Pre-service Teachers' Intelligent Education Literacy in the Age of AI: Conceptual Reconstruction, Practical Challenges, and Developmental Pathways

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Abstract: In the age of artificial intelligence, educational ecosystems are shifting toward human-machine collaboration, requiring teachers to transition from knowledge transmitters to co-educators. As the future backbone of the teaching profession, pre-service teachers' intelligent education literacy significantly impacts the process of educational digitalization. This paper traces the evolution of intelligent education literacy from information literacy to digital competence and finally to intelligent education literacy. It clarifies the connotation of this concept, analyzes the urgency of its development, identifies challenges such as structural imbalance, outdated training systems, and low acceptance among pre-service teachers, and proposes developmental strategies including immersive scenario-based experiences, curriculum restructuring, and collaborative practices. These strategies aim to equip future educators to thrive in the emerging human-AI symbiotic education environment.

Keywords: Artificial Intelligence Era; Pre-service Teachers; Intelligent Education Literacy

DOI:10.69979/3041-0843.25.02.017

1 Introduction

Artificial intelligence is profoundly transforming the educational ecosystem, driving the transition of teachers' roles from "knowledge transmitters" to "human-machine collaborative educators." As reserves of the future teaching force, pre-service teachers' intelligent education literacy plays a pivotal role in advancing educational modernization. Enhancing this literacy has become a key focus of teacher education reform and a crucial factor in promoting high-quality development in education.

2 The Multidimensional Connotation of Intelligent Education Literacy

2.1 Evolution of the Concept

The concept of intelligent education literacy has evolved alongside technological innovation and educational demand. According to Wang Runlan (2023), the development can be broadly divided into three major phases:

Information Literacy: First proposed by Zurkowski in 1974, this phase emphasized abilities in information retrieval, evaluation, and application, aiming to foster critical thinking.

Digital Competence: Emerging with the spread of digital technologies, this stage expanded to include communication, collaboration, security, and ethics, becoming a fundamental competency for teachers.

Intelligent Education Literacy: In response to the widespread adoption of AI, this phase emphasizes how teachers understand and harness technology to enhance teaching while maintaining a strong focus on humanistic care.

2.2 Definition of the Concept

Based on current developments in intelligent education, this paper defines intelligent education literacy as a comprehensive and dynamic professional competency that integrates knowledge, skills, emotional intelligence, ethical attitudes, and values. Cultivated through continuous learning and practice, it enables teachers to meet the demands of lifelong learning and innovative talent development in the AI era. This literacy encompasses knowledge of AI principles and disciplinary integration, the ability to apply AI tools and collaborate with data, an open yet critical attitude toward

technology, ethical stances on data privacy, and a commitment to human-centered educational values. As AI technologies evolve and are increasingly integrated into education, the scope and focus of intelligent education literacy also continuously adapt. Ultimately, it aims to empower teaching and improve educational quality by applying AI tools to solve practical problems in real or simulated classrooms, highlighting teachers' emotional care and value leadership in human-machine collaboration.

3 The Urgency of Enhancing Pre-service Teachers' Intelligent Education Literacy

3.1 Policy-Driven Imperatives

At the national strategic level, the cultivation of intelligent education literacy has become a core focus of teacher education reform. In 2018, the Ministry of Education issued the "Notice on Launching Pilot Programs for AI-Driven Teacher Development", explicitly identifying the enhancement of intelligent education literacy as a major initiative. In September 2021, the second round of pilot programs was launched. In 2022, the "Strengthening the Teaching Force in Basic Education for the New Era Plan", jointly issued by eight ministries including the Ministry of Education, further emphasized exploring new models and pathways for AI-supported teacher education reform. These policy documents collectively demonstrate that cultivating intelligent education literacy among pre-service teachers is not only a developmental goal but also an institutional requirement within the broader agenda of educational digital transformation.

3.2 Lagging Development in Practice

Currently, the cultivation of intelligent education literacy among pre-service teachers is significantly lagging. On one hand, their capacity for intelligent teaching practices remains weak, and their ability to ethically apply such practices is insufficient. On the other hand, existing training systems are disconnected from technological advancements—curriculum content is outdated, subject-based teaching is fragmented, and a gap remains between theoretical knowledge and practical application. Additionally, limitations in the performance of generative AI (GenAI) technologies and broader societal skepticism further hinder pre-service teachers' acceptance and willingness to engage with intelligent technologies. Without intervention, these deficiencies will impair their ability to fulfill their evolving role as "human-AI collaborative educators" in the era of intelligent education.

3.3 Laying the Foundation for Future Educational Competitiveness

The core of educational competition lies in the quality of talent, and pre-service teachers' intelligent education literacy directly affects their future competence in teaching and innovation. From a pedagogical perspective, intelligent technologies are driving a shift from standardized to personalized instruction (Zheng Wen & Wang Yu, 2024). Pre-service teachers equipped with intelligent education literacy can leverage AI-driven systems to tailor instruction, enhance classroom interaction, and integrate subject expertise with interdisciplinary knowledge. This helps guide students toward learner-centered cognitive models and improves learning outcomes. From a developmental perspective, intelligent education literacy enables pre-service teachers to combine AI's efficiency with educational wisdom—utilizing technological advantages in information processing while preserving the irreplaceable human aspects of emotional care and moral guidance. This, in turn, fosters students' information literacy, critical thinking, and innovation competence, establishing a virtuous cycle between technological empowerment and educational essence.

4 Challenges in Cultivating Pre-service Teachers' Intelligent Education Literacy

4.1 Structural Imbalances in Competency Development

Empirical data reveal significant imbalances in the development of intelligent education literacy among pre-service teachers. Wang Runlan and Li Mengxue (2023) conducted an in-depth study at H Normal University, which showed that among the three core dimensions of this literacy, pre-service teachers' intelligent teaching competency lagged behind their learning and moral competencies. This indicates a weakness in effectively integrating AI into instructional practice and a lack of initiative in designing AI-driven teaching scenarios from the perspective of future educators. Although their

awareness of professional ethics is relatively strong, this ethical understanding has not been effectively translated into actionable practice. These findings expose shortcomings in experiential immersion and practical transformation within the teacher training process.

4.2 Outdated Training Systems

The current curriculum structure in teacher education faces a dual dilemma: insufficient technological integration and a lack of practical relevance. Course content remains largely focused on traditional technologies, lacking systematic inclusion of cutting-edge intelligent education achievements. Moreover, the update mechanism for such courses is sluggish. In the AI era, knowledge is inherently unstable and interdisciplinary in nature (Zheng Wen & Wang Yu, 2024), yet existing training programs still rely on rigid disciplinary boundaries, hindering the cultivation of cross-disciplinary thinking crucial for intelligent education. Practicum components—such as simulated teaching and internships—often remain confined to traditional classroom scenarios, with little emphasis on the use of intelligent platforms. This absence of authentic training environments leads to a widespread gap between theoretical understanding and hands-on application, especially when pre-service teachers encounter new tools like AI-based tutoring systems or classroom behavior analytics platforms.

4.3 Barriers to Individual Acceptance

Pre-service teachers' acceptance of generative AI is hindered by two major factors: technical performance limitations and societal perceptual barriers. Ma Muqing (2024), through interviews with 15 English education graduate students from three teacher-training universities in the Yangtze River Delta region, found that GenAI tools in English teaching exhibited inconsistent output quality and poor integration with instructional goals, often requiring frequent trial-and-error adjustments—adding to teachers' operational burden. From a social perception standpoint, there are concerns that the integration of AI in classrooms might reduce teachers' professional engagement. Parents and schools often fear that increased AI use will undermine teachers' sense of responsibility. These external perceptions limit pre-service teachers' willingness to adopt and experiment with intelligent technologies.

5 Collaborative Pathways for Cultivating Pre-service Teachers' Intelligent Education Literacy

5.1 Constructing a Scenario-Immersive Technology Perception System

Teacher training institutions should build immersive teaching environments that integrate both hardware and software to enhance pre-service teachers' perception of intelligent technologies. On the hardware side, developing intelligent campuses with immersive tech environments—such as smart classrooms, AI laboratories, and intelligent assessment platforms—can digitize teaching, management, and activities. For example, by equipping AI-assisted lesson planning systems and classroom behavior analysis platforms, pre-service teachers can engage with the practical logic of intelligent educational tools in authentic contexts, thereby enhancing their technological awareness (Wang Runlan & Li Mengxue, 2023).

On the software side, it is essential to develop a support system driven by "faculty leadership and cultural motivation." This includes implementing a "dual strategy" of internal capacity building and external expert recruitment, inviting AI experts to form interdisciplinary teaching teams, and encouraging collaboration between education technology specialists and pedagogical experts in designing intelligent education cases. In parallel, institutions can establish platforms such as GenAI teaching innovation workshops and intelligent education forums to stimulate teachers' creative motivations (Ma Muqing, 2024). Through the cultivation of a robust software ecosystem, a cultural atmosphere and practical paradigm for technology application can be formed.

5.2 Advancing Knowledge Integration Through Curriculum Restructuring

Pre-service teacher education programs should restructure their curriculum by adopting a "technology foundation + disciplinary integration" model. Compulsory courses such as "Applications of AI in Education" and "Ethics of Intelligent Education" should be introduced to systematically cover technical foundations including large language models and learning analytics. High-quality online resources from national platforms—such as "Artificial Intelligence and the Future of

Education" and "AI Education for Youth"—can be incorporated into blended learning models to ensure the continuous update of technological knowledge.

In addition, traditional disciplinary boundaries should be broken to enable the development of "AI + discipline" integrated courses, such as "AI and Chinese Language Teaching" or "Intelligent Assessment in Mathematics." These courses should deconstruct cutting-edge AI applications—such as GenAI lesson plan generation and classroom behavior analytics—into subject-specific teaching cases. This will help pre-service teachers develop interdisciplinary perspectives and remain aligned with educational policies and industry practices. Course content should be regularly updated to maintain relevance and vitality.

5.3 Establishing Practice-Oriented Mechanisms for Competency Transformation

Teacher training institutions should build a "virtual-real integration + school-enterprise collaboration" system to facilitate the transformation of knowledge into practice. To address the disconnection between traditional practicum and emerging technologies, institutions can integrate the operation of AI teaching tools into internship assessments. Pre-service teachers should be encouraged to participate in real-world projects, including smart classrooms in K-12 schools and corporate AI education laboratories, where they can interact with AI tutoring systems and personalized learning platforms, thereby improving their practical teaching competencies.

Furthermore, VR/AR technologies can be leveraged to create virtual training environments that simulate complex teaching scenarios such as AI-based emotion recognition and intelligent Q&A. Through a progressive model of "virtual training to real-world application," the cognitive-practical gap can be bridged. Collaborations with AI enterprises may also lead to the development of remote teaching training platforms, where industry mentors guide pre-service teachers in using advanced educational technologies. These hybrid practical experiences enhance pre-service teachers' capacity to design and implement intelligent teaching solutions in real and simulated environments.

6 Conclusion

As AI technologies continue to evolve, education is rapidly moving toward a model of human-machine symbiosis. In this new paradigm, teachers are no longer mere users of technology, but integrators of technological capability and humanistic values. For pre-service teachers, only by actively updating their pedagogical philosophies and enhancing their practical competencies can they realize the true integration of "technological empowerment" and "educational essence" in future teaching contexts. This transformation is essential for them to grow into genuinely intelligent educators—professionals who are capable not only of using AI, but of leading learning with it, while preserving the irreplaceable emotional and ethical dimensions of teaching.

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