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Human-machine symbiosis and paradigm restructuring: theoretical logic, practical dilemmas and development paths of AI-enabled education

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Abstract: Breakthrough iterations of generative artificial intelligence (AI) and big data technologies have transformed AI from a marginal teaching auxiliary tool into a fundamental driving force for systemic educational reform, breaking the limitations of traditional homogenized and experience-oriented educational models. AI-enabled education is not a simple superposition of technology and education, but a systematic reconstruction of teaching procedures, teacher-student relationships, educational evaluation and talent cultivation paradigms based on multidisciplinary theories including pedagogy, philosophy of technology and cognitive science. This study comprehensively elaborates the underlying theoretical logic and educational value of AI empowering education, analyzes comprehensive practical dilemmas arising from the integration of technology and education, and proposes integrated solutions tailored to the national context of China's educational digital transformation. Moving beyond fragmented research perspectives, this paper adopts three overarching core modules to construct the overall framework, clarifies the fundamental academic principles of AI-education integration, and addresses the prevalent dilemma of overprioritizing technology at the expense of educational essence in current educational digitalization practices. It provides systematic theoretical support and practical guidance for the long-term implementation of human-machine collaborative education.

Keywords: artificial intelligence; educational empowerment; human-machine collaboration; educational paradigm; educational digitalization; moral education

1 Introduction

The new round of artificial intelligence revolution has permeated all fields of public services, bringing systematic paradigm changes to education, a fundamental public undertaking committed to moral education and all-round talent cultivation. The integration of AI and education has moved beyond superficial instrumental application represented by early programmed teaching machines and intelligent question banks. Currently, generative educational agents, full-domain learning analytics platforms and immersive smart classrooms have gained widespread application, pushing the integration of AI and education into a new stage of reshaping educational ecology and reconstructing educational logic.

In view of the above research gaps and practical dilemmas, this paper moves beyond fragmented item-by-item discussion and divides the main body into three progressive core sections: theoretical foundation and empowerment mechanism, practical dilemmas and underlying causes, and collaborative optimization paths. It responds to three core

research questions: how AI empowers education theoretically, what bottlenecks hinder the application of AI in education, and how to advance the sound integration of AI and education. This research adheres to the principle that educational value rationality takes precedence over technological rationality, and promotes AI to return to its original educational purpose.

2 Theoretical foundation and internal empowerment mechanism of AI-enabled education

The educational empowerment of AI is not a spontaneous technological byproduct, but is supported by mature philosophy of technology and cognitive learning theories. Equipped with functions including data collection, algorithm modeling and intelligent interaction, AI reconstructs traditional educational systems spanning teaching, learning, evaluation and educational governance [1], thereby solving the inherent contradiction between large-scale standardized instruction and personalized learning in traditional classroom instruction. This section conducts holistic elaboration on theoretical support and practical empowerment value avoiding scattered subdivision arguments.

2.1 Multidisciplinary theoretical support for AI-enabled education

The deep integration of AI and education relies on two theoretical systems: philosophy of technology and modern learning theories. The former defines the boundary of human-machine relations in educational scenarios, while the latter clarifies the generation rules of learning behaviors, jointly forming a complete theoretical framework for AI-enabled education. From the perspective of philosophy of technology, academic cognition of human-machine relations in education has experienced three evolutionary stages. Early instrumentalism regards AI as a neutral teaching tool without subjective initiative, which only undertakes repetitive teaching tasks to reduce teachers' workload. Subsequently, technological determinism and anthropocentrism fall into dualistic opposition, either exaggerating technological value unilaterally or insisting on the absolute dominant position of human beings. Later, social technology theory recognizes the two-way interactive relationship between technology and educational scenarios, and finally evolves into post-anthropocentrism, the most applicable theory for current intelligent education. Breaking the subject-object dichotomy mindset, post-anthropocentrism regards teachers, students and AI as equal actors in the educational ecosystem [2], constructing a new human-machine symbiosis and collaborative educational relationship.

2.2 Holistic internal empowerment mechanism of AI in education

Supported by the above theories, AI reconstructs traditional educational paradigms across four dimensions: teaching mode, learning modalities, educational evaluation and macroscopic educational governance, promoting the transformation from teacher-centered teaching to learner-centered learning and from experience-driven education to data-driven education. Firstly, AI restructures classroom teaching modes to address homogenized teaching defects. Based on learner profiling technology, AI collects full-process learning data to identify students' academic weaknesses accurately, and realizes individualized teaching via the collaborative model of teachers undertaking value guidance and AI handling routine teaching affairs. Secondly, AI transforms passive learning into active inquiry learning. With generative dialogue technology and virtual simulation scenarios, AI acts as a one-on-one learning partner to inspire independent thinking instead of instilling knowledge mechanically, and optimizes review schedule based on forgetting curve algorithms to form a closed-loop autonomous learning system. Thirdly, AI innovates educational evaluation systems. It replaces the traditional result-oriented evaluation focusing solely on examination scores, and constructs a multi-dimensional evaluation system covering knowledge mastery, learning literacy and thinking competence based on full-process learning data collected before, during and after class. Fourthly, AI optimizes macroscopic educational governance. By monitoring regional educational data, AI accurately identifies urban-rural and inter-school disparities in educational resources, providing empirical data support for teacher deployment, educational fund allocation and high-quality resource sharing, and promoting refined educational governance.

3 Practical dilemmas and underlying causes of AI-enabled education

Despite robust theoretical logic and enormous educational value, the practical implementation of AI in primary, secondary and higher education in China is hampered by cognitive misconceptions, inherent technological defects, imperfect institutional norms and unbalanced educational ecology. Interconnected practical bottlenecks constrain the realization of AI's educational value. This section analyzes practical dilemmas and deep-seated causes holistically from four dimensions: cognitive misunderstanding, algorithmic ethical risks, alienation of educational essence, and unbalanced educational ecology.

3.1 Cognitive misalignment: technological logic overriding educational logic

The fundamental dilemma of AI-education integration lies in the reversed priority between technological logic and educational logic. On the one hand, most intelligent educational products are developed by computer technicians who prioritize algorithm performance and functional richness yet lack pedagogical expertise. Such products deviate from students' cognitive rules and actual classroom demands, and only fulfill superficial functions including mechanical exercise training and text generation, failing to support higher-order thinking cultivation and moral education. On the other hand, most teachers hold outdated instrumentalist perceptions of AI. Some overly rely on AI and abandon their dominant role in dynamic classroom teaching, while others reject intelligent technology completely and resist educational digital transformation. Generally speaking, human-machine symbiosis philosophy oriented by educational essence is insufficient in current educational scenarios, resulting in technological rationality overwhelming educational value rationality.

3.2 Algorithmic ethical risks: coexisting data security and algorithmic fairness problems

AI systems function by relying on training datasets and algorithms, bringing inherent ethical risks, which are further amplified considering the minor-oriented attributes of education. Firstly, algorithmic bias aggravates educational stratification. Affected by differentiated training data covering urban-rural gaps and individual academic differences, algorithms tend to allocate high-quality learning resources to high-achieving students while assigning repetitive basic exercises to underachieving students, forming a Matthew effect and widening individual learning gaps. Secondly, student privacy faces leakage risks. Smart classroom platforms collect massive sensitive data including facial information, learning records and mental health data, while the whole-process supervision mechanism for educational data collection, storage and destruction remains incomplete, leading to potential privacy infringement. Thirdly, generative AI suffers from inherent hallucination problems, which may output incorrect knowledge and biased values and mislead students without manual review procedures [3].

3.3 Alienation of educational essence: loss of humanistic care and learner thinking degradation

Education is essentially interpersonal interaction, value guidance and character cultivation, which are irreplaceable core humanistic attributes beyond AI's capacity. Excessive dependence on intelligent devices reduces face-to-face teacher-student interaction in smart classrooms, depriving education of humanistic temperature and ignoring mental health counseling and character education. Meanwhile, over-reliance on AI to complete assignments, draft compositions and receive reasoning guidance leads to the degradation of students' independent thinking, logical reasoning and innovative ability, resulting in widespread learning inertia. Originally designed to free teachers and students from repetitive work and allow them to concentrate on high-level education, AI conversely leads to the loss of dual subjectivity among both educators and learners, violating the original intention of technological integration into education.

4 Collaborative optimization paths for high-quality development of AI-enabled education

Targeting the above comprehensive dilemmas concerning cognition, ethics, educational essence and ecological balance, this paper constructs an integrated optimization framework based on China's national educational context and the

fundamental task of moral education. Guided by four core principles including education-oriented concept, human-machine collaboration, ethical supervision and inclusive education [4], this research constructs a closed-loop optimization framework covering conceptual reconstruction, mechanism improvement, ethical supervision and ecological optimization to solve practical bottlenecks of AI-enabled education.

4.1 Reconstruct educational concept: establishing education-oriented human-machine symbiosis cognition

Reversing misplaced technological cognition is the prerequisite for solving practical dilemmas. Educational value should always take priority over technological application. First, popularize post-anthropocentrism philosophy to clarify the ternary educational subject structure: teachers play a leading role in value education, students act as learning subjects, and AI serves as a collaborative auxiliary partner. Two extreme tendencies, namely technological substitution of teachers and complete rejection of AI, should be avoided. Second, introduce pedagogical experts into the front-end development of intelligent educational products to ensure all AI educational tools conform to age-appropriate cognitive characteristics and teaching requirements, making educational demands lead technological innovation. Third, incorporate human-machine collaborative teaching theories and AI application skills into regular teacher training programs to improve teachers' digital literacy and critical thinking on educational technology.

4.2 Improve human-machine collaboration mechanism: clarifying division of labor and maintaining humanistic attributes of education

Clear division of labor between humans and AI should be formulated based on their inherent capability differences. Repetitive, standardized and procedural teaching tasks including automatic homework correction, learning data analysis, resource recommendation and basic knowledge Q&A should be undertaken by AI to release teachers from trivial work. In contrast, humanistic and dynamic educational practices such as emotional communication, value guidance, emergent classroom teaching, critical thinking cultivation and mental health education should be exclusively undertaken by teachers. A standardized human-machine collaborative teaching loop should be constructed: AI conducts pre-class learning diagnosis, teachers carry out in-depth teacher-student inquiry during class, and AI provides individualized after-class tutoring. In addition, schools should guide students to regard AI as an auxiliary tool for thinking, rather than a direct answer provider, cultivating students' critical ability to screen AI-generated content and preventing learning inertia.

4.3 Optimize ethical supervision system: building safeguards for educational data security and algorithmic fairness

Specialized ethical supervision system tailored for minor-oriented educational scenarios should be formulated, differentiated from universal AI supervision regulations. Firstly, follow the minimum data collection principle to prohibit excessive collection of students' biometric and private psychological data, and build a dedicated educational data supervision platform for full-track data monitoring. Secondly, establish regular algorithmic bias detection mechanisms to optimize training datasets and avoid solidified academic stratification caused by algorithmic discrimination. Thirdly, enforce mandatory manual review for all AI-generated educational content to eliminate AI hallucinations and biased values. Fourthly, clarify the responsibilities of AI developers, schools and teachers to form a well-defined ethical supervision system.

5 Conclusion

AI-enabled education is an irreversible trend of global educational digitalization. Its essence is not technological subversion of traditional education, but a return to individualized and human-oriented education empowered by digital technology. Theoretically, AI can reconstruct teaching modes, learning methods, evaluation systems and educational governance based on mature technological and pedagogical theories. However, misplaced cognitive concepts, algorithmic ethical risks, loss of educational humanistic care and unbalanced educational ecology restrict the release of AI's educational

value.

To realize sound integration of AI and education, educators must uphold the fundamental task of moral education and prioritize educational value rationality over technological rationality. By reconstructing human-machine symbiosis conception, clarifying human-machine labor division, establishing specialized ethical supervision mechanisms and bridging digital educational gaps, a human-machine collaborative educational ecosystem with full humanistic care, fairness and depth can be constructed. In the future development of educational digitalization, technology should always serve human development and educational essence. AI should act as a dependable assistant for teachers and a supportive learning partner for students, rather than taking a dominant role in educational activities, ultimately supporting China's educational modernization and high-quality educational development.

Conflicts of interest

The author declares no conflicts of interest regarding the publication of this paper.

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