The Impact and Countermeasures of Generative Artificial Intelligence on Critical Thinking among University Students in Hubei Province

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Abstract – **Generative artificial intelligence (GAI) tools like ChatGPT are intervening in human knowledge production and educational practice in unprecedented ways. In the critical domain of higher education, the emergence of GAI technology has profoundly impacted the learning methods of university students. This research focuses on the influence path and countermeasures of GAI on the critical thinking of university students in Hubei Province, exploring how contemporary university students can enhance their high-level cognitive qualities in the context of the digital and intelligent era. Critical thinking, as a core cognitive ability, emphasizes logical reasoning and independent thinking. However, quantitative research conducted by scholars on university students in various universities in Hubei Province has found that students exhibit insufficient critical thinking abilities and weak critical thinking tendencies in their studies and practices. They tend to fall into the comfort zone of "technological dependence", neglecting the cultivation of the ability to actively verify the authenticity of the information they obtain, thereby weakening their original critical thinking abilities. The research deeply analyzes the relationship between GAI and critical thinking, pointing out that while it may weaken students' thinking initiative, it also holds the potential to enhance cognitive quality. Based on this, it proposes diversified educational countermeasures, including integrating GAI usage literacy education into course design, guiding students to use GAI tools correctly and rationally, and establishing a critical thinking-oriented teaching evaluation system, aiming to achieve the goal of co-education between humans and machines and wisdom empowerment. This research, not only respond to the anxiety in the education sector regarding the ethical use of artificial intelligence and the weakening of abilities, but it also provides practical and feasible ideas for the path of improving the quality of higher education.**

Keywords – **Generative Artificial Intelligence, Critical Thinking, Hubei Province, University Students**

I. INTRODUCTION

At the end of 2022, the GAI (Generative Artificial Intelligence) tools represented by ChatGPT developed by OpenAI in the United States triggered a new wave of intelligence and caused strong vibrations in various important fields such as science and technology, economy, and education, and facilitated the change and development of various fields. From this moment onwards, generative AI technology has begun to develop rapidly. Big language modeling platforms worldwide have competed to launch their own big language modeling technology, such as China's Wenxin Yiyin and Doubao AI tools etc. In January 2025, Deepseek big language modeling AI tool, which was launched online by China's Hangzhou Depthseek AI Fundamental Technology Research Co. Generative AI further accelerated the development of its thinking process to show the function is to promote the iterative evolution of the AI tools, tools on various platforms to show their AI thinking process, to help users better understand the answer of the GAI tool.

Higher education is an important platform for developing society, science, and technology, and it is an important carrier for cultivating high-quality talents in the new era. It is of great significance to explore the use and effect of GAI tools for cultivating talents at the stage of higher education. As the implementation target of higher education, it is of far-reaching influence to explore the use of GAI tools by this group in developing AI tools and reforming the education field. As they have been iterated to date, GAI tools can retrieve almost all known human knowledge and answer questions correctly through extensive database searches. In higher education, the college student population can view GAI tools as after-school teachers and Cai (2025) states that ChatGPT is no less than the average teacher of any subject in terms of imparting knowledge and that its knowledge and learning capabilities have far exceeded those of the human brain, which can help humans with many busy and laborious tasks. It may revolutionize how humans acquire and produce knowledge and how they are taught. He and Yao (2024) believe that the era of artificial intelligence has put forward new requirements for cultivating college students' quality and higher-order abilities and paying more attention to cultivating students' higher-order cognitive abilities.

Furthermore, critical thinking is the core of higher-order cognitive ability, an important cornerstone for students' development. Critical thinking can help students analyse problems deeply, make rational judgments, and form independent opinions. Therefore, studying the impact and countermeasures of generative AI on the critical thinking ability of college students in Hubei Province positively improves the quality of higher education in today's situation.

II. PROBLEM STATEMENT

In the context of the significant data era, generative artificial intelligence has been developing rapidly in the past three years, and the technology has been widely used in various fields, such as text generation and assisted programming. With the gradual popularisation of the technology, all groups have access to the emerging technology of generative artificial intelligence. As representatives of higher education, college students have a strong ability to learn and accept new things, making it easier for them to access and use this technology. Critical thinking,

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as a way of thinking with the qualities of reasonableness, criticality, and reflection, aims to enhance the individual's ability to analyze, evaluate, and reason about information in depth and to form independent and critical views. This characteristic is fundamental in the university student population. Cai (2025) argues that one of the main tasks of higher education is to cultivate students' critical thinking ability to think independently; this is because the development of critical thinking ability plays a key role in students' knowledge learning, scientific research, and innovation, and even the improvement of civic literacy.

Hubei Province is one of the centers of higher education in China, with nearly one hundred higher education institutions of various types, which have cultivated many high-quality college students for China and the whole society. Generative AI technology provides university students in Hubei province with a convenient learning and creative tool that is easily accessible and easy to utilize in today's fast-developing Internet. However, overuse of technology may lead to university students' dependence on the technology and degrade critical thinking, which is particularly important. Liu and Zhang (2025) also stated that from big data and recommender systems to self-driving cars and generative artificial intelligence, people gradually and unconsciously begin to cede the opportunity of their autonomous thinking to artificial intelligence, the creativity of our thinking is moving from value rationality to instrumental rationality, and the criticality of our thinking is also moving from autonomy to dependence. Generative AI can retrieve information from all over the Internet and generate high-quality, comprehensive information, which is highly convenient to students' learning and life, but excessive use of this technology may lead to the gradual neglect of the importance of independent thinking by students, resulting in the weakening of critical thinking due to the learning habit of mere acceptance, and the rapid development of network informationisation, the degree of information supply is far greater than before. Some wrong or misleading information may easily be lost in learning. In addition, with the rapid development of network information technology, the degree of information supply is far greater than before. Some wrong or misleading messages can be easily summarised and displayed by generative AI. The excessive use of generative AI can easily lead to students accepting wrong messages for an extended period due to the lack of critical thinking, which leads to the bias of education.

There are fewer studies on the impact of generative AI on college students' way of thinking, especially in the area of critical thinking, which has not yet been explored in depth. Most studies have focused on the effects or shortcomings of generative AI technology. At the same time, there is a lack of research on its specific impact on students' cognitive development and thinking ability. Moreover, although some regional colleges and universities have already researched the application of AI, there are relatively few special studies on the changes in thinking and educational responses to the use of generative AI by college students in Hubei Province, and there is a lack of research with a regional perspective.

The following hypotheses are made in response to the findings of previous studies:

H1: The correct use of generative AI positively affects the critical thinking of college students in Hubei Province.

H2: The incorrect use of generative AI negatively affects the critical thinking of college students in Hubei Province.

H3: There is a difference in the impact of using generative artificial intelligence on university students in Hubei Province at different levels.

III. LITERATURE REVIEW

The rapid development of generative AI is profoundly affecting the field of education, offering new possibilities for personalized learning, interactive feedback, and innovative assessment. However, the application of AI in education has also triggered important reflections on its specific impact on students' cognitive abilities and academic achievements. Yan et al. (2024) systematically sorted out the potential benefits and challenges of generative AI on human learning from the perspectives of learning sciences and human-computer interaction, and the study explored the application of GAI in feedback mechanisms, resource diversification, and assessment innovations, as well as pointed out its brought ethical and cognitive risks. It is argued that AI technology facilitates the development of multimedia learning resources, making learning content more dynamic and interactive, and that students improve their learning efficiency and personalization with the help of GAI, especially in language learning and complex task decomposition. However, long-term reliance on AI may inhibit students' creative thinking and independent problem-solving skills. The empirical and knowledge gaps of this study lie in the lack of empirical analyses of the effects of GAI in different cultural and educational contexts in existing studies, as well as the lack of clear evidence on whether GAI enhances students' critical thinking skills in the long term and the under-researched mechanism of its role in modelling learning behaviours. Nie and Chen (2024) explored the application of generative AI, such as ChatGPT, in engineering education, including teaching personalization, teaching resource sharing, and teaching model innovation. They suggested the potential of generative AI to enhance engineering practice while analysing challenges such as data privacy leakage and students' over-reliance. Leng et al. (2024) argued whether generative AI products represented by ChatGPT would impact the enhancement of students' critical thinking skills, which triggered widespread concern and reflection in the academic community. Applying ChatGPT to critical thinking assessment helps enrich the assessment content, innovate the interaction mode, and improve the assessment efficiency and precision, providing new perspectives and methods for the multidimensional assessment of critical thinking. In his study, Wu (2023) stated that in the era of automation and artificial intelligence, competent citizens are not only required to have digital competence but also the ability to think critically. Critical thinking has always been indispensable for the survival and prosperity of human beings, and the need for critical thinking has become more prominent and urgent as we enter the age of automation and artificial intelligence.

The original concept of critical thinking was first proposed by the ancient Greek philosopher Socrates, but the theory of critical thinking, as one of the modern systems of higher-order cognitive abilities and educational theories,

was first proposed by Dewey (1910), who argued that the core of education should not be the mere transmission of knowledge, but rather the development of the ability of students to think reflexively, arguing that true thinking, which is an active, sustained thoughtful inquiry. This basic definition provided the starting point for the subsequent development of critical thinking theory. Ennis (1962), a representative of modern research on critical thinking education, asserted that critical thinking includes the skills of logical reasoning, evaluating evidence, and identifying assumptions and proposed a structural definition of critical thinking. Thus the definition of critical thinking began to be syntactically refined. Several scholars around the globe have refined the development of critical thinking theory; for example, Moore and Parker (2012), in their book Critical Thinking, argue that critical thinking refers to questioning, analyzing, reasoning, hypothesizing, judging, and other thinking activities that are involved in the argumentative process of forming an opinion, making a decision and reaching a conclusion by a person. Specifically, it involves a person's ability, when searching for and reading information, to 1) judge the correctness and reliability of the information, 2) distinguish between assertions based on reason and emotion, 3) distinguish between fact and opinion, 4) detect deficiencies and holes in the evidence; 5) identify logical errors in the argument; 6) independently analyze the data and information; 7) judge whether the source of the data and information is reliable; 8) detect contradictions and ambiguity; 9) gaining insight into weak arguments based on opinions rather than data facts; 10) finding out whether the premises from which conclusions are drawn are reliable and correct, etc.

However, using these criteria to measure Chinese students, especially those in Hubei Province, it is clear that their critical thinking skills need improvement. As early as in the 4th Chinese and Foreign University Presidents' Forum, the presidents of Oxford and Yale universities pointed out that Chinese students lacked the cultivation of critical thinking and did not dare to ask questions or challenge authority. Although the object of this opinion refers to college students in the whole of China in a general way, Hubei Province, as a central education province in China, can reflect the critical thinking ability of college students in Hubei in a disguised way. Chen (2023) argues through his research that in the future AI era, critical thinking ability is one of the core qualities of citizenship, which has become a consensus in all walks of life, and there is an urgent need for people's critical thinking ability. Higher education's most important purpose is cultivating students' critical thinking skills, which is especially crucial for the success of individuals and the country's development.

Meanwhile, Liu and Li (2017) stated that critical thinking is a kind of critical thinking ability that refers to the ability to analyze, discriminate, question, reflect, and evaluate things. It is an important ability that can improve students' innovation and comprehensive quality, and developing critical thinking ability is, moreover, one of the core objectives of higher education in China. Essien et al. (2024) stated that artificial intelligence tools could help students gain access to a broader range of perspectives and information, but how this information is presented, coupled with the tool's tendency to convey false 'illusions confidently,' results in the user accepting this information uncritically, thus undermining critical thinking in individuals and society. The tool also runs a significant risk of inhibiting critical thinking by providing answers quickly and authoritatively, which may lead people to assume that the output is objective and consistent, ignoring the bias inherent in its data and making it easier for students to access the information. However, the quality of the information produced may be low or questionable. Students may be less likely to conduct extensive or comprehensive search validation on their own, and thus, they do not doubt the results generated by AI.

In conclusion, generative AI can provide college students with more convenient retrieval and learning channels, providing brand-new possibilities for learning in the new era. However, it also triggers a series of problems and impacts, such as changing from active exploratory learning to purely passive acceptance, weakening the ability to think and think critically. At the same time, the retrieval of generative AI technology will be all kinds of information on the Internet without discrimination, the retrieval of generative AI technology will summarise all kinds of information on the Internet without distinguishing, which is easy to provide students with wrong information, affecting the learning effect of students and weakening their critical thinking.

IV. METHOD

This study mainly adopts the literature analysis method and observation method. Among them, the literature review method serves as the primary research method, which aims to explore the impact of generative AI tools on the critical thinking of college students in Hubei Province and their coping strategies by systematically reviewing and analyzing existing relevant literature. The literature review method effectively summarises, assesses, and interprets existing research results, which can help clarify the current research situation and existing research gaps in the field of study and thus provide a basis for this study. In order to ensure the reliability of the literature, China Knowledge Network was chosen as the central literature search platform for the search to ensure that the previous research groups were the student groups in China and even in Hubei Province to satisfy the population validity of this study. In the literature screening process, the research topic closely follows the impact of generative artificial intelligence on college students' critical thinking.

In contrast, the research object of the literature is Chinese college students or similar groups and involves relevant educational backgrounds in Hubei Province or other regions of China to ensure the authenticity and validity of the research findings. After the literature has been collected, the literature of previous studies will be analyzed step by step, focusing mainly on the objects and findings in the literature and focusing on the analysis of the data in the literature to ensure that the content of this study is detailed and valid. The theoretical frameworks and research methods used in different studies will also be summarised and compared to distill generative AI's multiple roles and potential in education.

The study will also use the observation method as a complementary research method. The observation subjects of this method are the current students of Logistics Management, Software Engineering, and Business English majors in Wuhan Business School, Wuhan, Hubei Province, to observe the behavior and reaction of this group in the process of using generative AI tools, and to further understand the actual impact of these tools on the student's critical thinking. The reason for choosing this group as the observation object is that these three majors cover business, engineering, and liberal arts majors, which is a more comprehensive coverage of majors, and the university is a university in Wuhan City, Hubei Province, which is more representative and can provide a further basis for this study. Students majoring in logistics management are mainly concerned with practical operation and management ability, and their critical thinking may be biased towards complex problem-solving and decision analysis; students majoring in software engineering need to have strong logical reasoning and problem-solving ability, so they may pay more attention to logical and technical thinking when using generative AI. Business English students' critical thinking may focus more on language comprehension and expression, so generative AI may help them improve their ability to analyze and evaluate multi-perspective, cross-cultural issues.

A combination of participatory and non-participatory observation methods is used in the observation method, and the main steps include: 1) Developing an observation framework. In order to ensure the systematic and scientific nature of the observation, the observation criteria need to be developed, and the specific behaviors of the observation need to be clarified. These include the way students ask questions, the extension of students' thinking after using the AI tool, whether students discuss AI feedback with others and engage in collective thinking collisions, and whether students can correct AI errors on their own or find inconsistencies in the information provided by the AI and carry out in-depth analyses; 2) Setting the observation criteria, based on the seven dimensions of critical thinking (e.g., open-mindedness, inquisitiveness, analytical ability, etc.), the Set observation criteria. For example, when a student asks a question and interacts with the AI, focus on the depth and breadth of his/her question, the reasonableness of the AI's answers, and whether the student further reflects on those answers; 3) Observation record, after each observation, record the process of the student's interaction with the generative AI tool, especially how the student treats the information provided by the AI, whether he/she thinks independently, critically, or explores at a deeper level, and other Behaviour.

V. FINDINGS

Literature analysis was conducted on 10 articles written by Chinese scholars. Among them, Cai (2025), in his article 'The Use of artificial intelligence in colleges and universities: an opportunity to improve critical thinking skills,' uses an experimental method to generate a paper on the differences between Chinese and foreign scholars' citation styles in essay writing as a sample for a review-like experiment in a course on essay writing and research methods for English majors in a certain university by using ChatGPT. In the course 'Essay Writing and Research Methods,' an English course offered by a university, an experiment was conducted using ChatGPT to generate a paper on the differences between Chinese and foreign scholars' citation styles in essay writing as a sample for a replay-like experiment. It was found that the students learned to ask questions and identify the reliability of the information. At the same time, they learned to find out the loopholes in the argumentation with the correct guidance of the teacher. He and Yao (2024) focused on the core principles of AI technology and its application in higher education, as well as the relationship between AI and critical thinking in their study on 'The Value of Artificial Intelligence for the Cultivation of Critical Thinking in College Students and the Strategies for Cultivating Critical Thinking.' It is proposed that schools build intelligent learning platforms and resource libraries, design AI-based critical thinking teaching modes, and establish AI-based critical thinking evaluation mechanisms, stressing that students need to be guided by certain evaluation mechanisms to promote the development of their critical thinking. Liu and Zhang (2025) sorted out critical thinking and its essence in the study of 'The Dilemma of Human Autonomy under Artificial Intelligence Technology--Based on the Perspective of Authenticity,' meanwhile carried out a multi-dimensional analysis of the impact of AI technology on human authenticity, and explored how AI technology affects human autonomy in four key mechanisms: critical reflection, independent decision-making ability, informed choice, and supportive environment, and proposes a new perspective on the impact of AI on college students learning. Leng et al. (2024) conducted an experimental analysis in the study' Generative Artificial Intelligence Enabling Critical Thinking Assessment - An Experiment Based on the Application of ChatGPT', in which 31 undergraduate students taking the course 'Intensive Reading of Professional English Literature' in a university were used as the research subjects. Thirty-one undergraduate students enrolled in the course 'Intensive Reading of Professional English Literature' at a certain university were used as the subjects of the study, and were given writing tasks on three topics (including the categories of stating advantages and disadvantages, graphic and textual situations, and opposing views). These students read and wrote online using the ChatGPT-based critical thinking assessment platform, producing 186 argumentative writing texts totalling about 56,000 words. As a result of the experimental study, it was concluded that students' critical thinking skills would be significantly weakened if they were disciplined in their use of AI. Whereas, if timely guidance and critical thinking skills are provided during students' use of AI technology, students will be more active in self-learning and enhance their critical thinking skills. Chi et al. (2024) used a 7-point Likert scale in 'The impact of generative AI tools on the critical thinking and independent learning ability of college students' and distributed questionnaires to 76 colleges and universities throughout China. 2694 questionnaires were collected, and 1781 questionnaires were valid, with a validity rate of 66.11%. The quantitative study found that generative AI tools have a positive effect on college students' critical thinking and independent learning abilities, especially when used correctly. Consistent use of these tools can significantly

improve students' depth of thinking and self-directed learning skills. However, incorrect use of these tools, especially by students who rely on closed-ended questions or lack of deep thinking, can negatively impact critical thinking. Therefore, correct usage is crucial. The impact of the use of generative AI tools varies among student groups from different backgrounds, with seniors, graduate students, and students at 'dual-tier' universities benefiting more than undergraduates and students at regular universities. This suggests that educational resources and students' academic backgrounds affect the application of AI tools to a certain extent. Wu (2023) analysed in 'Critical Thinking in the Age of Automation and Artificial Intelligence' that generative AI, such as ChatGPT, can help students ask better questions and promote critical thinking in the learning process. By guiding students to think deeply, AI technologies can assist students in better understanding issues and evaluating different perspectives, thus enhancing their critical thinking skills. The study also warns that students may weaken their ability to think independently if they rely too much on generative AI. Over-reliance on AI tools for information acquisition and answer derivation may cause students to lose their sense of critical analysis and self-validation, thus affecting the development of their critical thinking skills. Chen et al. (2019), in the article' Examination of the current situation of critical thinking and improvement strategies of postgraduate students in teachers' colleges', conducted a quantitative study through the Likert 6-point scale, which was designed to measure the qualities of seven aspects of critical thinking, with a total of 3,600 questionnaires sent out, 2,853 questionnaires returned, and 2,660 valid questionnaires. The survey data for the questionnaires came from four teacher training universities in four provinces: Hubei, Shaanxi, Guangdong and Shanxi. It covers 9 major disciplines such as law and education. Analysis of the data showed that students' critical thinking trait scores were significantly low, there were significant differences in the critical thinking ability of students at different educational levels, and there were no significant differences in the critical thinking trait scores of students in different disciplinary categories. Wang (2012) in his 'sports colleges and universities college students critical thinking ability cultivation mode research' on the Wuhan Institute of Physical Education and other seven sports colleges and universities to carry out a quantitative study, issued 1,000 questionnaires, valid questionnaires 922, the use of SPSS to analyse the data, the use of different levels of college students in Hubei Province, the impact of the use of generative Artificial Intelligence there are differences in the impact produced after using Generative Artificial Intelligence, and there is no significant difference in the impact produced after using Generative Artificial Intelligence by college students of different majors. Chen (2023) conducted a quantitative study in the article 'Empirical research on the development of critical thinking of primary education majors--Based on the survey data of primary education majors in 14 colleges and universities in Hubei Province', taking the students of primary education majors enrolled in 15 colleges and universities in Hubei Province as the target group. The quantitative study was conducted on students majoring in elementary education in 15 undergraduate and collegiate colleges in Hubei Province, and a total of 8,998 valid electronic questionnaires were collected. The study shows that students' critical thinking development is closely related to their exposure to educational resources and learning environments. Similarly, the correct use of generative AI can provide students with more dimensions of thinking and richer sources of information, thus promoting critical thinking. If students rely excessively on technological tools without critiquing and analysing them, it may lead to superficial thinking and weaken their ability to think independently, thus affecting the development of critical thinking. Liu and Li (2017) found in their study' Survey and Research on English Writing Critical Thinking Ability of English Majors. Taking Hubei Polytechnic College as an Example' that critical thinking is closely related to writing ability, especially among English majors, the critical thinking ability In particular, among English majors, the enhancement of critical thinking ability can help improve their writing skills. If they rely too much on technological tools, it may affect the cultivation of their core thinking skills, such as analyzing, reasoning, and evaluating.

The observation method was used to conduct field observations on current students majoring in logistics management, software engineering, and business English at Wuhan Business School in Wuhan City, Hubei Province. The observation results show the impact of generative AI tools on critical thinking among students with different professional backgrounds. Among students majoring in logistics management, AI tools mainly facilitated critical thinking skills in real-world problem-solving and decision analysis. Students demonstrated strong analytical and decision-making skills, could use AI tools to ask questions and think in-depth, and could evaluate problems from multiple perspectives and think about their feasibility, especially when confronted with complex management decisions. Software engineering students, on the other hand, pay more attention to logical and technical thinking, and AI tools help them improve their ability to think systematically, especially in algorithm design and problem-solving; students are not only able to ask valid questions but also to accurately verify and optimize the technical answers provided by AI. Among Business English majors, the use of AI tools promoted more critical thinking in language comprehension, cross-cultural communication, and multi-perspective analysis, and students were able to collide their thinking from multiple perspectives with the help of AI, which enhanced their ability to analyze and evaluate in complex linguistic and cultural contexts. Through a combination of participant and non-participant observations, this study found that although most students could extend their thinking in some depth with the assistance of AI, there were significant individual differences in students' critical thinking skills. In particular, when confronted with the information provided by the AI, some students could proactively identify the gaps in the information and self-correct. In contrast, others relied more on the answers provided by the AI tool and lacked proactive reflection and in-depth analysis. Observations also suggest that students who could effectively interact with the AI were more active in the critical thinking dimension, demonstrating greater depth and breadth of thinking.

VI. DISCUSSION

Hypothesis H1 proposes that the proper use of generative AI positively impacts the critical thinking of college students in Hubei Province. The study shows that when students use generative AI appropriately under the guidance of their teachers, their critical thinking skills significantly improve. In particular, using AI tools promoted students' abilities in problem analysis, decision reasoning, and multi-perspective assessment among different groups of students majoring in logistics management, software engineering, and business English. The introduction of AI provided students with more sources of information and perspectives, which stimulated their ability to think independently and evaluate critically.

Hypothesis H2 proposes that the incorrect use of generative AI negatively impacts the critical thinking of university students in Hubei Province. The findings support this hypothesis, suggesting that students' over-reliance on generative AI may lead to the degradation of critical thinking skills without proper guidance and supervision. In particular, when students fail to identify and analyze AI-generated information effectively, they are prone to accept one-sided or inaccurate conclusions, thus lacking deep reflection and reasoning.

Hypothesis H3 proposes differences in the impacts produced by using generative AI among university students in Hubei Province at different levels. It was found that there were significant differences in the extent to which students from different levels, majors, and academic backgrounds improved their critical thinking after using generative AI. Senior and graduate students were better able to extract valuable content from AI-generated information and analyze it critically compared to junior students. Especially among the senior students, they were more capable of critical thinking and could use AI tools to expand their thinking framework further.

VII. SUGGESTION FOR FURTHER STUDIES

Based on the assumptions and conclusions of this study, future research can further explore the impact of generative AI on college students' critical thinking ability and coping strategies in the following ways. First, it is recommended that more longitudinal studies on the use of generative AI on students' cognitive abilities should be conducted in different universities and in different disciplinary contexts to explore the long-term changes and developmental patterns of students' critical thinking skills. Secondly, educational institutions should strengthen the training of teachers so that they can effectively guide students in using generative AI tools while enhancing students' information discrimination and critical thinking. Third, it is recommended that universities design and implement AI-based critical thinking development programs to help students understand and master the core elements of critical thinking by combining theory and practice. In addition, an intelligent critical thinking assessment system can be combined with AI technology to provide real-time feedback on students' thinking development and data support for educational decision-making. Finally, future research could explore how generative AI can be combined with other emerging educational technologies, such as virtual or augmented reality, to explore the comprehensive effects of diverse educational tools on critical thinking development. These initiatives will help provide students with more comprehensive and diverse pathways for developing critical thinking in the digital age.

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