, we can not only understand the overall application effect of GenAI in education from a macro perspective, but also conduct more in-depth research on specific problems and challenges at the micro level. This analysis method ensures the comprehensiveness and depth of the research results, laying a solid foundation for us to propose practical and feasible suggestions and strategies. Through systematic quantitative analysis, scientific and effective evidence can be provided for the optimized application and further development of GenAI technology in the field of education.

3.5 Reliability and Effectiveness of Research

In this study, in order to ensure the effectiveness and reliability of the study, we took a series of measures to ensure the credibility of the data, the effectiveness of the research methods, and the reproducibility of the results. Firstly, in terms of data credibility, we verify the reliability of the data source through various means. For the questionnaire survey, we ensure the representativeness of the sample, covering respondents from different regions, educational stages, and backgrounds, in order to ensure the diversity and breadth of the data. In addition, we strictly clean and preprocess the data to exclude invalid or incomplete questionnaires, ensuring the accuracy and completeness of the data [44].

The effectiveness of research methods is the key to the success of this study. When designing research methods, we combine quantitative research methods to ensure comprehensive coverage of all aspects of the research question. Quantitative research obtains extensive data support through large-scale questionnaire surveys, which not only improves the comprehensiveness of the research, but also enhances the interpretability and practicality of the results. To ensure the reproducibility of the research results, we have documented in detail each step of the study, including questionnaire

design, data collection, data analysis, and result interpretation. All data analysis processes use standardized software tools and statistical methods, such as SPSS, to ensure transparency and standardization of the analysis process. In addition, we repeatedly validate the data and methods during the analysis process and conduct multiple tests to ensure the stability and consistency of the results.

In the data analysis stage, we used various statistical techniques and quantitative analysis methods to ensure the accuracy and reliability of the analysis results. Through discussions and feedback with domain experts, we continuously adjust and optimize our research methods and analytical processes to ensure the scientific and effective results.

In summary, by implementing a series of strict measures, we have ensured the effectiveness and reliability of our research. The credibility of data, the effectiveness of research methods, and the reproducibility of results are not only the foundation of this study, but also the key to ensuring the scientific and practical nature of research results. Through these measures, we can provide scientific and effective guidance and suggestions for the application of GenAI in the field of education, promoting its optimization and development in education.

3.6 Ethical Considerations

In this study, upholding ethical standards is paramount to ensure that both the methodology and findings are conducted responsibly, safeguarding participant rights and maintaining data confidentiality. At every phase of our research, we are committed to ethical integrity, beginning with securing informed consent from all participants. Prior to the survey, we thoroughly briefed participants on the study's objectives, methodologies, potential risks, benefits, and expected outcomes. Participation was contingent upon their full understanding and voluntary agreement.

Furthermore, we uphold the right of participants to withdraw from the study at any time without any adverse consequences. Ensuring data privacy and safeguarding confidentiality are critical components of our ethical framework. We adhere rigorously to data protection laws, employing both technological solutions and stringent management protocols to prevent any unauthorized access to or misuse of participant information. For instance, data collection methods include anonymization of survey records to eliminate any personally identifiable information. During the data storage phase, we implement encryption technologies and restrict access solely to authorized members of the research team.

Additionally, strict limitations are placed on data usage, confining it exclusively to the purposes outlined in the study and prohibiting external use. In our reports and publications, we take care to

ensure that no participant can be personally identified, presenting all data and analyses in aggregated forms.

The ethical rigor of our study extends to securing approvals from relevant ethics committees. This includes the submission of comprehensive research proposals, detailing our data handling protocols and the informed consent process, followed by their scrutiny and endorsement by the ethics committee. This approval not only verifies the legality and ethical compliance of our study but also reinforces participant safeguards.

Throughout the research process, we continually evaluate and reflect on our ethical practices. By actively soliciting participant feedback, gauging their experiences and concerns, we adapt our research methodologies accordingly to better respect and protect participant rights and interests. In summary, our study meticulously adheres to established ethical principles, ensuring informed consent, protecting data privacy, securing ethics committee approvals, and fostering an ongoing dialogue with our participants. These efforts not only guarantee the ethical conduct of our research but also bolster the reliability and societal value of our findings.

3.7 Summary

In summary, this study provides a detailed introduction to research design, data collection methods, research tools, data analysis methods, research effectiveness and reliability, as well as ethical considerations in Chapter 3. Firstly, through systematic research design, we have clarified the purpose, hypotheses, and specific issues of the study, ensuring its directionality and scientist in terms of data collection, we comprehensively utilized various methods such as literature review, existing data analysis, questionnaire surveys, as well as experiments and observations, to ensure the comprehensiveness and representativeness of the data. Through well-designed data collection tools and advanced data analysis software, we have effectively improved the accuracy and efficiency of data processing. In terms of data analysis methods, we combine quantitative analysis, using various techniques such as descriptive statistics, multiple regression analysis, factor analysis, content analysis, and thematic analysis to ensure the depth and breadth of the analysis results. Meanwhile, through strict data validation and multiple tests, we ensured the stability and reliability of the research results. We have also taken a series of measures to ensure the effectiveness of the research and the reproducibility of the results. We have recorded each research step in detail, ensuring the transparency and standardization of the research process.

Through the above systematic research methods and strict ethical considerations, we not only provide scientific and effective evidence for the application of GenAI in the field of education, but also propose practical suggestions and strategies for its optimization and development. The summary of

this chapter lays a solid foundation for the discussion and conclusions of subsequent chapters, ensuring the scientific, effective, and practical nature of the research results.

Chapter 4 - GenAI Empowers the Reshaping of Future Education Forms

GenAI has achieved significant technological breakthroughs and transformations in various aspects such as technological logic, technological achievements, and technological significance, bringing new opportunities and driving forces for the digital transformation of education. The deep integration of GenAI and future education reshapes the form of human education and learning, specifically in aspects such as the relationship between educational subjects, the educational environment, educational resources, teaching methods, educational evaluation, and ethical governance.

4.1 Analysis and Discussion of Obtained Results

In this questionnaire survey on the application of GenAI in education, there were a total of 100 participants. According to the basic information statistics of the survey, as shown in Figure 1, teachers constitute the largest proportion of the survey group, accounting for 40% of the total. This indicates that education professionals have a high interest and attention in the application of AI technology in the field of education. Student participants account for 30% of the total, indicating that the younger generation plays an active role in educational innovation and has a high acceptance of emerging technologies. Education administrative personnel account for 25%, while other relevant personnel account for 5%. These data reflect that various educational stakeholders are open to the application of AI in education and willing to participate in relevant discussions and evaluations.

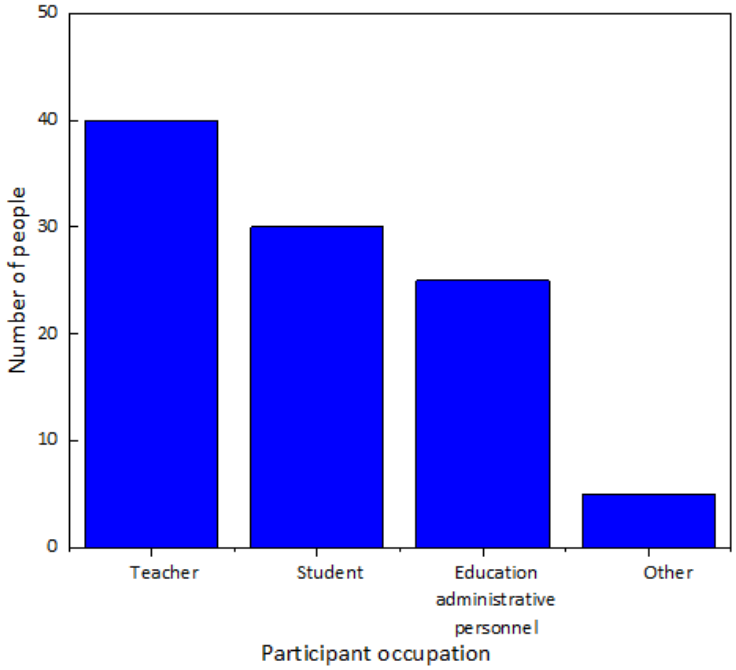

Figure 1 Participant Information

From Figure 2, we can see that 35 participants (35%) expressed a high level of familiarity with AI technology, which may be related to their professional background and continuous attention to new technologies. 45 participants (45%) expressed some familiarity, indicating that although they have some understanding, further education and practical experience are still needed. 20 participants (20%) expressed unfamiliarity, indicating that there is still significant education and popularization work to be done to ensure that all education related personnel can understand and apply AI technology.

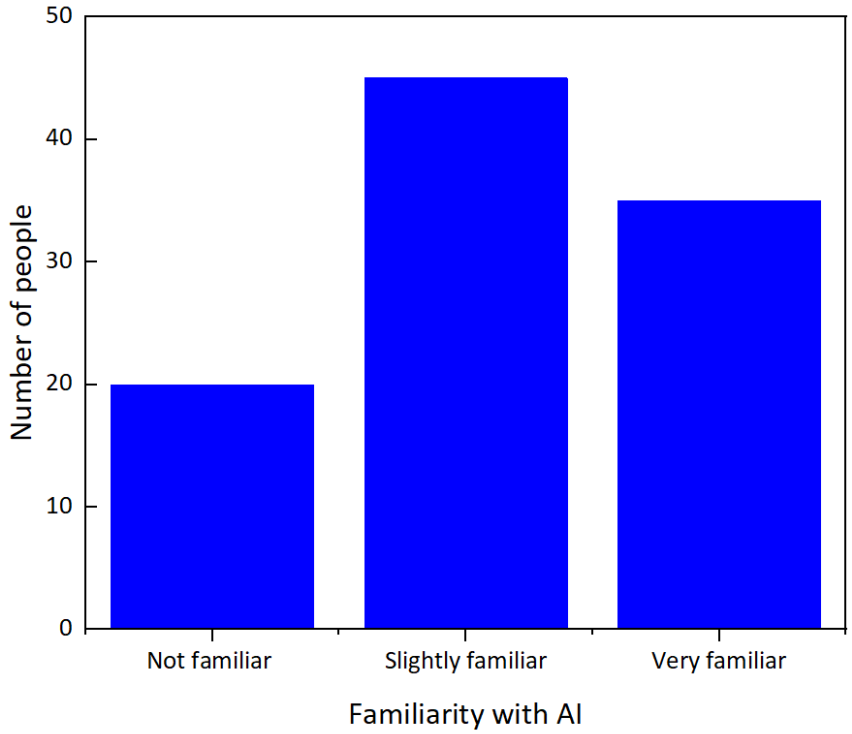

Figure 2 Participants' Familiarity with AI

The survey results indicate that despite the high level of interest and acceptance of AI in education, there are still clear challenges in terms of technology adoption and adoption. These challenges mainly include a lack of technical familiarity, data security concerns, and concerns about the accuracy of AI technology. To address these issues, the study proposes a range of strategies, including AI technology training for educators and students, the development and implementation of high-quality educational AI systems, and the development of relevant policies and standards to ensure the fairness and accuracy of the technology. Provide training to educators and students in AI technology with the aim of improving their familiarity with and operational skills in AI. This could be done by developing and integrating teaching modules on AI at all levels of the education system, from primary to tertiary education, by holding workshops, seminars and online courses, and by tailoring course content to

different skill levels. Through these trainings, educators and students would be more effectively understand, use, and leverage AI technologies to improve teaching and learning.

Develop and implement high-quality AI systems for education. This requires working with AI experts and educational technologists to design and deploy AI systems that are tailored to the specific needs of educational institutions. These systems should be rigorously tested and validated to ensure their effectiveness and suitability. By introducing customized AI systems, the quality of education and management efficiency can be improved, while ensuring the impartiality and accuracy of technology. Finally, develop policies and standards to ensure equity and accuracy of AI technologies in education. This includes the development of comprehensive policies and standards to guide and regulate the use of AI technologies in education, ensuring compliance and ethics in the use of technology. These policies and standards should also focus on data protection and privacy to enhance societal trust and acceptance of AI applications for education. Through the implementation of these strategies, it is possible to effectively drive the widespread adoption and positive impact of AI technologies in the field of education, while addressing current challenges.

By providing comprehensive technical support and systematic training, we can ensure that everyone involved in education can effectively understand and apply AI technologies to improve teaching efficiency and the learning experience.

This systematic improvement and strategy implementation not only addresses the key challenges currently facing GenAI in education, but also drives digital transformation in the global education sector to achieve universal access and equity in educational technology.

About the use experience of AI, we can learn from Figure 3. There are 75% of participants are already using AI tools in their teaching or learning process, indicating that the application of AI technology in education has been widespread and deep. This high percentage of use reflects the education community's recognition of AI tools for improving teaching efficiency, personalizing learning experiences, and accessing resources. However, another 25% of participants said they have not used AI tools for a variety of reasons, including unfamiliarity with AI technology, lack of adequate technical support, hesitation to adopt new technologies, and concerns about privacy protection and data security. These factors highlight the challenges in the adoption and effective integration of AI technologies. According to the survey results, it is necessary to strengthen AI technology training for educators and students, and provide necessary educational resources and technical support to enhance their familiarity with AI tools and operation ability. Develop strict data protection policies and standards to ensure that the use of all AI tools meets the highest standards of security and privacy protection, enhancing user confidence. In addition, improve resource allocation, especially in resource-constrained Settings, to ensure that all educators and students have equitable access to and utilization of advanced AI tools. Finally, through policy advocacy and financial support, we should

promote equitable access to educational technology and avoid technology application exacerbating existing educational inequalities. By implementing these strategies, we can effectively modernize education, increase the penetration and acceptance of AI tools, thereby achieving educational equity and ensuring the sustainable and responsible application of GenAI technology in education worldwide. These measures not only directly support the realization of research objectives, but also help to promote the fundamental reform of education form, and provide continuous impetus and support for the development of education in the future.

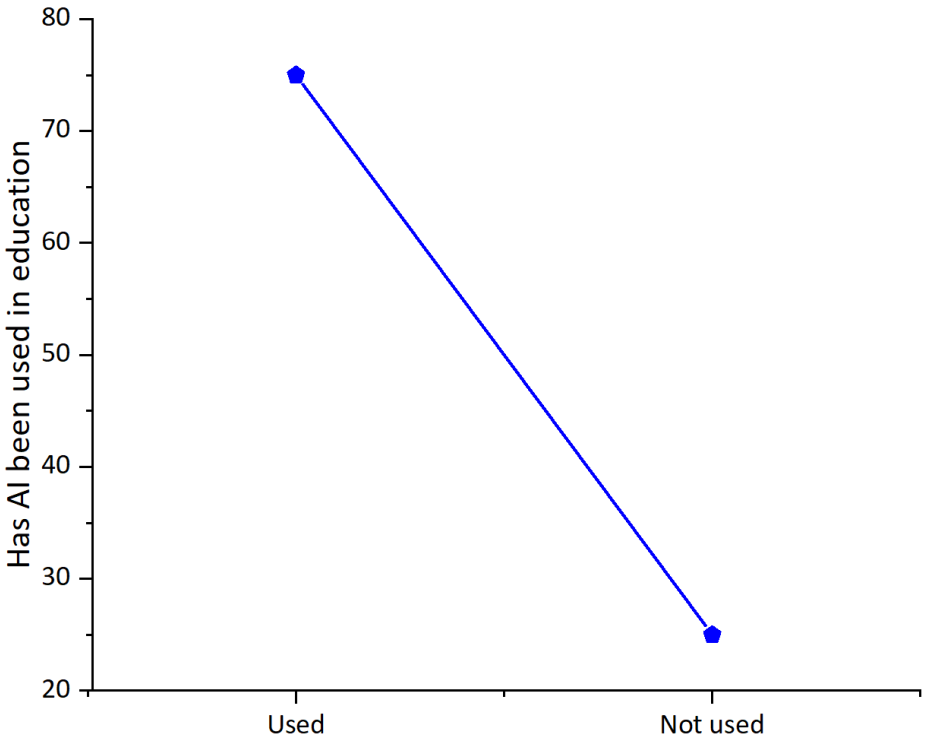

Figure 3 Has AI been used in Education

As for the application of AI in the field of education, we see the multi-dimensional impact of AI application from the survey results. As shown in Figure 4, 60% of respondents believe AI is effective and very effective in education, which is very high, and it is enough to show the positive potential of AI for personalized learning paths, automated content generation, and timely feedback. These applications can significantly improve the interactive and adaptive learning experience, enhance the relevance and timeliness of learning content, and thus improve learning efficiency. However, another 20% of respondents were neutral about AI applications, and 20% considered AI to be ineffective or very ineffective, a view that reveals the complexity and challenges of applying AI technologies in education.

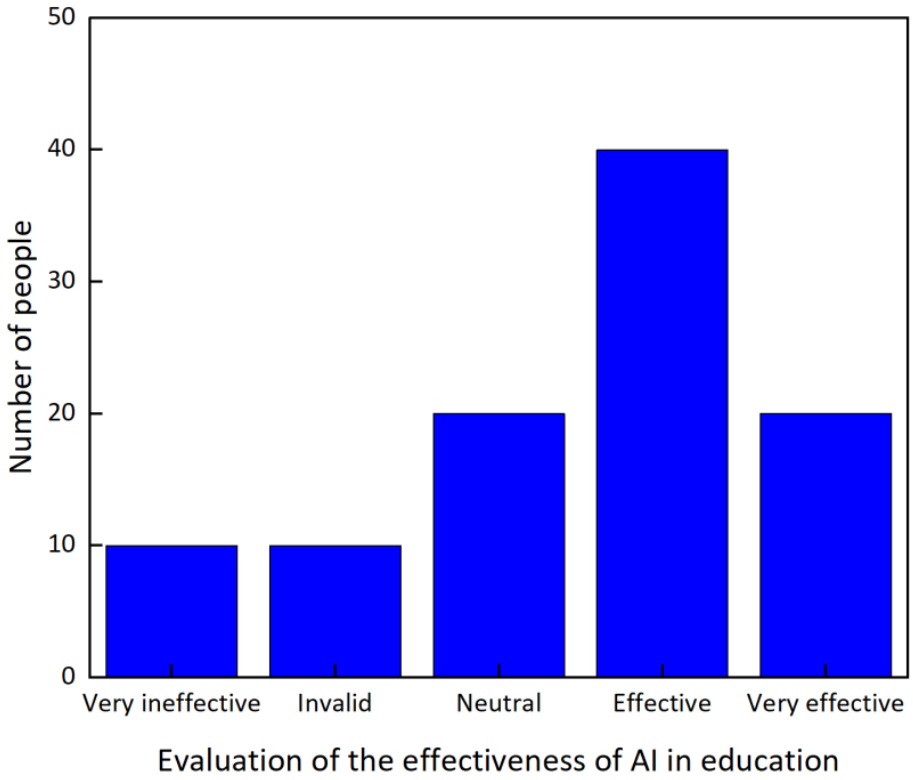

Figure 4 Assessing the Effectiveness of AI in the Field of Education

Compatibility issues between AI tools and existing education systems are one of the main obstacles. The problem of technical adaptability leads to the difficulty of integrating AI tools into traditional teaching activities, which requires targeted technical improvement and customized development. Uncertainty about the outcomes of AI applications, especially in terms of learning outcomes and student feedback, may make educators and students wary of adopting these technologies. This requires AI systems to provide more accurate and reliable output, ensuring their effectiveness in educational decision-making. AI systems often require specialized knowledge to operate and maintain, which is a major challenge for teachers and students from non-technical backgrounds. Simplifying the user interface and operational flow of AI tools is the key to improving their affinity. The use of AI in education involves large amounts of personal and sensitive data. Data security and privacy concerns are one of the main factors impeding the widespread adoption of AI, requiring strict data protection measures and policy support. According to the research results, the following contents are summarized to effectively solve the above problems.

Work closely with educational software developers to develop AI tools that are more suitable for the education sector, especially to enhance their compatibility with existing education systems. Provide regular AI technical training and ongoing technical support to help educators and students improve their proficiency and confidence in using AI tools. Optimize the user interface of AI tools to

make them more intuitive and easier to use, reduce operational complexity, and improve user experience. Strict data protection policies are implemented, using advanced encryption technologies and access controls to ensure the security and privacy of learning data. Through these measures, the challenges of AI application in education can be effectively solved, and its acceptance and effect can be improved, so as to better achieve the goal of education modernization and fairness.

Regarding the application of AI in education, most participants agreed that integrating AI into education would bring many benefits. Specifically, according to the data in Figure 5, 33% believe that the greatest benefit of AI is to improve the efficiency of personalized learning, which reflects AI's ability to customize learning content and paths according to each student's learning habits and abilities. In addition, 26% believe that AI can enhance student engagement and motivation, mainly because AI can provide more interactive and engaging learning experiences, such as through gamified learning and VR simulations. Another 30% believe that AI enriches teaching resources and methods by generating new teaching content, such as customized textbooks and interactive exercises, while supporting multimedia and multimodal learning to make teaching more diverse. In addition, 11% believe that AI has optimized teacher workflows, as evidenced by AI tools helping teachers automate tedious tasks such as grading and record-keeping, allowing them more time to focus on teaching and student interaction.

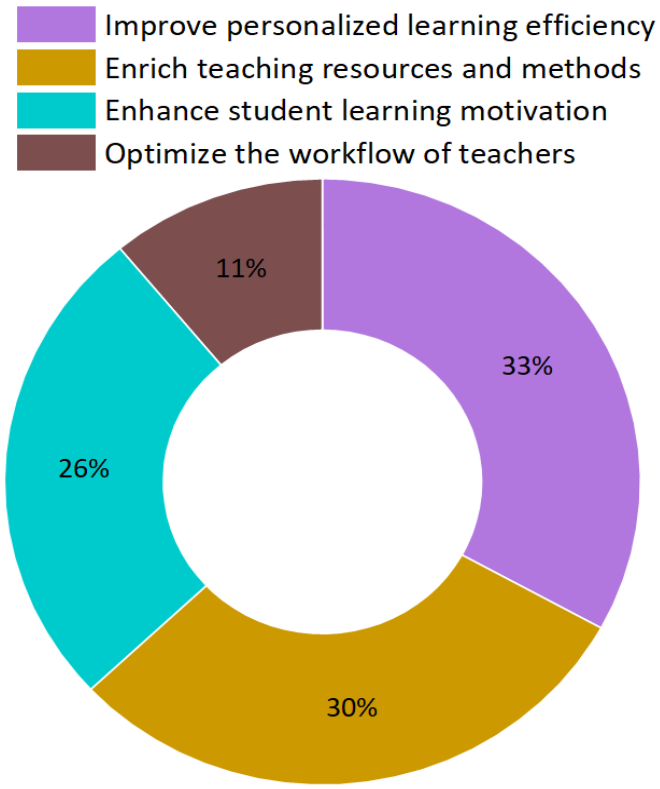

Figure 5 Participants' Views on AI

This feedback makes it clear that the application of AI in education can not only enhance the personalization and engagement of the learning experience, but also dramatically support the work of teachers, reduce their administrative burden, and improve teaching efficiency. However, despite the many positive changes AI brings, in order to realize these potential benefits, schools and educational institutions need to ensure the appropriate infrastructure and training support to enable teachers and students to use these technologies effectively. In addition, attention needs to be paid to potential issues associated with AI applications, such as data privacy and security issues, to ensure that the use of these technologies does not exacerbate existing educational inequalities. Through continuous optimization of technology and enhancement of relevant policy support, the application of AI in education can be more widely promoted, providing strong support for education modernization and fairness.

According to the data in Figure 6, participants expressed a number of concerns about the use of AI technology that needed to be addressed in optimizing AI application strategies to achieve the objectives of the study - ensuring that AI technology improves teaching efficiency and learning experience while maintaining data security, ensuring information is accurate, and that access to the technology should be fair and unbiased. Among them, 30% of respondents are concerned about privacy and security, which underscores the importance of protecting students' personal information in educational Settings, making it clear that any attempt to integrate AI into educational tools must adhere to strict data protection regulations. 40% of respondents expressed concern about the accuracy of AI-generated content. This points to the need to train AI by using proven, high-quality data sources to reduce the risk of bias and misleading information. For 20% of respondents, they are concerned that AI technology may change or even marginalize the traditional role of teachers, which suggests that we need to balance the use of technology with the professional development of teachers when promoting AI technology. The issue of technology accessibility was also raised by 10% of respondents, reflecting the uneven distribution of educational resources that could hinder the adoption of AI technologies. This situation is likely to exacerbate educational inequality and prevent certain groups of students from enjoying the educational advantages of AI.

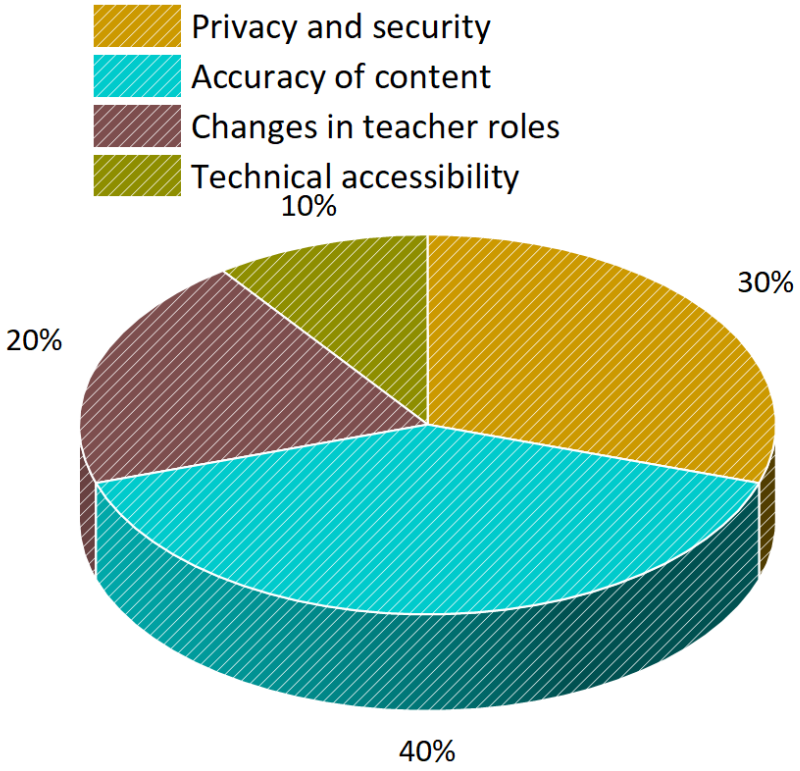

Figure 6 Participants' Concerns about AI Applications

To address these challenges, policymakers, educational institutions, and technology providers need to work together to develop sound strategies to improve the accessibility and applicability of AI tools and ensure that all students can benefit equitably from AI technologies. By strengthening these strategies, we can ensure that AI technologies improve the quality and efficiency of education without creating additional privacy, security, and inequality issues, thereby achieving research goals and promoting modernization and equity in education. This requires continued technological improvements, user training, enhanced data protection measures, and broad policy support and community engagement to ensure that AI's application in education is both effective and responsible.

Based on the survey results, participants generally believe that AI technology has great potential for application in the field of education, especially in curriculum and instructional design, student assessment and feedback, student support and tutoring, and teacher development and training. Specifically, Figure 7 shows that 35% believe that AI is particularly useful in curriculum and instructional design because it helps create instructional content that is more aligned with student needs and learning styles. In addition, 32% saw the advantages of AI in student assessment and feedback mechanisms, particularly its ability to provide real-time and personalized learning feedback, helping students adjust learning strategies in a timely manner. In terms of student support and tutoring, 28% highlighted how AI technology can help students solve learning difficulties and improve their overall learning efficiency through automated and personalized interventions. This includes learning support

through AI-powered chatbots and the use of data analytics to predict potential learning disabilities students may encounter and provide help ahead of time. For teacher development and training, 5% believe that the application of AI can help teachers better understand the needs and learning progress of students, so as to optimize teaching methods and strategies. AI can also help teachers improve their teaching skills and methods by providing targeted professional development resources and online training.

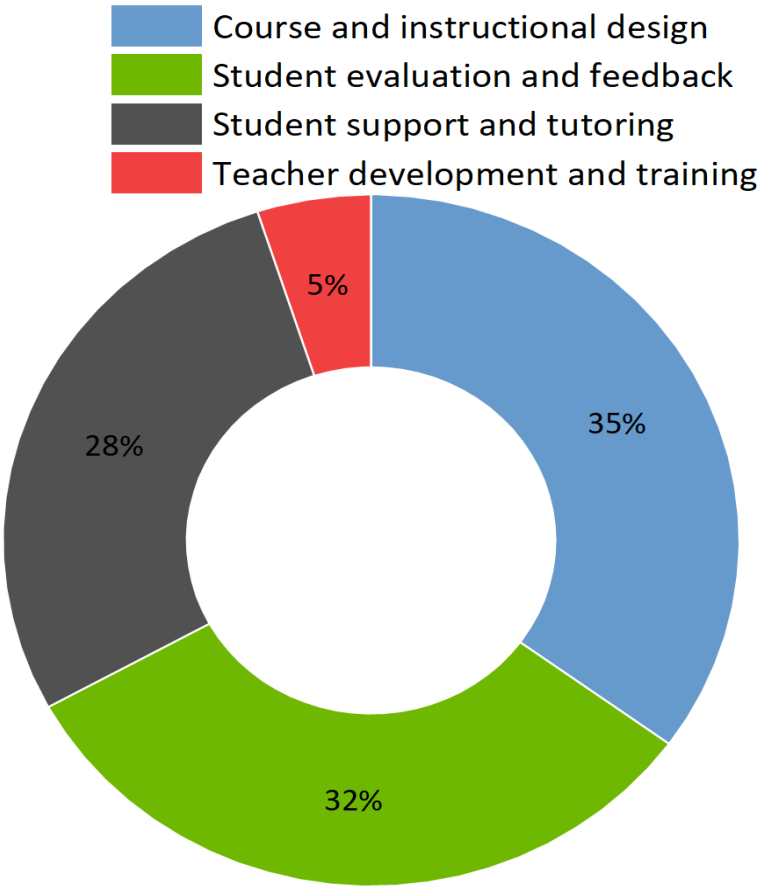

Figure 7 AI Application Potential in the Field of Education

In general, the application of AI in education can not only improve the quality of teaching and learning outcomes, but also enhance the efficiency and accessibility of the entire education system. However, in order to fully harness the potential of AI, it is essential to ensure that all those involved have access to the relevant technologies and receive appropriate training. At the same time, ethical and privacy issues need to be considered to ensure that the application of AI enhances the educational experience while protecting the data security and privacy of students and teachers. The implementation and optimization of these measures directly respond to the setting of the research goal, that is, to improve the quality and efficiency of education by optimizing the application of AI in

education, while ensuring the fairness and security of technology, and promoting the modernization and popularization of education.

Then, according to the survey results, there is a clear and urgent need for improved AI tools in education. Figure 8 shows that 30% of respondents would like to see AI education tools improve in providing more precise personalized learning paths. This includes adjusting the content and difficulty of education according to students' specific needs, learning speed and ability to improve learning efficiency and effectiveness. In addition, 28% highlighted the need for broader language and cultural adaptation, noting that current AI tools often ignore diversity and inclusion and fail to fully accommodate learners from diverse cultural backgrounds. 12% of respondents expect AI tools to enhance interactivity and simulation capabilities, such as providing a more vivid learning experience through more advanced simulation and VR technologies. This interactivity can greatly increase students' interest and motivation when learning complex or abstract subjects. In addition, 28% expect AI tools to provide more stringent data protections to protect student information from misuse or leakage, especially as more schools rely on distance learning and digital learning platforms.

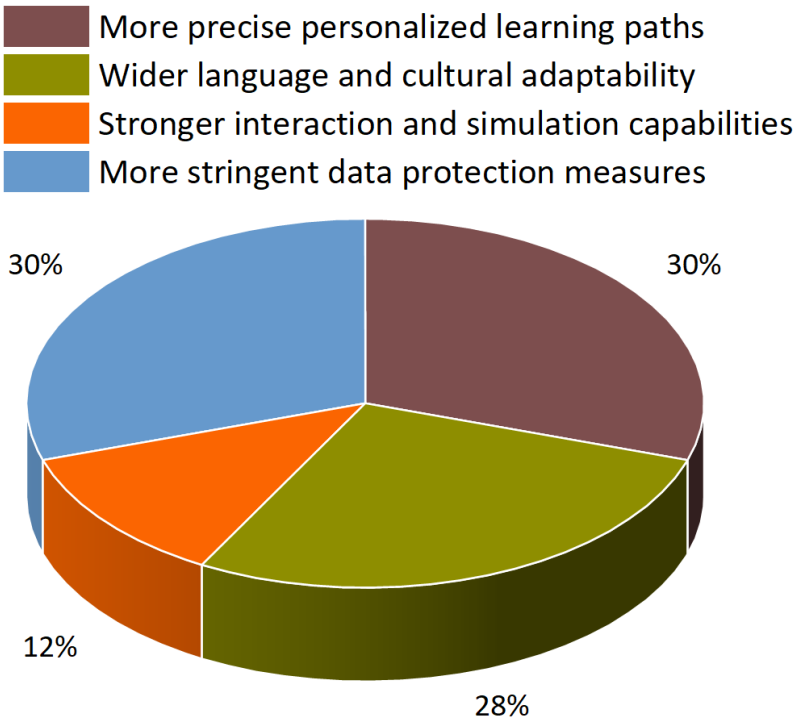

Figure 8 Improvement Requirements for AI Education Tools

From here we see that, although AI educational tools have shown great potential in various aspects, in order to achieve widespread acceptance and effective use of these tools, they must be adjusted and improved in detail to meet the actual needs of educators and learners. This would require

close collaboration among technology developers, education experts, and policy makers to drive innovation and progress in education technology and ensure that these tools serve all users safely, effectively, and equitably. This multi-faceted improvement and collaboration is a direct response to the research goal set by optimizing the application of AI in education to improve the quality and efficiency of education, while ensuring the equity and security of the technology, and promoting the modernization and popularization of education. This is not only an improvement in technology, but also an important contribution to equity and inclusion in education.

About the attitude of AI's future development in education. Figure 9 shows that 66% believe AI drive personalization and efficiency in education. This optimistic view focuses on how AI technology can optimize the teaching and learning process by providing customized learning experiences and real-time feedback, making education more tailored to students' individual needs and pace of learning.

However, 20% were neutral, arguing that while AI offers many potential benefits, it also comes with challenges and risks, such as the complexity of technology implementation, high costs, and potential ethical and privacy concerns. This suggests that there are still some reservations about the future development of AI technology. In addition, 14% expressed pessimism that further development of AI could exacerbate educational inequalities, especially in resource-limited Settings where advanced AI solutions may not be affordable. This pessimism highlights the need for policies and measures to ensure inclusive and equitable technological development.

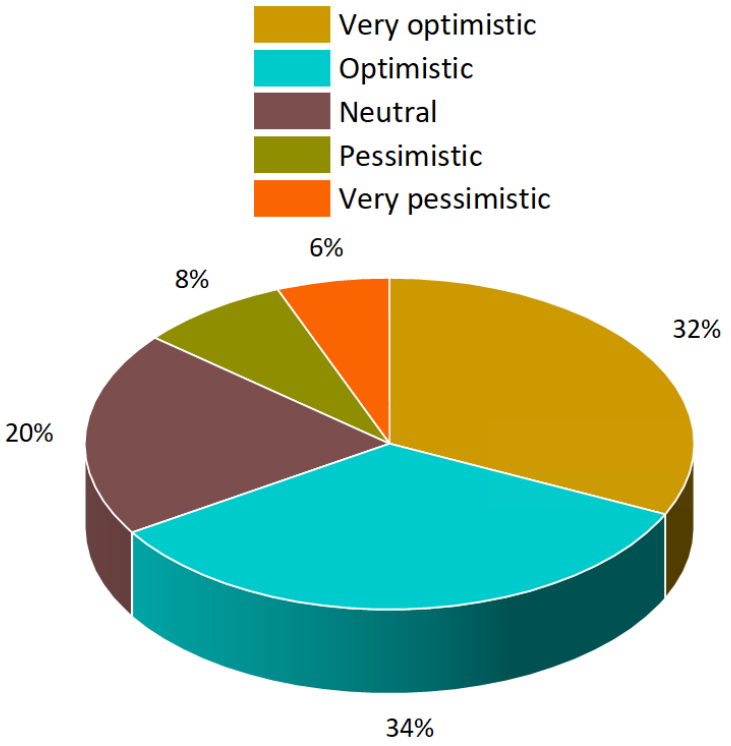

Figure 9 Views on the Future Development of AI in Education

Overall, although there are different views on the future development of AI application in education, most people believe that with proper management and planning, AI can effectively support reform and innovation in the field of education. This requires close collaboration between policy makers, educational institutions and technology developers to drive sustainable development of educational technology while ensuring that all students can benefit from it regardless of the economic conditions of their region. In this way, advances in AI technology are expected to have a broad and far-reaching positive impact.

In this survey on the application of AI in education, we can see various insights and expectations. From the basic information, various education related personnel such as teachers, students, and educational administrators generally show interest in the educational application of AI technology, reflecting a wide range of participation and diverse backgrounds. Most participants believe that the use of AI in education has brought or is expected to bring significant positive effects, such as improving the efficiency of personalized learning, enhancing student engagement, enriching teaching resources, and optimizing teacher workflows. Despite these positive factors, participants also hold a reserved attitude towards the challenges faced by introducing AI into the education field, especially in terms of privacy and security, content accuracy, changes in teacher roles, and technological accessibility.

In addition, for the improvement needs of AI educational tools, participants hope to see more precise personalized learning paths, enhanced interaction and simulation abilities, wider language and cultural adaptability, and stricter data protection measures. For the future development of AI in education, although most people are optimistic that AI can further promote personalization and efficiency in education, there are also some people who are concerned that this may exacerbate educational inequality, especially in areas with limited resources.

In summary, although the application of AI technology in education is generally promising, its development and implementation need to be handled with caution to ensure that the introduction of technology not only enhances the educational experience, but also fairly and safely benefits all students. This requires coordination and cooperation among education policy makers, schools, and technology providers to achieve this goal.

4.2 Insights from the questionnaire

4.2.1 Human-machine optimization to promote the transformation of educational subject relationship

In teaching practice, GenAI can accurately identify students' learning preferences, ability levels and progress space through algorithms and big data analysis, so as to tailor a personalized learning path

for each student. For example, AI systems can dynamically adjust the content and difficulty of instruction based on student feedback and test results, ensuring that learning activities are both challenging and not beyond the comprehension of students. In addition, through AR and VR technologies, AI is able to create immersive learning environments that make abstract scientific concepts and complex mathematical problems intuitive and understandable.

In terms of student support, AI technology can monitor students' learning status and emotional fluctuations in real time, and provide emotional support and learning help in a timely manner. Intelligent chatbots can answer students' questions 24 hours a day, provide recommendations for learning resources, and even conduct psychological counseling to help students manage study pressure. In addition, the AI system can predict the learning disabilities students may encounter and proactively provide solutions and additional learning materials to prevent the occurrence of learning difficulties.

In terms of teacher development, GenAI provides teachers with powerful data analysis tools that enable teachers to gain a deeper understanding of student learning outcomes and the effectiveness of teaching activities. AI analytics tools can help teachers identify what is working in their teaching and where improvement is needed, supporting teachers for reflection and professional growth. For example, by analyzing student interaction data, AI can prompt teachers as to which students need more attention and which teaching methods are most effective.

In the course design, AI can not only help design the teaching syllabus and learning activities that meet the needs of students, but also automatically update the course content according to the educational trends and the latest scientific research results around the world. AI systems can integrate resources across disciplines to design cross-cultural and multilingual educational content, ensuring that education is global and inclusive.

Through these specific embodiments and methods, GenAI significantly improves the personalization, interactivity, and efficiency of education, achieving a high degree of customization and optimization of education. However, achieving these goals requires close collaboration among educators, policymakers, and technology developers to create a supportive, transparent, and fair AI ecosystem for education. Such a system would not only maximize the educational potential of AI, but also ensure the responsible use of the technology and protect the interests of all students.

4.2.2 Accelerating the Development of Specialized Educational Large Models for Intelligent Upgrading of Information Educational Environment

Specialized educational large models are an inevitable choice for empowering the digital transformation of education. Although general large language models have important value for

transforming and transitioning the education field, they require higher knowledge accuracy, controllable ideological safety, and appropriate content generation for subject and grade-specific use in educational settings. Applying existing large language models that have not been specifically trained on professional educational datasets to the education field may lead to algorithmic and data biases, which could affect academic judgments and decisions of teachers and students. Therefore, constructing and applying high-quality and education-oriented data-trained large models can reduce content creation biases, improve the accuracy of educational knowledge generation, the appropriateness for subject and grade levels, and the controllability and safety of ideological content. This is imperative for empowering the digital transformation of education through GenAI. Specialized educational large models accelerate the intelligent upgrading of the information teaching environment. By building specialized educational large models on the basis of general models, educational platforms, tool applications, and product intelligence can be enhanced, providing reliable environmental support for the practical implementation and effectiveness of digital education. For example, language learning tools can be upgraded with multi-round dialogue and scene generation capabilities based on specialized large models, enabling smart oral assessment and precise grammar correction, significantly improving the effectiveness and user-friendliness of language learning tools. Moreover, based on the upgraded multimodal capabilities of specialized large models, teaching tools can create speech interaction data analysis assistants, intelligently generating classroom teaching quality reports, student learning reports, and other content based on voice command input, enhancing the intelligence of teaching tools and products to provide intelligent technological environment support for improving teaching efficiency and quality.

4.2.3 Empowering Generative Teaching Resource Supply and Innovating Personalized Configuration of High-Quality Resources

The production of teaching resources is shifting from manual creation to intelligent generation. Digital resources are essential elements of digital education. Currently, the development of digital teaching resources in China involves multiple development entities, various user participation, and multiple modes of resource sharing. However, there are still bottlenecks, such as insufficient volume of high-quality resources, insufficient variety of resource types, the need to improve resource development efficiency, and the incomplete guarantee of resource quality. The rapid, synchronous, and multi-dimensional intelligent generation capabilities demonstrated by GenAI offer the potential to solve these current bottlenecks through human-machine collaborative participation in resource development. This can promote the batch production, mass production, and efficiency improvement

of educational resource development, shifting the focus from labor input to scientific control and creative generation.

In the intelligent era, the way of obtaining teaching resources is shifting from "people finding resources" to "resources finding people". Presently, digital teaching resources available on the internet suffer from issues such as uneven quality, unclear logical relationships between resources, and imperfect resource supply mechanisms, posing significant challenges in resource retrieval, screening, and utilization for teachers and students. In the practice of digital education, the shift from an emphasis on the generation of teaching resources toward catering to the needs of teachers and students and providing customized services has become a focal point for users. GenAI differs from the resource retrieval provided by search engines, as it intelligently aggregates and reorganizes digital teaching resources, generates text results with clear structural frameworks and semantic logic, and provides precise recommendations, thus transforming the mode of resource acquisition from passive distribution to proactive recommendation, realizing demand-driven personalized resource services.

4.2.4 Reshaping Intelligent Teaching and Learning Methods to Enhance Effective Teaching New Momentum for Teachers and Students

Stimulating teaching innovation potential and helping teachers reduce burdens and improve efficiency. Currently, teachers face heavy pressures in lesson preparation, teaching, and related work, as well as the dual pressures of mastering new technologies and devices under digital transformation, urgently requiring effective solutions. The high-quality content generation capability of GenAI aligns with the daily work needs of teachers, providing support in teaching design, classroom teaching, after-class tutoring, and assignment design and correction. For example, it can generate lesson plans and courseware with one click, expand classroom knowledge content, inspire students' independent exploration, and automatically extract key points from student compositions for correction, thereby reducing the daily workload of teachers. Furthermore, GenAI reduces the difficulty of human-machine interaction, enabling dialogue interaction through online platforms and solving teachers' technological pressure issues. Innovating dialogical learning methods to promote personalized learning and cultivate high-level thinking.

GenAI can leverage its dialogical interaction characteristics to mine learning situations and task requirements from multi-round dialogues with students, forming learning materials in various forms such as text, images, videos, and audio, to support students' learning. It can also recommend suitable learning paths and tasks to students based on their learning level, style, and knowledge background, generating customized learning scaffolding to enhance students' collaborative, creative, and critical

thinking abilities [45], stimulating students' learning motivation and potential, and achieving a higher level of personalized learning.

4.2.5 Strengthening Competency-Oriented Evaluation Concepts and Deepening Diverse Collaborative Evaluation Methods

In terms of evaluation concepts, further strengthen the transition from a knowledge-centered approach to a "knowledge + competency" approach. Educational evaluation plays an important guiding role in the development of education. To meet the demands of talent cultivation in the digital society, the goal of education is to cultivate individuals capable of independent thinking with correct values and judgment, developing core competencies rather than merely acquiring and memorizing specific knowledge. Therefore, it is necessary to establish an evaluation concept of "knowledge + competency." The powerful information integration capability of GenAI accelerates the process of information acquisition and knowledge dissemination. Traditional knowledge evaluation struggles to meet the demands of information over-loaded, thus it is crucial to focus on students' information application and the development of higher-order thinking skills in evaluation practices, constructing a more comprehensive competency evaluation system.

At the same time, the evaluative focus should not be solely on declarative knowledge that GenAI can answer. Effective learning and assessment content should possess higher-order and open characteristics, be related to real-world contexts, and emphasize the examination of students' innovative awareness and abilities. In terms of evaluation content and methods, the "interpersonal + human-machine" collaborative approach facilitates comprehensive evaluation. GenAI provides new empowerment means for evaluation improvement, emphasizing comprehensive evaluation through interpersonal collaboration and human-machine coordination. In terms of evaluation content, fixed knowledge-based questioning is transformed into open-ended problem-solving, allowing students to collaborate through "interpersonal + human-machine" multi-party interactive communication to develop integrated solutions, shifting traditional paper-based result evaluation to situational, problem-based comprehensive evaluation.

In terms of evaluation methods, GenAI leverages its dynamic, multimodal, and companionable features, integrating machine-assisted evaluation into interpersonal evaluations between teachers and students and among students, conducting data collection, automated content correction, and evaluation through continuous human-machine interactive dialogue, comprehensively analyzing students' learning situations and performance.

4.2.6 Coordinating Innovative Applications of Intelligent Education and Promoting the Beneficial Development of AI

In July 2023, Japan's Ministry of Education, Culture, Sports, Science and Technology issued Interim Guidelines for the Use of GenAI in Primary and Secondary Education and Guidelines for Universities and Technical Colleges to Respond to GenAI Education, which detail the role and application of GenAI in the field of education. For example, the guidelines specifically highlight the need to ensure algorithmic transparency and interpretability when using GenAI for personalized learning and student assessment, as well as how to effectively protect the privacy and security of student data.

China is also actively promoting the development of policies and standards related to the education grand model. In April 2023, the China Academy of Information and Communications Technology officially launched the compilation of the education Grand Model standard, which aims to provide reference and guidance for the application of education grand model. These standards detail the data processing and user interaction guidelines to be followed in the design and application of educational grand models, as well as how to ensure the fairness and effectiveness of the models through ongoing review and evaluation.

In July 2023, the National Information Technology Standardization Committee and other institutions released relevant research results and proposed the establishment of a standardization system for general AI models in education. The establishment of this system aims to promote the healthy development of educational AI through clear technical and operational standards, ensuring that the application of technology is not only in line with educational objectives, but also in line with the country's regulatory and ethical requirements.

In terms of ethical governance frameworks, UNESCO published GenAI and the Future of Education and GenAI Guidance in Education and Research in 2023, pointing out that GenAI may exacerbate the digital divide, infringe intellectual property rights, leak private data, and create biased content risks. These guidance documents recommend that when using GenAI in education, appropriate regulations, policies, and human resource development programs should be planned to ensure the responsible and ethical use of the technology.

In July 2023, the Cyberspace Administration of China issued the Interim Management Measures for GenAI Services, which put forward specific management requirements for the provision and use of GenAI services. These management measures include qualification requirements for service providers, security audit mechanisms for services, and mandatory provisions for user data protection to ensure that GenAI services are secure, controllable, and ethical.

Through the above specific policy and implementation details, it can be seen that while promoting the application of GenAI in the field of education at home and abroad, they attach great importance

to establishing and maintaining a policy and institutional environment that is inclusive and innovative, safe and controllable, and promotes prudent development. These efforts show that with careful management and planning, GenAI has the potential to be a tool that truly benefits educators and learn

Chapter 5 - Conclusion and Future Research

5.1 Final Conclusions

Based on the content of the document provided by you, this study provides a comprehensive analysis of the application of GenAI in the field of education, with a special focus on how it is driving the transformation of education and the reshaping of education in the future. GenAI technology can not only improve teaching efficiency and learning experience, but also promote access and equity while ensuring data security and accurate information. By deeply exploring the core competence and typical applications of GenAI, this study reveals its significant potential and value in text generation, language understanding, knowledge query and logical reasoning.

The research also focuses on how GenAI drives the transformation of educational relations, intelligently upgrades educational environment, innovates educational resource supply, reshapes intelligent teaching methods, changes evaluation concepts, and governance of ethical issues in intelligent education. These changes help to reshape human education and learning paradigm and promote the development of education form to a more personalized, interactive and creative direction.

In addition, the study proposes solutions to meet the challenges of education reform, including providing AI technology training for educators and students, developing and implementing high-quality AI systems for education, and developing relevant policies and standards to ensure the fairness and accuracy of the technology. Through the implementation of these strategies, the research aims to address the key challenges currently facing GenAI technology and promote its sustainable and responsible application in the global education sector.

Overall, this study not only provides an in-depth analysis of the application of GenAI in education, but also looks ahead to how this technology has the potential to shape the future of education, pointing the direction of policy support and technological innovation needed to achieve this goal to ensure the healthy development of educational technology and truly benefit educators and learners at large.

5.2 Contributions and Limitations

The contributions of this study are manifold, focusing on both theoretical and practical advancements in the application of GenAI within the field of education. Theoretically, the study enriches the existing literature by providing a comprehensive analysis of how GenAI can reshape educational paradigms, including personalized learning, innovative teaching methodologies, and the overall digital transformation of the educational environment. By exploring the core competencies of GenAI, such as

text generation, language understanding, and intelligent resource allocation, this study advances the understanding of GenAI's potential to enhance teaching efficiency and learning experiences. Practically, the research provides actionable insights into how educators and policymakers can implement GenAI tools in a sustainable and responsible manner, addressing key challenges such as data privacy, content accuracy, and equitable access to technology. Furthermore, the study offers practical guidelines for optimizing the integration of GenAI in classrooms, focusing on teacher training, system compatibility, and fostering ethical usage. These contributions collectively aim to support a more effective and inclusive digital transformation of the education sector, enhancing both teaching practices and student learning outcomes on a global scale.

Also, it still has several limitations that may affect the generalizability and implementation of its findings. Firstly, the rapid development and integration of generative AI technologies present challenges in ensuring consistent accuracy and reliability of AI-generated educational content. The study also faces limitations regarding data privacy and security, particularly due to the collection and processing of student data, which may pose ethical and legal risks.

Furthermore, the uneven accessibility to technological resources across different educational institutions limits the scalability of the proposed AI-driven solutions, potentially exacerbating educational inequality. Finally, the transition in the role of educators due to AI integration raises challenges related to training and acceptance among teachers, who must adapt to new technologies and rethink their traditional methods, which may not be addressed comprehensively in this research.

5.3 Future Research

The limitations suggest that further studies are required to address these challenges in diverse educational contexts.

Deep integration of education and AI: Research how to further promote personalized and intelligent education through GenAI, such as developing specific large-scale models that are more suitable for the education field and improving the accuracy and security of teaching content.

Development and application of intelligent teaching resources: Explore how to improve the efficiency and quality of teaching resource development through GenAI technology, achieve intelligent generation and personalized configuration of teaching resources, and meet the learning needs of different students.

Innovation in teaching methods and evaluation systems: Research how to use GenAI technology to change teaching methods and learning methods, such as providing immersive learning experiences through VR and AR technologies and developing learning evaluation tools based on AI to improve teaching effectiveness and interactivity.

Ethical issues and policy formulation: With the continuous deepening of the application of GenAI technology in the field of education, it is necessary to pay attention to its ethical issues and legal risks. Research should include developing corresponding policies and standards to ensure the healthy development of AI, protecting students' privacy and data security.

Exploration of new modes of human-machine collaboration: Analyze and design new modes of human-machine collaborative teaching, study the auxiliary role of AI in education, explore how to optimize the interaction between teachers and intelligent systems, enhance humanistic care and critical thinking cultivation in education.

These directions can not only promote the development of educational technology, but also help improve the quality and efficiency of education, while addressing the challenges faced by current and future education.

References

[1] Abell, S.K., Appleton, K., & Hanuscin, D. (Eds.). (2007). Handbook of Research on Science Education (1st ed.). Routledge. https://doi.org/10.4324/9780203824696

[2] Al-Zahrani, A. M. (2024). Unveiling the Shadows: Beyond the hype of AI in education. *Heliyon*, *10*(9). https://doi.org/10.1016/j.heliyon.2024.e30696

[3] Baidoo-Anu, D., & Leticia, O. A. (2023). Education in the Era of Generative Artificial Intelligence (AI): Understanding the potential benefits of ChatGPT in promoting teaching and learning. *Social Science Research Network*. https://doi.org/10.2139/ssrn.4337484

[4] Brown, T., & Wyatt, J. (2010). Design thinking for social innovation. *Development Outreach*, *12*(1), 29–43. https://doi.org/10.1596/1020-797x_12_1_29

[5] Chablo, A. (1996). What can artificial intelligence do for anthropology? *Current Anthropology*, *37*(3), 553–555. https://doi.org/10.1086/204518

[6] Chan, C. K. Y., & Hu, W. (2023). Students' voices on GenAI: perceptions, benefits, and challenges in higher education. *International Journal of Educational Technology in Higher Education*, *20*(1). https://doi.org/10.1186/s41239-023-00411-8

[7] Chew, H. S. J. (2022). The Use of Artificial Intelligence–Based Conversational Agents (Chatbots) for Weight loss: Scoping review and Practical recommendations. *JMIR Medical Informatics*, *10*(4), e32578. https://doi.org/10.2196/32578

[8] Deng, M., Xunjian, R., Dongqin, Y., & Ju, Z. (2019). Research on the Reform and Promotion Strategy of Mixed Teaching Mode in Colleges and Universities. *Research on the Promotion of Teaching Reform*. https://doi.org/10.23977/icamei.2019.225

[9] Deshpande, M., & Rao, V. (2017). Depression detection using emotion artificial intelligence. *The Use of Artificial Intelligence*. https://doi.org/10.1109/iss1.2017.8389299

[10] Dwivedi, Y. K., Kshetri, N., Hughes, L., Slade, E. L., Jeyaraj, A., Kar, A. K., Baabdullah, A. M., Koohang, A., Raghavan, V., Ahuja, M., Albanna, H., Albashrawi, M. A., Al-Busaidi, A. S., Balakrishnan, J., Barlette, Y., Basu, S., Bose, I., Brooks, L., Buhalis, D., . . . Wright, R. (2023). Opinion Paper: "So what if ChatGPT wrote it?" Multidisciplinary perspectives on opportunities, challenges and implications of generative conversational AI for research, practice and policy. *International Journal of Information Management*, *71*. https://doi.org/10.1016/j.ijinfomgt.2023.102642

[11] Elo, S., & Kyngäs, H. (2008). The qualitative content analysis process. *Journal of Advanced Nursing*, *62*(1), 107–115. https://doi.org/10.1111/j.1365-2648.2007.04569.x

[12] Erl, T. (2006). *Service-Oriented architecture: Concepts, technology, and design*. Prentice Hall PTR. http://portal.acm.org/citation.cfm?id=1088876

[13] Forbes, C. T., & Davis, E. A. (2007). Exploring preservice elementary teachers' critique and adaptation of science curriculum materials in respect to socioscientific issues. *Science & Education*, *17*, 829–854. https://doi.org/10.1007/s11191-007-9080-z

[14] Furey, H., & Martin, F. (2019). AI education matters. *AI Matters*, *4*(4), 13–15. https://doi.org/10.1145/3299758.3299764

[15] Miao, F., & Wayne, H. (2023). *Guidance for GenAI in education and research*. UNESCO. https://doi.org/10.54675/ewzm9535

[16] Huang, H., Zheng, O., Wang, D., Yin, J., Wang, Z., Ding, S., Yin, H., Xu, C., Yang, R., Zheng, Q., & Shi, B. (2023). ChatGPT for shaping the future of dentistry: the potential of multi-modal large language model. *International Journal of Oral Science*, *15*(1). https://doi.org/10.1038/s41368-023-00239-y

[17] Javaid, M., Haleem, A., Singh, R. P., Khan, S., & Khan, I. H. (2023). Unlocking the opportunities through ChatGPT Tool towards ameliorating the education system. *BenchCouncil Transactions on Benchmarks, Standards and Evaluations*, *3*(2). https://doi.org/10.1016/j.tbench.2023.100115

[18] Jhaver, S., Birman, I., Gilbert, E., & Bruckman, A. (2019). Human-Machine collaboration for content regulation. *ACM Transactions on Computer-human Interaction*, *26*(5), 1–35. https://doi.org/10.1145/3338243

[19] Komasawa, N. (2024). Transformative Landscape of Anesthesia Education: Simulation, AI Integration, and Learner-Centric Reforms: A Narrative review. *Anesthesia Research*, *1*(1), 34–43. https://doi.org/10.3390/anesthres1010005
[20] Krausman, P. R. (2023). Managing artificial intelligence. *The Journal of Wildlife Management*, *87*(8). https://doi.org/10.1002/jwmg.22492
[21] Kydland, F. E., & Prescott, E. C. (1982). Time to build and aggregate fluctuations. *Econometrica*, *50*(6), 1345. https://doi.org/10.2307/1913386
[22] Leahy, S. M., Holland, C., & Ward, F. (2019). The digital frontier: Envisioning future technologies impact on the classroom. *Futures*, *113*. https://doi.org/10.1016/j.futures.2019.04.009
[23] Li, Y., Gong, M., Zhang, X., & Koh, L. (2018). The impact of environmental, social, and governance disclosure on firm value: The role of CEO power. *The British Accounting Review*, *50*(1), 60–75. https://doi.org/10.1016/j.bar.2017.09.007
[24] Liu, S., & Yi, M. (2024). Construction of a multimedia instructional effect assessment system of college foreign language translation based on artificial Intelligence. *International Journal of Information Systems and Supply Chain Management*, *17*(1), 1–20. https://doi.org/10.4018/ijisscm.343259
[25] Luckin, R., & Holmes, W. (2016). Intelligence Unleashed: An argument for AI in Education. *Intelligent Educational Products*. http://oro.open.ac.uk/50104/
[26] Masschelein, J., & Simons, M. (2015). Education in times of fast learning: the future of the school. *Ethics and Education*, *10*(1), 84–95. https://doi.org/10.1080/17449642.2014.998027
[27] Medical Professionalism in the New Millennium: A physician Charter. (2002). *Annals of Internal Medicine*, *136*(3), 243. https://doi.org/10.7326/0003-4819-136-3-200202050-00012
[28] Michel-Villarreal, R., Vilalta-Perdomo, E., Salinas-Navarro, D. E., Thierry-Aguilera, R., & Gerardou, F. S. (2023). Challenges and opportunities of Generative AI for higher Education as explained by ChatGPT. *Education Sciences*, *13*(9), 856. https://doi.org/10.3390/educsci13090856
[29] Prather, J., Denny, P., Leinonen, J., Becker, B. A., Albluwi, I., Craig, M., Keuning, H., Kiesler, N., Kohn, T., Luxton-Reilly, A., MacNeil, S., Petersen, A., Pettit, R., Reeves, B. N., & Savelka, J. (2023). The Robots Are Here: Navigating the Generative AI Revolution in Computing Education. *Application, Problems and Prospects of GenAI*. https://doi.org/10.1145/3623762.3633499
[30] Rueden, C. T., Schindelin, J., Hiner, M. C., DeZonia, B. E., Walter, A. E., Arena, E. T., & Eliceiri, K. W. (2017). ImageJ2: ImageJ for the next generation of scientific image data. *BMC Bioinformatics*, *18*(1). https://doi.org/10.1186/s12859-017-1934-z
[31] Shahroom, A. A., & Hussin, N. (2018). Industrial Revolution 4.0 and education. *International Journal of Academic Research in Business & Social Sciences*, *8*(9). https://doi.org/10.6007/ijarbss/v8-i9/4593
[32] Shen, Y., Heacock, L., Elias, J., Hentel, K. D., Reig, B., Shih, G., & Moy, L. (2023). ChatGPT and other large language models are double-edged swords. *Radiology*, *307*(2). https://doi.org/10.1148/radiol.230163
[33] Singh, R., & Agrawal, M. (2008). Potential benefits and risks of land application of sewage sludge. *Waste Management*, *28*(2), 347–358. https://doi.org/10.1016/j.wasman.2006.12.010
[34] Soni, M., Anjaria, P., & Koringa, P. (2023). The revolutionary impact of chatGPT: advances in biomedicine and redefining healthcare with large language models. *Future Medicine AI*. https://doi.org/10.2217/fmai-2023-0011
[35] Strait, G. G., McQuillin, S., Terry, J., & Smith, B. H. (2014). School-based motivational interviewing with students, teachers, and parents: new developments and future direction. *Advances in School Mental Health Promotion*, *7*(4), 205–207. https://doi.org/10.1080/1754730x.2014.949064
[36] Stubbs, M., & Piddock, P. (1985). Artificial Intelligence in Teaching and Learning: An Introduction. *PLET. Programmed Learning & Educational Technology*, *22*(2), 150–157. https://doi.org/10.1080/1355800850220207
[37] Suarez, M., Fernandez, A., Menendez, J., Torrecillas, R., U, H., Hennicke, J., Kirchner, R., & Kessel, T. (2013). Challenges and Opportunities for spark Plasma sintering: a key technology for a new generation of materials. *InTech*. https://doi.org/10.5772/53706

[38] Tadić, M., Bakker, A. B., & Oerlemans, W. G. (2013). Work happiness among teachers: A day reconstruction study on the role of self-concordance. *Journal of School Psychology*, *51*(6), 735–750. https://doi.org/10.1016/j.jsp.2013.07.002

[39] Turnbull, J. (2008). Reassembling the social: An introduction to actor-network-theory. *New Zealand Geographer*, *64*(3), 246–247. https://doi.org/10.1111/j.1745-7939.2008.00151_4.x

[40] Wang, Y., Shen, H., & Chen, T. (2023). Performance of ChatGPT on the pharmacist licensing examination in Taiwan. *Journal of the Chinese Medical Association*, *86*(7), 653–658. https://doi.org/10.1097/jcma.0000000000000942

[41] War of the chatbots: Bard, Bing Chat, ChatGPT, Ernie and beyond. The new AI gold rush and its impact on higher education. (2023). *Journal of Applied Learning and Teaching*, *6*(1). https://doi.org/10.37074/jalt.2023.6.1.23

[42] Weng, Q. (2012). Remote sensing of impervious surfaces in the urban areas: Requirements, methods, and trends. *Remote Sensing of Environment*, *117*, 34–49. https://doi.org/10.1016/j.rse.2011.02.030

[43] Wolfram, M., Frantzeskaki, N., & Maschmeyer, S. (2016). Cities, systems and sustainability: status and perspectives of research on urban transformations. *Current Opinion in Environmental Sustainability*, *22*, 18–25. https://doi.org/10.1016/j.cosust.2017.01.014

[44] Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education – where are the educators? *International Journal of Educational Technology in Higher Education*, *16*(1). https://doi.org/10.1186/s41239-019-0171-0

[45] Zhuo, F. (2021). Human-machine co-creation on artistic paintings. *2021 IEEE 1st International Conference on Digital Twins and Parallel Intelligence (DTPI)*. https://doi.org/10.1109/dtpi52967.2021

Appendix

Survey questionnaire: The impact of applying Generative Artificial Intelligence in education

Part 1: Basic Information of Participants

1.What is your profession?

- Teacher

- Student

- Education administrative personnel

- Other, please specify: _____

2.How familiar are you with the application of artificial intelligence technology in education?

- Not familiar

- Slightly familiar

- Very familiar

Part 2: Perception and Experience

3.Have you ever used artificial intelligence tools in your teaching or learning process?

- Yes

- No

-If you choose "Yes", please describe your experience: _____

4.How do you think artificial intelligence technology is effective in improving educational outcomes?

- Very ineffective

- Invalid

- Neutral

- Effective

- Very effective

5.What do you think is the greatest benefit of integrating Generative Artificial Intelligence in education? (Multiple options available)

- Improve personalized learning efficiency

-Enrich teaching resources and methods

- Enhance student learning motivation

- Optimize the workflow of teachers

- Other, please specify: _____

Part 3: Challenges and Concerns

6.What is your biggest concern when using artificial intelligence technology in education? (Multiple options available)

- Privacy and security
- Accuracy of content
-Changes in teacher roles
- Technical accessibility
- Other, please specify: _____

7.Have you ever encountered any ethical issues when using artificial intelligence educational tools?

- Yes
- No
-If you choose "Yes", please specify: _____

Part 4: Future Prospects and Improvements

8. Which education fields do you think can benefit the most from artificial intelligence technology? (Multiple options available)

- Course and instructional design
- Student evaluation and feedback
- Student support and tutoring
- Teacher development and training
- Other, please specify: _____

9. What improvements or features would you like to see in artificial intelligence education tools?

- More precise personalized learning paths
-Wider language and cultural adaptability
- Stronger interaction and simulation capabilities
- More stringent data protection measures
- Other, please specify: _____

10. How do you view the development of artificial intelligence in education in the next decade?

- Very optimistic
- Optimistic
- Neutral
- Pessimistic
- Very pessimistic

Part 5: Final Ideas

11. Any other comments or suggestions regarding the application of artificial intelligence in education?