Vol.6 Iss.5 2025 Communication & Education Review
https://doi.org/10.37420/j.cer.2025.099

AI-Enhanced "Educational Technology Applications" Curriculum: Innovative Pathways for Developing Preservice Teachers' Intelligent Literacy

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Abstract

Anchored in the emerging demands placed on teacher development in the age of intelligence, this study focuses on the reform of the Educational Technology Applications course and seeks to conceptualize innovative approaches to enhancing preservice teachers' intelligent literacy through artificial intelligence. Addressing the persistent issue of superficial technology usage in current training models, the study proposes a three-dimensional theoretical framework encompassing "Objectives–Pathways–Support." This framework explicates how AI reshapes curricular structures, transforms instructional models, and builds smart learning ecosystems, thereby promoting a paradigm shift in teacher preparation—from mere technical operation to cognitive empowerment and professional identity reconstruction. The findings highlight the mechanisms through which AI enables a transition from knowledge transmission to cognitive augmentation and from standardized procedural training to personalized and generative learning. The study aims to offer a theoretical foundation and developmental direction for teacher education curriculum reform in the intelligent era.

Keywords

AI empowerment; preservice teachers' intelligent literacy; Educational Technology Applications course; theoretical framework

1. Theoretical Challenges and Opportunities in Teacher Education in the Age of Intelligence

1.1 Problem Origins: A Paradigm Shift from Instrumental Rationality to Value Rationality

In the current stage of integrating artificial intelligence into teacher education, practice is broadly trapped in a paradigm of instrumental rationality. Under this view, AI is treated merely as a neutral tool—more efficient, more powerful—valued primarily for its capacity to help preservice teachers operate intelligent teaching software, generate instructional materials, or manage classroom tasks. Within this framework, the core course Application of Educational Technology still focuses largely on introducing software and training technical

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operations at a superficial level. As a result, the deep integration of technology and education is artificially fragmented: preservice teachers may master operational skills, yet often lack the capacity and ethical awareness to apply technology creatively in authentic and complex teaching scenarios, solve instructional problems, or improve the educational process in innovative ways[1].

Such limitations signal an urgent need for a paradigm shift—from the pursuit of efficiency-driven instrumental rationality toward a value-oriented substantive rationality centered on educational meaning and human development. The core theoretical question lies not in how well AI tools can be operated, but in how AI can fundamentally reshape the goals, content systems, and pedagogical models of teacher education. This requires AI to be understood not as an external auxiliary mechanism, but as a transformative force capable of reconstructing the educational ecology and reshaping teachers' professional knowledge, competencies, and identity structures.

1.2 Conceptual Framework: Core Connotations of Intelligent Literacy and the Academic Definition of AI Empowerment

Within this context, the concept of intelligent literacy for preservice teachers must be redefined. It should not be reduced to narrow technical proficiency. Drawing on international literacy frameworks and theories of teacher professional development, this study conceptualizes intelligent literacy as a multidimensional and integrated professional capability[2]. It incorporates at least four dimensions: (1) Technological Cognition and Operation—understanding the principles and potentials of AI in education and mastering essential intelligent tools; (2) Instructional Integration and Innovation—designing, implementing, and evaluating AI-supported teaching and promoting human–AI collaborative pedagogy; (3) Ethical Reflection and Decision-Making—cultivating sensitivity to issues such as data privacy, algorithmic fairness, and technological dependence, and making responsible professional judgments; and (4) Professional Development and Identity—recognizing the evolving role of teachers in the AI era and developing the capacity and motivation for lifelong learning and self-directed growth.

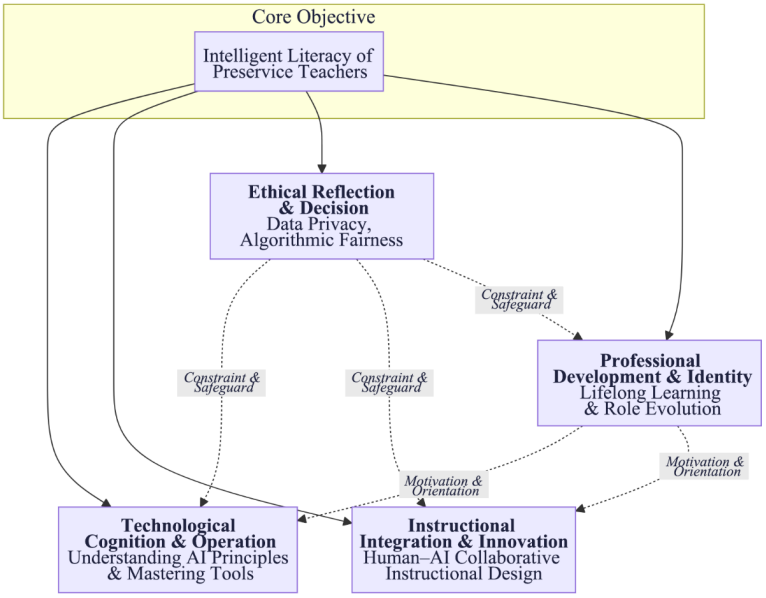


Figure 1 Theoretical Framework of Preservice Teachers' Intelligent Literacy

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As illustrated in Figure 1, the framework highlights the trinitarian logic of intelligent literacy: one core goal—instructional integration and innovation, which represents the transformation of intelligent technology into educational productivity; two foundational pillars—technological cognition and operation as methodological support, and ethical reflection and decision-making as normative safeguards; and one internal driving engine—professional development and identity, which sustains continuous learning, role adaptation, and pedagogical innovation.

In this study, AI empowerment is not conceptualized as a one-way enhancement of teacher capabilities, but as a bidirectional constructive process. As shown in Figure 2, AI empowerment operates through a dynamic loop: on the one hand, it fosters preservice teachers' competencies and professional identity; on the other hand, AI plays three evolving roles—tool, collaborator, and cognitive partner—each carrying distinct educational functions. Together, these interactions form a system of mutual construction between AI and teachers, where growth on one side triggers transformation on the other.

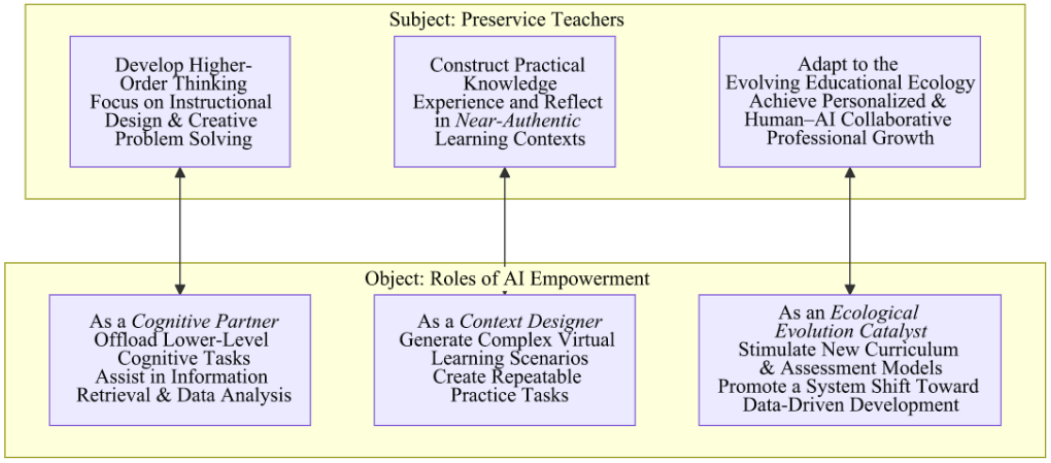


Figure 2. Theoretical Connotations of AI Empowerment

As a Cognitive Partner, AI functions as an external cognitive scaffold capable of undertaking lower-order cognitive tasks such as information retrieval, data analysis, and preliminary logical processing. By offloading these cognitive demands, AI frees preservice teachers' mental bandwidth, allowing them to concentrate on higher-order thinking activities, including instructional design, situational judgment, and creative problem-solving (Wang & Wang, 2024).

As a Context Shaper, AI leverages virtual simulation and generative task environments to construct highly authentic, complex, and repeatable teaching scenarios. These environments enable preservice teachers to experience "near-real" teaching conditions, through which they engage in the construction of practical knowledge and iterative reflection.

As an Ecological Evolution Catalyst, AI triggers new forms of curriculum, pedagogy, and assessment, thus driving the teacher education ecosystem toward greater personalization, data-driven decision-making, and human–AI collaboration.

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1.3 Research Objectives: Building a Theoretical Model and Interpreting the Mechanisms of Change

Grounded in the issues identified above and the conceptual clarifications previously established, this study pursues two primary objectives.

First, it aims to construct a systematic "Theoretical Model for AI-Empowered Cultivation of Preservice Teachers' Intelligent Literacy," outlining its core components, structural relations, and operating logic, thereby offering a conceptual blueprint for deep reform of the Educational Technology Application curriculum.

Second, it seeks to explicate the internal mechanisms through which AI drives profound curricular and instructional transformation, revealing how AI reshapes preservice teachers' cognitive patterns, practical pathways, and professional identities. In doing so, the study provides theoretical support and developmental direction for teacher education in the age of intelligence.

2.1 Theoretical Foundations: Integrating Human-AI Teaming and Constructivism

The traditional instructional paradigm of Educational Technology Application courses is largely built on the metaphor of technology as a neutral tool, positioning AI as a passive, instrumental external entity. In contrast, the theoretical foundation of the present model integrates two dynamic, interaction-oriented perspectives—Human-AI Teaming and deep Constructivism.

The theory of human-AI teaming broadens the conceptual space for reimagining teacher–technology relationships. It moves beyond the simple hierarchy of "human-led, machine-assisted" toward a reciprocal, complementary, and co-evolving partnership between humans and AI (Wang & Wang, 2024). In educational contexts, this means that AI is no longer merely a conduit of information or a skill-training apparatus; rather, it functions as an intelligent partner capable of interpreting instructional contexts, responding to learner states, and providing adaptive, personalized support. This shift reframes the preservice teacher's learning experience—not as learning how to operate tools, but as learning how to collaborate with AI to address complex instructional problems. Such a perspective better prepares future teachers for real classroom environments characterized by human-AI co-teaching.

Meanwhile, constructivism is enhanced and materially realized through AI-generated learning environments rich in authenticity and complexity. Constructivist learning theory posits that knowledge is not passively received but actively constructed through interaction with one's environment (Jonassen, 1999). AI, particularly in its role as a context shaper, enables the creation of cognitively demanding, highly realistic, and repeatable cognitive-apprenticeship scenarios. In AI-generated virtual classrooms, preservice teachers engage with diverse "virtual learners," make pedagogical decisions, and immediately receive data-based feedback and performance evaluation. This iterative practice–feedback–reflection loop significantly accelerates the formation, articulation, and refinement of tacit practical knowledge [6].

2.2 Interpretation of the "Goal–Path–Support" Three-Dimensional Framework

Building on these theoretical foundations, this study constructs a three-dimensional framework—Goal, Path, and Support—as illustrated in Figure 3, to systematically articulate the internal logic of AI empower-

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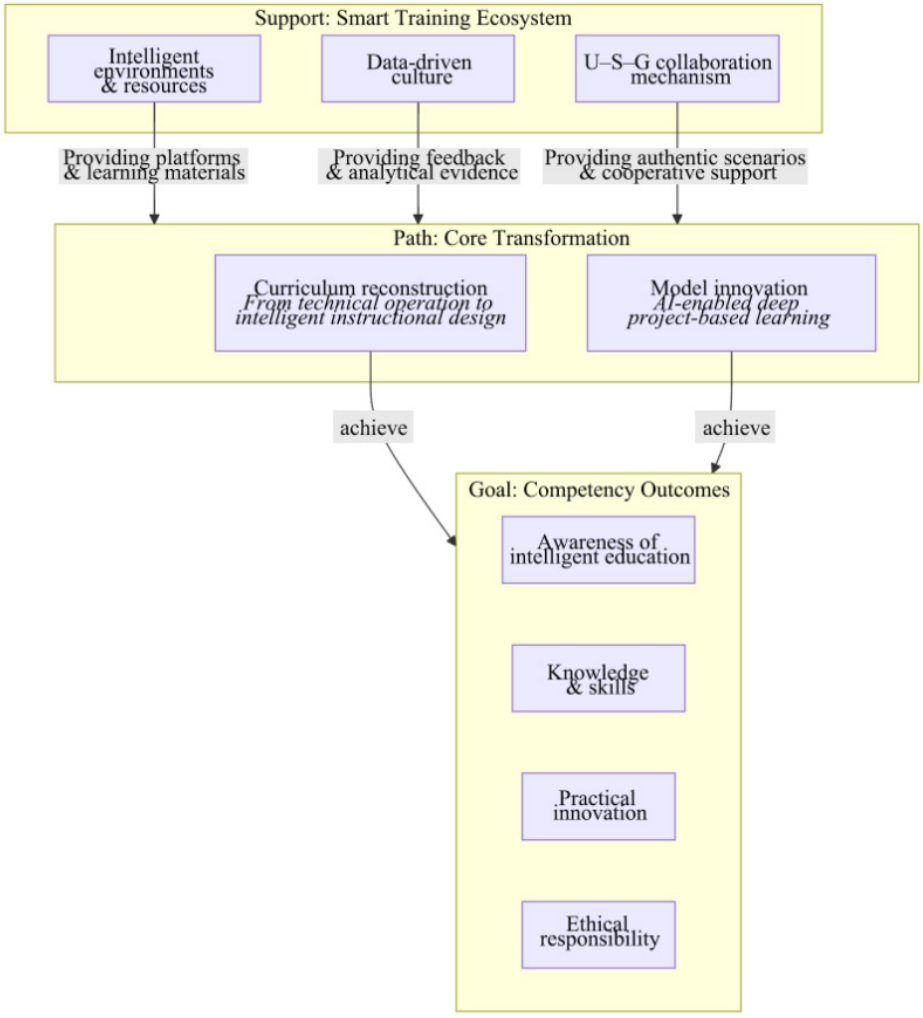


Figure 3 "Goal–Path–Support" 3D Theoretical Model

2.2.1 Goal Dimension: An Integrated Framework for Intelligent Literacy

The goal dimension of this model refers to the integrated intelligent literacy that preservice teachers are expected to develop. It moves beyond technical operational proficiency and constitutes a four-layer composite structure: awareness of intelligent education, emphasizing a rational understanding of the value, potential, and limitations of AI in education; knowledge and skills, referring to mastery of fundamental AI concepts and essential intelligent tools; practical innovation, the ability to incorporate AI into instructional design, implementation, and evaluation, and to conduct human–AI collaborative innovation in teaching; and ethical responsibility, which involves cultivating acute ethical awareness and the capacity for critical decision-making related to issues such as data privacy and algorithmic fairness [7].

2.2.2 Path Dimension: Dual-Level Transformation in Curriculum and Pedagogy

The path dimension represents the concrete channels through which the goals are achieved, encompassing fundamental transformation at both the curriculum and instructional levels.

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(1) Curriculum Reconstruction: From Technical Operation to Intelligent Instructional Design

Curriculum content must be structurally reconfigured—shifting from software-operation-centered training toward a curriculum grounded in intelligent instructional design. This restructuring should incorporate modules such as intelligent pedagogy theory, principles of human–AI collaborative instructional design, data-driven thinking and learning analytics, and ethics in intelligent education. The aim is to prepare preservice teachers to design innovation with AI, rather than merely adapt to technical procedures as passive learners shaped by technology.

(2) Pedagogical Innovation: AI-Enabled Deep Project-Based Learning

Instructional transformation should adopt an AI-enabled deep project-based learning model, wherein AI is embedded throughout the entire project cycle. During initiation, AI functions as a brainstorming partner that supports idea generation; during planning, it serves as a research assistant for information retrieval and solution optimization; during practice, it acts as a simulation coach providing real-time feedback in virtual scenarios; and during reflection, it operates as a data analyst, generating formative evaluation reports [8]. The core mechanism lies in the cognitive scaffolding provided by AI—by assuming low-level cognitive tasks, it enables preservice teachers to focus their mental resources on higher-order thinking such as problem framing, solution design, and iterative creation.

2.2.3 Support Dimension: Building an Intelligent Professional Training Ecosystem

The support dimension ensures the effective functioning of the path dimension through the construction of an intelligent training ecosystem.

Intelligent environments and resources include national intelligent education platforms, virtual simulation laboratories, and AI-supported teaching spaces that together constitute a seamless smart-learning environment.

A data-driven culture fosters organizational norms that leverage instructional and learning-process data to enable precise evaluation, personalized intervention, and evidence-based decision-making.

U–S–G collaborative mechanisms—linking universities, schools, and government/industry—jointly establish training standards, develop instructional cases, and build practicum bases, ensuring that training paths align closely with actual needs in K–12 educational contexts [9].

3. Theoretical Interpretation: Mechanisms Driving AI-Enabled Curriculum Innovation

3.1 From Knowledge Transmission to Cognitive Augmentation: A Paradigm Shift in Learning

Traditional Educational Technology Applications courses primarily reflected a knowledge-transmission paradigm focused on operational procedures and static teaching models. With AI assuming low-order cognitive tasks such as information retrieval, data processing, and resource generation, preservice teachers experience

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cognitive liberation. According to cognitive load theory, when extraneous load is effectively reduced, learners can devote more working memory to schema construction and higher-order reasoning [10]. Under this mechanism, learners are freed from repetitive operational procedures, enabling them to channel cognitive resources into creative lesson design, decision-making in complex teaching contexts, and problem-solving. AI thus acts not merely as a tool but as a cognitive collaborator within a distributed cognition system—realizing substantive professional empowerment rather than incremental efficiency improvement [11].

3.2 From Standardized Training to Personalized Generation: Innovation in Practice Pathways

Conventional practicum activities often rely on standardized cases and uniform evaluation criteria, failing to accommodate diverse learner profiles. Through data perception and dynamic modeling, AI can accurately identify each preservice teacher's prior knowledge, skill level, cognitive preferences, and disciplinary interests—thereby generating personalized learning tasks and tailored scaffolding. Within project-based learning, AI dynamically adjusts task difficulty, recommends customized resources, and produces targeted feedback reports. This dynamic-adaptive pathway replaces "one-size-fits-all" training with truly personalized professional formation, turning practice from routine skill drills into a formative process of identity development [12].

3.3 From Technology User to Intelligent Instructional Designer: Re-authoring Teacher Identity

The deepest mechanism lies in the identity shift stimulated by AI. As intelligent systems increasingly assume routine and procedural tasks, the professional focus of preservice teachers shifts from technical operation to design, orchestration, and critical evaluation of AI-mediated instruction. In this role evolution, teachers become intelligent instructional designers who define learning goals, configure human–AI collaborative processes, select and integrate appropriate tools, and critically appraise AI-generated outputs from both pedagogical and ethical standpoints [13]. Rooted in sociocultural theory, this transformation reflects how new tools reshape both behavior and self-perception 14]. Thus, the aim of the curriculum is no longer to produce teachers who merely use AI, but to cultivate educators who can harness AI to innovate education.

4. Conclusion and Prospects: Theoretical Contributions and Future Outlook

4.1 Theoretical Synthesis and Value

This study develops and explicates a tri-dimensional "Goals–Pathways–Environment" bidirectional construction model, revealing the internal logic and operative mechanisms through which AI empowers the development of pre-service teachers' intelligent literacy.

First, the study articulates the multidimensional connotations of intelligent literacy, expanding it beyond narrow technical proficiency and redefining it as a comprehensive framework encompassing awareness, knowledge, innovative capacity, and ethical responsibility. This reconceptualization provides a theoretical benchmark for establishing professional teacher standards in the era of intelligence.[1]

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Second, the study underscores the essentially bidirectional nature of AI-enabled development. AI is not a passive auxiliary external to the educational system; rather, through continuous interaction with pre-service teachers, it functions as a cognitive partner, a contextual shaper, and an ecological catalyst. In doing so, it actively participates in—and reshapes—their cognitive processes, practical engagements, and professional identity formation. This recognition surpasses the limitations of technological instrumentalism and offers a new theoretical lens for understanding human–AI collaborative learning paradigms.[2]

Finally, the study outlines three transformative mechanisms—shifts from knowledge transmission to cognitive empowerment, from standardized training to personalized generation, and from technology operator to intelligent educational designer. This provides a clear theoretical roadmap for deep reform of Educational Technology Application curricula and holds significant value for advancing teacher-education theory in the intelligent era.

4.2 Theoretical Deepening and Future Directions

Although this study proposes an initial theoretical framework, AI-empowered teacher education remains an emerging domain with many foundational theoretical questions requiring further investigation. Future research may be deepened along the following directions:

(1) Ethical boundaries and the locus of teacher agency.

As AI systems gain higher autonomy, critical questions arise: how should ethical responsibility be distributed within human–AI collaboration? How can pre-service teachers develop the capacity to critically interrogate, supervise, and ultimately arbitrate AI-generated decisions? These issues constitute an important frontier of theoretical inquiry.

(2) Emotion and trust formation in human–AI interaction.

Education is inherently an emotionally charged process. Future studies should examine how pre-service teachers build pedagogical trust with AI systems, and how AI can recognize, respond to, and shape emotional climates in teaching—while also acknowledging its limitations. This represents a current gap in the model.

(3) Prospective evolution of teacher-education ecologies toward AGI.

Existing research is largely grounded in present-day narrow AI. Looking ahead to the emergence of AGI, it is critical to consider how pre-service teachers' core competencies, curriculum structures in teacher-training programs, and even institutional organizational forms may undergo fundamental transformation. Future scholarship therefore requires stronger foresight, theoretical imagination, and paradigm reconstruction.

In summary, AI-empowered teacher development is a complex and systemic undertaking. It requires attention not only to technological iteration, but more importantly to the reconstruction and renewal of educational theory. Continued research should deepen engagement with the theoretical questions identified above, validate and refine the model through practice, and ultimately contribute to building a high-quality teacher-education system capable of both adapting to and leading the intelligent age.

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Funding

2024 Zhaoqing Institute of Educational Development Research Project: Cultivating Preservice Teachers' Intelligent Educational Literacy in the Era of Digital Intelligence—A Case Study of the "Educational Technology Applications" Course (Grant No. ZQJYY2024104)

2024 Zhaoqing University Scientific Research Fund (Youth Program): Exploring AI-Driven Pathways for Teacher Professional Development (Grant No. QN202410)

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