

# **Educational Transformation in the Age of Artificial Intelligence: Integrating Generative AI and Human Intelligence to Enhance Educational Quality**



Macao Association for Internet Research  
Athena Seng Jing Li Angus Cheong

APRIL 2025



# Writing Group



## Think Tank

Macao Association for Internet Research

## Author

Athena Seng Jing Li Angus Cheong



# Introduction

---

The report titled Educational Transformation in the Age of Artificial Intelligence: Integrating Generative AI and Human Intelligence to Enhance Educational Quality (hereinafter referred to as “Report” ) published by the Macao Association for Internet Research in April 2025, explores the transformative impact of generative AI on the education sector. The Report highlights that generative AI helps enhance teaching efficiency and provide smarter and more personalized support for students and teachers, facilitating a shift from traditional education to "intelligent education." The potential applications of generative AI in education are enormous. However, its implementation also faces multiple challenges: the authenticity, safety, and ethical issues of output content threaten the rigor of education; uneven resource distribution may exacerbate concerns about educational equity in the short term; and there are concerns regarding the misuse of AI technology. Therefore, the Report advocates for the establishment of an educational ecosystem that synergizes "AI and human intelligence," emphasizing that AI, as an auxiliary tool, should be deeply integrated with teacher guidance. It calls for the enhancement of ethical standards, strengthening AI literacy among teachers and students, and optimizing the inclusivity of technology to empower inclusive innovation, promoting educational equity and sustainable development.





# Table of Contents

Introduction	01
I. Introduction and Research Background	03
II. Empowerment through Technology and Innovation in Models: The Application and Potential of Generative AI in the Field of Education	05
III. The Double-Edged Sword of Technology: The Challenges of Generative AI in the Field of Education	08
IV. Artificial Intelligence + Human Intelligence: Building a Collaborative New Educational Model	11
V. Building a New Education Ecosystem Driven by AI Literacy	13

# I.Introduction and Research Background

With the rapid development of artificial intelligence (AI), a wave of technology centered around generative artificial intelligence (Gen AI) is reshaping global society and economic structures at an unprecedented pace. Since the emergence of ChatGPT in 2022, generative AI has quickly penetrated key areas such as education, healthcare, and manufacturing, thanks to its powerful content creation capabilities, multimodal interaction potential, and self-learning characteristics. In 2025, the continuous development of generative AI saw the Chinese artificial intelligence company DeepSeek release the open-source model DeepSeek-R1, which quickly accumulated a large user base due to breakthroughs in deep learning and neural network technology. This advancement has facilitated the gradual transition of generative AI into a mature stage characterized by technological consolidation and commercial implementation. Currently, the core features of generative AI are manifested in Multimodal Fusion, the development of Vertical-specific models, and the autonomy of AI agents.

In the field of education, the introduction of AI technology has brought unprecedented opportunities for transformation to traditional educational models. The essence of education is the transmission of knowledge and the cultivation of abilities. With the integration of AI technology, not only can teaching efficiency be enhanced, but it can also provide smarter and more personalized support for both students and teachers. Generative AI can offer customized learning paths and content recommendations based on students' learning progress and individual needs, thereby providing teachers with effective teaching assistance tools. At the same time, generative AI has enhanced students' interactive experiences and improved teaching efficiency by simulating a real learning environment, which promoted the transition of education from traditional education to "intelligent education."

However, the application of AI technology has also brought new challenges and issues, such as educational equity, academic integrity, changes in teacher-student relationships, and technology ethics. Specifically, generative artificial intelligence in educational settings may lead to unstable feedback quality due to issues like "AI hallucinations" and the randomness of output results, and even trigger ethical risks in complex tasks. For example, generative AI may pose risks of plagiarism or the spread of misinformation regarding academic integrity, and it may also cause students to rely excessively on technology, thereby weakening their ability for independent learning and impacting educational equity. Additionally, the application of generative artificial intelligence may impact the role of teachers and traditional education models, prompting educators to reevaluate the relationship between humans and machines. Therefore, how to leverage the advantages of generative artificial intelligence while achieving a complementary relationship between technology and human intelligence to effectively address these challenges has become an important issue that needs to be resolved in the current education sector.

In recent years, scholars both domestically and internationally have conducted extensive research on the application of generative AI in the field of education. The research hotspots focus on areas such as educational reform, risk governance, human-machine relationships, and competency development. Our country also places great importance on the application and innovation of generative AI in education. In 2022, the Ministry of Education issued the "Guiding Training Program for Graduate Students in the Field of Artificial Intelligence (Trial)," which clarified the training direction for high-level talent in the field of artificial intelligence and is committed to building a training system for interdisciplinary talents in artificial intelligence<sup>1</sup>. Based on this, in 2024, the Ministry of Education launched an artificial intelligence campaign to boost education, making overall strategic deployments to promote the deep application of artificial intelligence in the field of education and efforts to modernize education. In Macau, the newly revised basic academic requirements and curriculum guidelines in 2024 have added artificial intelligence and programming content to the information technology curriculum. The Macau Education and Youth Development Bureau has also introduced supporting curriculum guidelines to assist educators in conducting artificial intelligence courses and teaching, nurturing the necessary artificial intelligence literacy for students.

In this context, this study aims to explore in depth the current state and potential of generative AI in the field of education, analyze the opportunities and challenges it brings, and propose corresponding strategies to address these issues, with the hope of promoting the digital transformation and sustainable development of the education industry by combining generative AI with human intelligence.



<sup>1</sup> Ministry of Education of the People's Republic of China. (2022, July 27). Notice on Issuing the "Guiding Postgraduate Training Program in the Field of Artificial Intelligence (Trial)". [http://www.moe.gov.cn/s78/A22/tongzhi/202207/t20220729\\_649598.html](http://www.moe.gov.cn/s78/A22/tongzhi/202207/t20220729_649598.html)

## II. Empowerment through Technology and Innovation in Models: The Application and Potential of Generative AI in the Field of Education

The application of large models in artificial intelligence has enriched educational resources and learning pathways, and the use of generative AI in the field of education is becoming increasingly widespread. With the maturity of multimodal large models and autonomous intelligent agents, generative AI has evolved from a singular auxiliary tool into a driving engine for educational system reform, encompassing various aspects from student learning to teacher instruction. This is reflected in innovations in educational models, improvements in teaching efficiency, personalized learning, and the optimization of educational assessment and feedback.

In terms of innovation in educational models, in the context of generating reading comprehension questions, generative AI can effectively extract and understand semantic information from a large amount of reading text data, creating interactive reading comprehension questions that are syntactically fluent, align with the theme or context of the reading article, and have correct answers<sup>1</sup>. Research has shown that generative AI performs well in generating items for multiple-choice questions, effectively creating a high-quality set of distractor candidates that exhibit strong grammar, language fluency, relevance, and interference capability based on the stem of the multiple-choice question, background text, and correct options<sup>2</sup>. In addition, the classroom teaching analysis system based on generative AI can also integrate and collect multimodal data from teachers. By using technologies such as speech recognition, posture recognition, facial expression recognition, and brain data recognition, it gathers data including teaching design and teaching characteristics, transforming it into structured data for intelligent analysis, thereby providing important support for teachers to improve their teaching methods.

In terms of improving teaching efficiency, generative AI can automatically create teaching materials such as textbooks, courseware, exercises, and test papers, thereby reducing the preparation burden on teachers and allowing them to devote more energy to teaching innovation and student guidance. Survey data show that nearly 45% of surveyed teachers in the UK reported using artificial intelligence to develop students' foundational skills weekly, saving two hours of time; over 40% of surveyed teachers in the US indicated that using AI tools to help students enhance their reading, writing, and arithmetic skills saves more than one hour each week<sup>3</sup>. Teachers use generative AI to organize and associate knowledge points, gaining a more accurate understanding of the connotations and extensions of these concepts, thereby enhancing the richness and extensibility of generated resources. Moreover, a study released by the online learning platform Study.com in 2024 shows that 65% of educators in the United States reported an increase in their teaching enthusiasm with the use of artificial intelligence. There is a clear connection between the level of training in artificial intelligence and teachers' enthusiasm for their profession; among teachers whose professional enthusiasm has increased, 50% have received comprehensive training in artificial intelligence<sup>4</sup>. These studies demonstrate the importance of generative AI in enhancing teaching efficiency and professional development for teachers.

<sup>1</sup> Dijkstra, R., Genç, Z., Kayal, S., & Kamps, J. (2022). Reading comprehension quiz generation using generative pre-trained transformers. In S. Sosnovsky, P. Brusilovsky, & A. Lan (Eds.), *Proceedings of the Fourth International Workshop on Intelligent Textbooks 2022 co-located with 23rd International Conference on Artificial Intelligence in Education (AIED 2022)*: Durham, UK, July 27, 2022 (pp. 4-17). Aachen: CEUR-WS.

<sup>2</sup> Bitew S K., Deleu J., Develder C., & Demeester, T. (2023). Distractor generation for multiple-choice questions with predictive prompting and large language models. *arXiv*.

<sup>3</sup> Kerrison, C. (2024, September 16). AI poses significant time-saving benefits to teachers, but training and confidence hurdles persist. Retrieved from <https://www.futuresource-consulting.com/insights/ai-poses-significant-time-saving-benefits-to-teachers-but-training-and-confidence-hurdles-persist/>

<sup>4</sup> Lehtinen-Vela, A., & Bharadwaj, N. (2024). One year later: The impact of generative AI in education. Study.com. <https://study.com/academy/lesson/one-year-later-the-impact-of-generative-ai-in-education.html>

Personalized learning is a major highlight of generative AI in the field of education. Traditional educational models often struggle to meet the unique needs of each student, while generative AI can develop personalized learning plans based on each student's learning style and progress. Research shows that generative AI can provide customized learning paths and resources for each student by analyzing their learning data and behavioral patterns. For example, based on a student's learning history, knowledge mastery, and learning style, generative AI can dynamically adjust the difficulty and presentation of teaching content, thereby achieving precise instruction<sup>1</sup>. Moreover, generative AI can also serve as a virtual teaching assistant, answering students' questions in real-time, providing personalized tutoring and Q&A services, enhancing classroom interactivity and learning experiences. In addition, generative AI can generate diverse learning resources tailored to different students and simulate real learning scenarios, stimulating students' interest in learning and creativity<sup>2</sup>. For example, immersive learning experiences have been shown to significantly improve students' learning outcomes, a finding validated in multiple studies. In an experiment involving college students, those who used AI-assisted learning performed significantly better than the control group in both exam scores and assignment quality. Furthermore, in science experimental teaching, generative AI can simulate experimental environments, allowing students to conduct experiments in a virtual setting, thereby enhancing their practical skills<sup>3</sup>. Additionally, the use of generative AI also helps improve students' learning efficiency. According to the latest research by Macao Association for Internet Research in 2024, among internet users who are aware of generative AI, 22% expressed that they are most looking forward to it enhancing their learning or work efficiency<sup>4</sup>. Furthermore, a joint survey conducted by Pearson and Morning Consult found that 56% of surveyed American

college students indicated that generative AI helps them learn more efficiently, 51% stated that generative AI has helped them achieve better grades, and nearly 60% are interested in trying out the next generation of AI tools<sup>5</sup>.

Additionally, in the area of educational assessment and feedback, generative AI, through intelligent analysis tools, can automatically grade and provide feedback on students' assignments and exams, offering more comprehensive and accurate evaluation results. Research shows that generative AI can analyze students' learning behavior data to create learner profiles, helping teachers organize teaching activities more effectively<sup>6</sup>. Furthermore, generative AI can conduct adaptive assessments based on students' abilities and learning progress, providing personalized feedback and suggestions. This intelligent assessment method not only improves assessment efficiency but also offers teachers richer data on student learning. Studies indicate that emotionally rich AI feedback helps reduce students' negative emotions towards receiving feedback, especially anger<sup>7</sup>. This indicates that generative AI, when providing feedback, can not only focus on the students' mastery of knowledge but also positively and actively influence their psychological state through the integration of emotional elements, thereby increasing students' engagement in learning.

<sup>1</sup> Shi, W., & Han, X. (2024). The impact of generative artificial intelligence on learning analytics research: Current situation and prospects - Review of the 2024 International Conference on Learning Analytics and Knowledge (LAK24). *E-education Research*, (12), 15-28

<sup>2</sup> Zhang X, Zhang P, Shen Y, et al. (2024). A Systematic Literature Review of Empirical Research on Applying Generative Artificial Intelligence in Education. *Frontiers of Digital Education*, 1(3): 223-245

<sup>3</sup> Zhu, Y., Liu, Q., & Zhao, L. (2025). Exploring the impact of generative artificial intelligence on students' learning outcomes: a meta-analysis. *Education and Information Technologies*.

<sup>4</sup> Macao Association for Internet Research. (2024, June 11). "Generative AI" Usage in Macao 2024. Macao Internet Project. <https://www.macaointernetproject.net/blog/generative-ai-usage-in-macao-2024-executive-summary/>

<sup>5</sup> HOBOKEN, N.J. (2024, June 24). End of semester AI report: More college students say AI is helping them get better grades. Pearson. <https://plc.pearson.com/en-GB/news-and-insights/news/end-semester-ai-report-more-college-students-say-ai-helping-them-get-better>

<sup>6</sup> Dai, Y. (2024). Empowering Teachers with Generative Artificial Intelligence Technology to Evaluate the Quality of Classroom Teaching. *Advances in Education*, 14(6), 1264-1271

<sup>7</sup> Alsaiani, O., Baghaei, N., Lahza, H., Lodge, J. M., Boden, M., & Khosravi, H. (2024). Emotionally enriched feedback via generative AI. *arXiv preprint arXiv:2410.15077*

In the long term, the application potential of generative AI in the field of education is not limited to current core scenarios, and its future development potential is even more immeasurable. In recent years, with the continuous advancement of technology, more and more scholars have conducted in-depth discussions and analyses on this topic in their research. Through the sorting and summarization of previous discussions, it is evident that the trend of technology driving the intelligentization of education is becoming increasingly apparent. Research has shown that the combination of generative AI with virtual reality (VR) and augmented reality (AR) technologies can create entirely new educational scenarios, such as virtual laboratories and immersive history classrooms. These innovative teaching methods not only stimulate students' interest in learning but also enhance their practical skills and hands-on abilities<sup>1</sup>. According to the "2024 intelligent education development blue paper: Generative artificial intelligence in education", it is predicted that generative AI will play a key role in the innovation of educational technology in the future, driving education towards a more intelligent and personalized direction. This will enable each student to receive a learning experience that is more suitable for their individual learning characteristics and needs, undoubtedly bringing profound changes and impacts to the education industry.

In addition, interdisciplinary comprehensive applications provide strong support for the digital transformation of education. Whether in language learning, scientific experiments, or artistic creation, generative AI can play an important role. Many universities, both domestically and internationally, are accelerating their exploration of the deep application of artificial intelligence in higher education. For example, researchers at a certain academic medical center in South Korea are conducting feasibility studies on the use of generative AI for virtual patient medical history collection<sup>2</sup>.

East China Normal University has established a research platform for educational neuroscience and formed a professional team to attempt to combine educational neuroscience methodologies with AI meta-analysis<sup>3</sup>. The potential for this interdisciplinary application will not only promote the integration between disciplines and provide students with a broader and deeper learning experience, but it will also offer new methods for educational measurement and evaluation.

Generative AI also demonstrates great potential in promoting educational equity, providing new solutions to narrow the gap in the uneven distribution of educational resources. On one hand, generative AI can generate personalized, high-quality teaching content and learning resources based on the needs of different students, offering fairer learning opportunities for students in various regions. On the other hand, the application of generative AI can significantly reduce the cost of accessing educational resources. Scholars have indicated that by connecting to Smart Education of China and other public education service platforms, AI technology can achieve widespread sharing of educational resources, ensuring that more students can benefit from high-quality educational content<sup>4</sup>, which helps promote the widespread dissemination of the concept of educational equity.

<sup>1</sup> Aqusag Technologies. (2024, September 2). Future education: How AI is transforming learning. LinkedIn Pulse. Retrieved from <https://www.linkedin.com/pulse/future-education-how-ai-transforming-learning-aqusag-technologies-odzhc>

<sup>2</sup> Yi, Y., Kim, K J. (2025). The feasibility of using generative artificial intelligence for history taking in virtual patients. BMC Res Notes, 18, 80

<sup>3</sup> Yang, Z., Wang, J., Wu, D., & Chen, X. (2023). Exploring the Impact of ChatGPT/AIGC on Education and Strategies for Response. Journal of East China Normal University (Educational Science), 41(7), 26-35

<sup>4</sup> Wang, J., Zhang, Y. J., Wang, C., Min, X., & Kong, W. (2024). Research on the application status and path optimization of the National Primary and Secondary School Intelligent Education Platform—Based on a sample of 30,605 primary and secondary school students nationwide. E-education Research, 45(6), 50-56, 65



### III. The Double-Edged Sword of Technology: The Challenges of Generative AI in the Field of Education

Although generative AI has brought about numerous transformations and opportunities, the series of challenges it presents cannot be overlooked as its applications continue to deepen. These challenges are reflected not only in the changes to teaching methods but also involve various aspects such as inadequate technological accessibility, over-reliance, the lack of policies and regulations, and deficiencies in ethical standards and regulatory systems.

The technical characteristics of generative AI lead to issues of content reliability in educational applications. Firstly, the outputs of generative AI exhibit randomness and inconsistency, which is particularly prominent in disciplines that require precise terminology, such as law, medicine, and academic writing<sup>1</sup>. Asking the same question multiple times may yield different answers, and this variability makes it difficult for teachers and students to rely on its outputs as authoritative references. Furthermore, due to insufficient training data, biases in training data, lack of domain knowledge, or flaws in the model architecture, generative AI is prone to producing "AI hallucinations," which refers to the generation of content that is factually incorrect or biased during the use of generative AI. This leads to a lack of accuracy in the generated subject knowledge, affecting students' correct understanding of fundamental concepts, diminishing the quality of classroom teaching, and further impacting its reliability in education. For example, As shown in Figure 1, according to the latest research by Macao Association for Internet Research in 2024, among generative AI users in Macao, 41% expressed concerns about the risks associated with using generative AI, with the highest concern being the authenticity of generated information (20%)<sup>2</sup>.

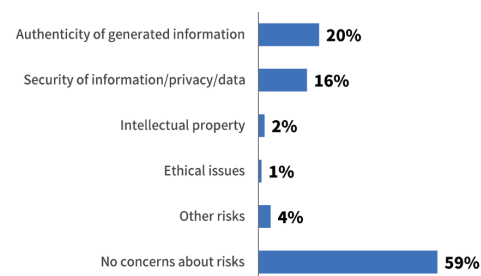


Figure 1 American educators observing instances of students misusing AI

Secondly, the practical effects of generative AI providing personalized learning for students may not meet expectations. On one hand, different students have varying degrees of adaptation to artificial intelligence tools, which means not all students can effectively utilize these tools to enhance their learning outcomes. On the other hand, the technical thresholds and resource dependencies of generative AI exacerbate the phenomenon of "digital stratification" in education. The gaps in computing power, data, and teaching resources between developed and underdeveloped regions allow schools in developed areas to utilize AI technology to assist teaching more comprehensively and earlier, providing students with richer and more efficient learning experiences. This easily leads to the application of generative AI exhibiting a "Matthew effect," further widening the gap in educational quality between different regions<sup>3</sup>.

<sup>1</sup> Werder, K. (2025). The challenge of consistency in generative AI: Will we adapt or fix the system? Communications of the ACM. Retrieved from <https://cacm.acm.org/blogcacm/the-challenge-of-consistency-in-generative-ai-will-we-adapt-or-fix-the-system/>

<sup>2</sup> Macao Association for Internet Research. (2024, June 11). "Generative AI" Usage in Macao 2024. Macao Internet Project <https://www.macaointernetproject.net/blog/generative-ai-usage-in-macao-2024-executive-summary/>

<sup>3</sup> Hu, X., Lin, Z., & Liu, X. (2024). Integrating Artificial Intelligence into Education: Global Trends and China's Path. E-education Research, 45(12), 13-22

Again, the widespread application of generative AI in education has a profound impact on the role of teachers, who are no longer the sole purveyors of knowledge but need to shift into guides and facilitators of learning. As early as 2010, scholars raised this issue, noting that while this transition brought by artificial intelligence can enhance students' ability for autonomous learning, it also imposes higher requirements on teachers' professional competencies. Some scholars have pointed out that teachers' understanding of generative AI is inadequate; on one hand, blind trust and dependence on generative AI may lead to its unrestricted use in the teaching process, turning educational activities into mere showcases of technology<sup>1</sup>; on the other hand, inherent distrust of generative AI technology may lead teachers to develop resistance and doubt their own technological application abilities<sup>2</sup>. Teachers need not only to master how to effectively integrate AI tools with curriculum content and find a balance between traditional teaching and technology-assisted teaching, but also to consider how to address new issues arising from the introduction of AI, such as classroom management and student psychology<sup>3</sup>. This places higher professional demands and greater pressure on teachers. If schools and educational institutions cannot provide sufficient support and training, teachers may find it difficult to smoothly transition to the new teaching model.

Furthermore, while the immediate feedback and solutions provided by generative AI can help students complete tasks in the short term, in the long run, some students may weaken their ability to think independently and solve problems due to an over-reliance on these tools. Scholars have pointed out that when students face complex problems and directly turn to AI for help without attempting to explore independently, they may feel lost in situations where AI assistance is unavailable<sup>4</sup>. This dependency not only affects students' autonomy and



initiative in learning, limiting diversity and creative thinking, but it may also hinder their ability to adapt to changes in future learning and work environments. The content generated by generative artificial intelligence may sometimes lack accuracy and relevance due to the current limitations of technology, which can pose a potential threat to students' learning outcomes. If students become overly reliant on these tools while neglecting the development of critical thinking and information discernment skills, it may lead to superficial and one-sided knowledge acquisition, adversely affecting their long-term academic development and overall quality enhancement.

<sup>1</sup>Cui, X., & Zhu, X. (2024). Promoting Wisdom in Smart Teaching: The Dilemma and Breakthroughs of Smart Teaching in Higher Vocational Colleges in the Era of Smart Education. *Vocational Technology*, 23(6), 55-63

<sup>2</sup>Wei, X. (2023). Research on digital technology stress among public elementary school teachers and management countermeasures (Master's thesis). East China Normal University, Shanghai.

<sup>3</sup>Ertmer, P.A. & Ottenbreit-Leftwich, A.T. (2010). Teacher Technology Change: How Knowledge, Confidence, Beliefs, and Culture Intersect. *Journal of Research on Technology in Education*, 42(3), 255-284

<sup>4</sup>Wang, W., & Li, Y. (2024). Development and Reflection on International Generative Artificial Intelligence Application in Education. *Open Education Research*, 30(3), 37-44



Finally, the rapid development of generative AI presents adaptive challenges to existing educational policies and regulatory mechanisms. On one hand, the current educational legal and regulatory framework is primarily based on traditional teaching models, and its content and provisions are difficult to cover the complexity and dynamism of generative AI. With the widespread use of generative AI in education, there is significant involvement in the collection and analysis of personal data from a large number of students, requiring high attention to data privacy and security issues. Additionally, due to the vast and complex data sources of generative AI, the content it generates may lead to intellectual property or copyright issues<sup>1</sup>, and could even involve concerns related to academic integrity. On the other hand, the existing regulatory mechanisms appear inadequate when faced with generative AI, struggling to adapt to the rapidly evolving technological landscape. For example, many schools and educational institutions lack clear regulatory standards and effective supervision processes regarding the use of generative AI. The misuse of generative AI by students, such as having AI write essays or falsifying experimental data, is undermining the foundation of academic ethics. This not only poses a series of potential risks but may also negatively impact the quality of education in the future. For example, As shown in Figure 2, a study released by the online learning platform Study.com in 2024 shows that 58% of educators across the United States have noticed instances of students abusing AI, with the issues being most severe in Florida and California, where the abuse rates reach 66% and 65%, respectively<sup>2</sup>. Major universities in China are also trialing or implementing regulations to standardize students' use of AI for thesis writing. For instance, Fudan University has specific trial regulations for undergraduate theses that clearly prohibit the use of AI tools, while Tianjin University of Science and Technology requires that the proportion of AI-generated content in theses does not exceed 40%.

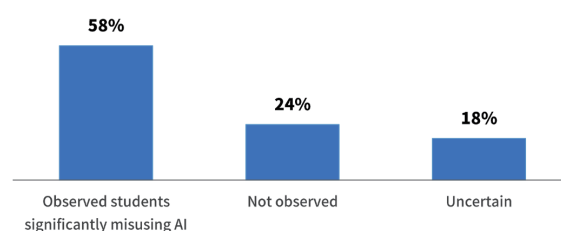


Figure 2 Concerns of Generative AI Users in Macao Regarding AI Usage Risks

As can be seen from the above, the challenges posed by generative AI in the field of education exist in multiple aspects. Therefore, education needs to actively adapt to the rapid development of artificial intelligence technology, holding a more open and inclusive attitude towards it, and encouraging mutual promotion and progress between education and technology.

<sup>1</sup> Xiong, R. (2024). Research on Copyright Infringement in Generative Artificial Intelligence (Master's thesis). Jiangxi University of Finance and Economics.

<sup>2</sup> Lehtinen-Vela, A., & Bharadwaj, N. (2024). One year later: The impact of generative AI in education. Study.com. <https://study.com/academy/lesson/one-year-later-the-impact-of-generative-ai-in-education.html>

## IV. Artificial Intelligence + Human Intelligence: Building a Collaborative New Educational Model

To address the various challenges posed by generative AI in the field of education, solely relying on technological optimization or passive regulation is insufficient. Therefore, we still need the intervention of Human Intelligence (HI) in the education system. The future of education should not be about choosing between human teachers and AI, but rather about embracing the immense potential of their collaboration. It is particularly important to build a cooperative educational ecosystem where AI and HI work together. Such a system can not only enhance teaching efficiency but also promote deep understanding and creativity development in learners, while providing powerful support tools for educators. This education system can be achieved through the following methods:

First, AI, as an enhanced auxiliary tool for HI, plays a key role in collaborative education systems. Through generative AI, teachers can provide personalized learning feedback to students, helping them optimize their writing style, structure, and clarity. This intelligent feedback mechanism not only alleviates the workload of teachers but also allows students to receive more targeted guidance. Additionally, AI-driven educational platforms can automatically generate adaptive resources and exercises based on students' learning performance and pace, thereby meeting the personalized needs of different learners.

Secondly, the construction of collaborative learning platforms is another important direction for the integration of AI and HI. Through AI-enhanced online discussions, students can engage in real-time interactions on the platform, sharing viewpoints, asking questions, and collaborating on projects. AI technology can analyze discussion content in real-time, extract key themes, and summarize discussion outcomes, while also providing students with recommendations for relevant resources. This intelligent discussion tool not only improves learning efficiency but also promotes deeper student engagement. In addition, AI-assisted team project management tools can help students collaborate

In addition, AI-assisted team project management tools can help students collaborate in brainstorming, content generation, and project planning, thereby enhancing the team's creativity and efficiency.

Third, AI can provide students with intelligent reflection prompts and feedback mechanisms. Through reflection writing assignment prompts created by generative AI, students can critically think about their learning processes and the effectiveness of using AI tools. At the same time, AI-generated feedback can help students identify their strengths and areas for improvement, thereby promoting autonomous learning and self-enhancement. Additionally, AI tools can assist in the peer review process by providing preliminary feedback before students exchange their works, helping them focus on higher-level revisions and optimizations.

Fourth, as a core role in the education system, the enhancement of teachers' abilities also relies on AI support. By constructing a "teacher-AI-student" collaborative teaching model, teachers can track and record students' learning performance, engagement, and emotional state in real-time. This data can help teachers understand trends, identify students' learning difficulties in a timely manner, and implement targeted interventions. AI-generated reports can also provide teachers with an overview of the overall class performance as well as individual student performance, supporting data-driven decision-making and the formulation of personalized teaching strategies. In addition, educational institutions should provide professional development courses for teachers to help them master the use of AI tools, effectively enhancing their teaching practice skills supported by technology.

Fifth, the combination of AI and HI is not without challenges; it needs to fully consider ethical issues within the education system, particularly transparency and data privacy concerns. Educational institutions should clearly explain to students how AI tools are used and their limitations, as well as explicitly regulate the reasonable application of artificial intelligence to avoid students becoming overly dependent on AI, which could affect independent thinking. Moreover, cultivating students' critical thinking skills is especially important; teachers should guide students to recognize the limitations of AI-generated content and emphasize the importance of human judgment in interpreting and applying AI outputs. As mentioned in the "2024 intelligent education development blue paper: Generative artificial intelligence in education", it is essential to promote the alignment of generative AI with human values, develop ethical and compassionate artificial intelligence, and enhance the educational appropriateness of generative AI, truly campaigning to boost education<sup>1</sup>.

Sixth, community building is one of the keys to the success of the AI + HI collaborative education system. By organizing collaborative AI projects, students can engage in practical solutions to real-world problems, thereby experiencing the integration of technology and human wisdom in real contexts. For example, students can use AI tools to design educational applications or develop community service projects. This practice not only enhances technical skills but also fosters a sense of social responsibility. Additionally, establishing a feedback mechanism that allows students to provide input on their experiences with AI tools can help educators continually optimize the application of AI in the education system, ensuring it better meets students' needs.

Education is essentially a process of value guidance and cognitive construction as the core field of the transmission and innovation of human civilization. This process can only achieve sustainable development through a collaborative model led by human wisdom and assisted by artificial intelligence. By combining generative AI with human intelligence, we can build an intelligent, personalized, and highly collaborative educational ecosystem. This AI + HI collaborative educational model redefines the learning relationship, enhancing teaching efficiency while also promoting learners' deep engagement and the development of critical thinking. The key point lies in using AI as a supportive tool rather than a replacement for human intelligence. By leveraging the efficiency of AI and the creativity of human intelligence, we can achieve an organic integration of technology and the humanities. The classrooms in the future will no longer be traditional knowledge transmission settings but become student-centered interactive environments that encourage exploration and innovation. Teachers and AI will become the best partners, jointly inspiring students' potential, allowing each student to find the best path in their learning journey and face future challenges.



<sup>1</sup> iFLYTEK Institute of Educational Technology. (2024). 2024 intelligent education development blue paper: Generative artificial intelligence in education. iFLYTEK Co., Ltd.

## V. Building a New Education Ecosystem Driven by AI Literacy

The rapid development of generative AI has driven the transformation and upgrading of educational models, but this transformation also brings new challenges and opportunities. Among these, the cultivation of AI literacy has become one of the core elements of future education. AI literacy refers to the ability of students and teachers to effectively utilize AI tools for learning and teaching in an AI-driven educational environment, while also possessing critical thinking and independent judgment skills.

A study released by the online learning platform Study.com shows that 72% of educators believe that AI literacy is "very important" or "extremely important" for students, while 37% of students think that AI literacy is crucial for their competitiveness<sup>1</sup>. As shown in Figure 3, according to the latest research from Macao Association for Internet Research in 2024, Macao's generative AI users self-rate their ability to use generative AI at a medium level (on a scale of 0-10, scoring 5.9), and some users encounter difficulties when using it (42%), such as generated content not meeting expectations (21%) and unfamiliarity with questioning techniques or prompt settings (11%). It indicates that users' AI literacy still needs improvement<sup>2</sup>.

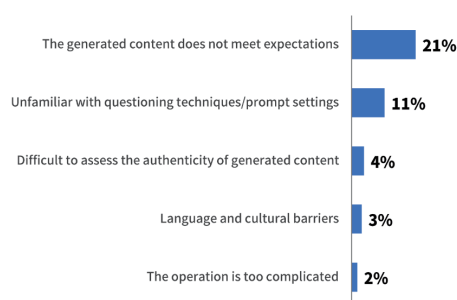


Figure 3 Challenges faced by generative AI users in Macao while using AI (Top 5)

Looking to the future, AI literacy, as one of the core competencies, forms the foundation of education alongside traditional core learning skills (such as reading, writing, and mathematics) and should be incorporated into educational goals and curriculum design. Specifically, AI literacy includes several aspects: first, students need to understand the basic principles

and application scenarios of AI, as well as its advantages and limitations. Secondly, students should be able to effectively use AI tools, such as intelligent learning platforms, voice assistants, and data analysis tools, to enhance their learning efficiency. Finally, students should possess critical thinking skills to assess the credibility of AI-generated content and make decisions by incorporating human judgment when necessary.

The AI literacy of teachers is equally important. Future teachers not only need to master traditional educational skills but should also possess a certain level of AI technical knowledge, allowing them to integrate AI tools into their teaching practices. For example, teachers should be able to design AI-based teaching activities and adjust their teaching strategies based on the data feedback provided by AI. At the same time, teachers should have foundational knowledge in AI data, enabling them to understand and analyze AI-generated data reports and make teaching decisions based on this data. Only in this way can teachers truly become the core role in the AI education ecosystem, rather than being replaced by traditional instructors.

Goal Four of the United Nations Sustainable Development Goals (SDGs) reveals the objective of "ensuring inclusive, equitable, and high-quality education and promoting lifelong learning." Generative AI can serve as an excellent tool to implement this goal, helping to achieve fairness and high quality in education. AI technology can provide quality educational resources to more students, helping them overcome geographical, economic, and ability constraints to realize their individual potential.

<sup>1</sup> Lehtinen-Vela, A., & Bharadwaj, N. (2024). One year later: The impact of generative AI in education. Study.com. <https://study.com/academy/lesson/one-year-later-the-impact-of-generative-ai-in-education.html>

<sup>2</sup> Macao Association for Internet Research. (2024, June 11). "Generative AI" Usage in Macao 2024. Macao Internet Project <https://www.macaointernetproject.net/blog/generative-ai-usage-in-macao-2024-executive-summary/>