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# A Supply-Demand Alignment Study of Preservice Teacher Education Programs in the Context of Artificial Intelligence

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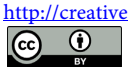



## Abstract

The systemic transformation of the educational ecosystem driven by artificial intelligence technologies has imposed new demands on preservice teacher education. Based on a self-developed supply-demand alignment framework for preservice teachers' AI literacy, this study employed a mixed-methods approach combining questionnaire surveys and semi-structured interviews to empirically examine the current status of preservice teachers' AI literacy and the provision of teacher education programs. The questionnaire was distributed across multiple teacher education institutions, yielding 112 valid responses. Semi-structured interviews were conducted with 15 preservice teachers from diverse backgrounds, generating approximately 80,000 Chinese characters of qualitative data. The findings revealed an uneven development pattern across different dimensions of preservice teachers' AI literacy. On the demand side, preservice teachers demonstrated a gradient profile characterized by positive AI awareness, moderate AI knowledge, limited AI competencies, and fragmented AI ethical understanding. On the supply side, teacher education programs showed several structural limitations, including sporadic classroom integration, insufficient practical platforms, and insufficient support for AI ethics education. The supply-demand alignment analysis identified four core gaps: perceived gaps in institutional support for AI awareness development, superficial knowledge provision, structural mismatches in competency development, and systemic neglect of AI ethics education. To address these gaps, this study proposes three strategies: developing a progressive AI curriculum framework, strengthening immersive practical training, and embedding continuous AI ethics education throughout teacher preparation. These recommendations aim to provide empirical evidence and practical pathways for the targeted optimization of preservice teacher education programs.

**Keywords**

Artificial Intelligence, Preservice Teachers, Teacher Education Programs, Supply-Demand Alignment

## 1. Introduction

Currently, a new wave of technological revolution is sweeping across the globe, and the global education sector is undergoing a profound digital transformation driven primarily by artificial intelligence. The systemic reshaping of educational ecosystems by AI technologies has attracted widespread international attention, with an increasing number of countries incorporating AI applications in education into their national strategic agendas. Since the release of the New Generation Artificial Intelligence Development Plan (The State Council of the People's Republic of China, 2017) by the State Council of China in 2017, China has successively introduced a series of policy documents, including the Opinions on Deepening the Reform of Teacher Workforce Development in the New Era (2018) (The Central Committee of the Communist Party of China & The State Council of the People's Republic of China, 2018) and the industry standard of Digital Literacy for Teachers (2022) (Ministry of Education of the People's Republic of China, 2022). These initiatives have systematically outlined pathways for the deep integration of AI and education, while positioning the enhancement of teachers' digital literacy as a strategic priority in the reform and development of the teaching workforce in the new era. Within this broader policy context, the impact of AI on teachers' professional roles and its potential to reshape the teaching profession have become subjects of sustained academic debate. Can artificial intelligence replace teachers? How should teachers adapt their knowledge structures and competency frameworks to respond effectively to technological transformation? These questions represent not only central issues in teacher education research but also critical practical challenges that must be addressed in the reform of teacher preparation and training systems.

Current scholarship on artificial intelligence and teacher education has primarily developed along three major lines of inquiry. First, research has examined how AI facilitates pedagogical transformation. Existing studies have demonstrated that the deep integration of AI technologies is driving a shift in educational objectives from knowledge transmission toward competency development (Yi & Han, 2025; Wu, 2024). Meanwhile, teaching content and learning resources are increasingly characterized by multimodality and contextual adaptability (Li, 2024), learning environments are expanding beyond physical boundaries toward ubiquitous and personalized learning spaces (Sun & Zhou, 2024), and educational assessment is evolving toward data-driven, refined, and continuous diagnostic approaches (Zhang & Zhou, 2025). Second, researchers have critically examined the risks associated with the application of AI in education. Scholars have identified potential risks from multiple perspectives, in-

cluding cognitive alienation (Guo, 2025), educational and developmental functions (Hu et al, 2024), data governance (Guo et al, 2024), and psychological adaptation (Luo, 2025), revealing the emotional limitations and ethical tensions arising from AI integration into educational practices. Third, studies have focused on teachers' strategies for responding to AI-driven educational change. Researchers emphasize that teachers should develop a human-AI collaborative cognitive framework (Hou & Wang, 2025), establish a multifaceted professional identity encompassing roles such as knowledge deconstructors, value guides, and personalized learning facilitators (Zhou & Xie, 2025), and systematically enhance their competencies in intelligent educational tool utilization and educational data analysis (Zheng & Wang, 2024).

Existing studies have accumulated substantial theoretical insights and provided an important foundation for further inquiry; however, three major areas remain open for further exploration. In terms of research focus, existing scholarship has predominantly examined what competencies teachers ought to possess from a normative perspective, while paying comparatively limited attention to whether and to what extent teacher education programs actually respond to these competency demands in practice. Regarding research perspectives, most studies have adopted a single disciplinary lens, such as educational technology or teacher professional development, and have primarily focused on strategies for enhancing teachers' individual capacities. Insufficient attention has been devoted to the structural influence of teacher education curricula as institutional provisions shaping the development of preservice teachers' competencies. Methodologically, theoretical deduction and conceptual analysis remain dominant approaches, whereas empirical investigations employing quantitative and qualitative methods are relatively underdeveloped.

Building upon this foundation, the present study examines the alignment between the provision of teacher education programs and the competency demands of preservice teachers as its analytical entry point. Employing a mixed-methods approach that integrates quantitative surveys and qualitative interviews, this study empirically diagnoses the current supply-demand dynamics of artificial intelligence literacy development within preservice teacher education programs, with the aim of providing evidence-based insights for the targeted optimization of teacher education curricula.

## 2. Definition of Key Concepts and Theoretical Foundations

### 2.1. Definition of Key Concepts

#### 2.1.1. Artificial Intelligence Literacy of Preservice Teachers

Artificial intelligence literacy represents a further advancement and extension of digital literacy in the era of artificial intelligence. As artificial intelligence technologies rapidly permeate the educational field, identifying the types of AI literacy required for teachers and preservice teachers to effectively undertake future teaching practices has become an urgent issue that warrants scholarly attention.

Focusing on preservice teachers, this study defines preservice teachers' artificial intelligence literacy as an integrated competency framework that they should possess in the AI era, characterized by AI awareness as the foundation, AI knowledge as the basis, AI-related competencies as the core, and AI ethics as the safeguard.

#### 2.1.2. Preservice Teachers' AI Literacy Development Needs

Need refers to the competencies and developmental requirements necessary for individuals to adapt to specific contextual demands. In the era of AI-enhanced education, preservice teachers' AI literacy development needs are not equivalent to their current AI literacy levels; instead, they reflect the gap between the AI-related competencies required for future teaching practices and their existing capabilities.

In this study, preservice teachers' AI literacy development needs are defined as the requirements for developing AI awareness, knowledge, competencies, and ethics necessary for future teaching practices. These needs are interpreted through the discrepancy between preservice teachers' current AI literacy status and the competencies required in AI-integrated educational contexts.

#### 2.1.3. Preservice Teacher Education Programs

A preservice teacher education program refers to a systematically designed instructional plan and implementation framework developed by teacher education institutions to achieve their educational objectives and serves as a guiding document for talent cultivation. In a broader sense, preservice teacher education programs encompass multiple dimensions, including curriculum structure design, instructional scheduling, educational internships and practical experiences, mentoring systems, and the selection and development of teaching materials.

### 2.2. Theoretical Foundations and Analytical Framework

Building upon the conceptualization of preservice teachers' artificial intelligence literacy and teacher education programs, this study systematically reviews existing competency framework models in the literature and develops a supply-demand alignment analytical framework accordingly. This framework provides both a theoretical foundation and an analytical instrument for the subsequent empirical investigation.

Drawing upon the graduation requirements of teacher education accreditation, namely "one commitment and three competencies," some scholars have developed an intelligent education literacy framework for preservice teachers consisting of three first-level dimensions: intelligent learning literacy, intelligent teaching literacy, and professional ethics literacy (Wang & Li, 2023). This framework is closely aligned with professional standards for teachers. The dimension of "professional ethics literacy" positions technology application within the fundamental educational goal of fostering virtue through education, thereby highlighting the distinctive educational value orientation of preservice teacher literacy compared with general artificial intelligence literacy.

Other scholars have approached intelligent education literacy from the perspec-

tive of its explicit and implicit characteristics and developed an "iceberg model" of teachers' intelligent education literacy, comprising three first-level dimensions: knowledge and skills, competencies, and ethical beliefs (Li, X., 2021). Furthermore, the model categorizes teachers' intelligent education literacy into four levels ranging from explicit to implicit dimensions: AI foundational knowledge, AI-integrated pedagogical content knowledge, AI-integrated teaching competencies, and AI-related educational ethical beliefs. This framework reveals the hierarchical structure and implicit nature of literacy development.

At the international level, the UNESCO AI Competency Framework for Teachers, released in 2024 (UNESCO, 2024), outlines 15 competencies that teachers should possess across five dimensions: human-centered mindset, AI ethics, AI foundations and applications, AI pedagogy, and AI professional learning. This framework provides a valuable reference for teachers to enrich their AI knowledge base and enhance related pedagogical skills while adhering to these guiding principles.

Integrating the aforementioned findings and research objectives, this study develops a supply-demand alignment framework for preservice teachers' artificial intelligence literacy, incorporating dual analytical dimensions from both the demand side and the supply side **(See Table 1)**.

**Table 1.** Analysis framework for supply-demand matching of artificial intelligence literacy among normal school students.

| Analysis Level | First-level dimension | Secondary Dimensions | Dimension Interpretation |
|---|---|---|---|
| Demand side (Current status of Teacher Education Students' literacy) | Ai consciousness | Value cognition | An overall assessment of the development trends of artificial intelligence technology and its impact on education |
| | | Role positioning | Recognition and understanding of the unique advantages that teachers have over AI |
| | Knowledge of AI | Application scenario knowledge | Understanding of typical application scenarios of AI in the field of education |
| | | Knowledge of tool functionality | Awareness of the features and differences of common AI educational tools |
| | AI capabilities | Information acquisition ability | Operational skills in using AI tools to acquire teaching information and resources |
| | | Instructional design skills | The ability to use artificial intelligence tools to assist in instructional design, such as generating lesson plans and creating courseware |
| | | Classroom management skills | The ability to use artificial intelligence for classroom management (such as analyzing data on student engagement) |
| | | The ability to analyze students' situations | The ability to use artificial intelligence to analyze students' learning situations, such as generating error reports |
| | Ethics of Artificial Intelligence | Content critical consciousness | The ability to discern and critically evaluate the reliability, accuracy, and suitability of AI-generated content |
| | | Awareness of risk norms | Awareness and normative awareness of ethical risks such as privacy protection, algorithmic bias, and technology dependency in AI educational applications |

**Continued**

| | | | |
|---|---|---|---|
| Supply-side (Culture program supply) | Teaching courses | Artificial intelligence course module | Professional courses have required or elective modules related to artificial intelligence |
| | | Teacher demonstration | Teachers demonstrate how to use AI tools during the teaching process |
| | | Assignment Requirements | Course assignments are required to be completed in combination with artificial intelligence |
| | Practice Platform | The platform offers | The school provides a practical platform for the application of artificial intelligence in education |
| | | Access Opportunities | Get in touch with AI educational tools during course study or internship |
| | | Technical practice | Schools offer AI educational technology practice opportunities (such as virtual simulation LABS) |
| | | Practical activities | Schools organize AI practice activities |
| Evaluation Side (Evaluation of the training program) | Effect perception | Course fit | The degree to which the course content fits the latest developments in artificial intelligence technology |
| | | Interest stimulation | The stimulating effect of courses on continuous learning of artificial intelligence technology |
| | | Sense of gain | The extent to which training programs help acquire sufficient knowledge and skills in artificial intelligence |
| | Overall feedback | Overall satisfaction | Overall satisfaction with the training program |
| | | Insufficient feedback | In what ways does the training program fail to help address AI challenges |
| | | Improving expectations | A course or practice direction that you hope the school will add |

## 3. Investigation of Preservice Teachers' Artificial Intelligence Literacy and the Current Status of Teacher Education Programs

### 3.1. Design of Measurement Instruments and Data Collection

This study adopts a mixed-methods research design integrating quantitative and qualitative approaches. The quantitative component employs questionnaire surveys as the primary instrument to examine the current status of different dimensions of preservice teachers' artificial intelligence literacy and the supply-demand alignment of teacher education programs through descriptive statistical analysis. The qualitative component utilizes semi-structured interviews to provide in-depth interpretations and complementary insights into the quantitative findings, thereby exploring the underlying causes of the identified supply-demand gaps.

#### 3.1.1. Design of Measurement Instruments

1) Questionnaire Design

Based on the aforementioned supply-demand alignment framework for preservice teachers' artificial intelligence literacy, this study developed the Questionnaire on Preservice Teachers' Intelligent Education Literacy and the Current Status of Teacher Education Programs, which consists of five sections **(See Table 2)**.

Table 2. Questionnaire design.

| Analysis Level | Questionnaire Section | First-level dimensions | Secondary Dimensions | Corresponding item | Item content | Question types |
|---|---|---|---|---|---|---|
| / | Basic Information | Control variables | / | Question 1 | Grade | Single choice |
| | | | | Question 2 | Specialization Directions | Single choice |
| | | | | Question 3 | Do you have any internship or apprenticeship experience in primary or secondary schools | Single choice |
| Demand side | Cognition and Consciousness | AI Consciousness | Value cognition | Question 4 | What basic qualities should a qualified teacher possess (solid subject knowledge, rich educational and teaching knowledge, teaching ability, communication skills, teaching wit, caring for students, dedication to work, emotional stability, digital literacy, etc.) | Multiple Choices |
| | | | | Question 5 | How will artificial intelligence technology transform the future classroom (improving teaching efficiency by freeing up personalized teaching time, changing teaching methods by increasing interactivity and fun, providing data analysis support for precise teaching, increasing the diversity and accessibility of teaching resources, etc.) | Multiple Choices |
| | | | Role positioning | Question 6 | Ranking of teachers' strengths in education compared to artificial intelligence (emotional guidance, classroom flexibility, interdisciplinary design, innovative thinking, interpersonal communication skills) | Sorting |
| | Technical mastery | Knowledge of artificial intelligence | Application scenario knowledge | Question 14 | Have a clear understanding of the basic application scenarios of AI in the field of education (such as intelligent marking, personalized learning, etc.) | Likert Five-point Scale |
| | | | Knowledge of Tool functions | Question 15 | Be able to distinguish the functional differences of common AI educational tools such as ChatGPT, Wenxin Yiyan, etc | Likert Five-point Scale |
| | | AI capabilities | Information acquisition ability | Question 16 | Master how to use artificial intelligence to get information | Likert Five-point Scale |
| | | | Instructional design ability | Question 17 | Be able to independently use AI tools to assist in instructional design (such as generating lesson plans, making courseware) | Likert five-point Scale |
| | | | Classroom management skills | Question 18 | Be able to use artificial intelligence for classroom management (such as automatically analyzing students' engagement data) | Likert five-point Scale |
| | | | The ability to analyze students' situations | Question 19 | Be able to use AI tools to analyze students' learning situations (such as generating error reports) | Likert five-point scale |

**Continued**

| | | | | | | |
|---|---|---|---|---|---|---|
| Demand side | Technical mastery | AI Ethics | Content critical consciousness | Question 20 | (Reverse question) AI-generated content can be directly used in teaching without discrimination and evaluation of its accuracy, reliability, and suitability for teaching | Likert five-point scale |
| | | | Awareness of risk norms | Question 21 | When using artificial intelligence to assist teaching, there is an active focus on and prevention of potential ethical risks such as privacy leaks, algorithmic biases, and excessive technological reliance | Likert Five-point Scale |
| Supply side | Current status of training program supply | Teaching courses | Artificial intelligence course module | Question 7 | My major course has compulsory or elective modules related to artificial intelligence | Likert Five-point Scale |
| | | | Teacher demonstration | Question 8 | Teachers demonstrate how to use artificial intelligence tools in the teaching process | Likert five-point scale |
| | | | Assignment Requirements | Question 9 | Some course assignments require the use of artificial intelligence | Likert five-point Scale |
| | | Practice Platform | The platform offers | Question 10 | Schools provide practical platforms for the application of artificial intelligence in education | Likert Five-point Scale |
| | | | Access opportunities | Question 11 | Exposure to AI educational tools (such as smart marking, virtual classrooms, etc.) during course study or internship | Likert Five-point Scale |
| | | | Technical Practice | Question 12 | Schools offer opportunities for AI educational technology practice (such as virtual simulation LABS) | Likert five-point scale |
| | | | Practical activities | Question 13 | Schools organize AI practice activities | Likert five-point Scale |
| Evaluation side | Effect evaluation and improvement expectations | Effect perception | Course fit | Question 22 | The course content learned can be relevant to the latest developments in artificial intelligence technology | Likert five-point scale |
| | | | Interest stimulation | Question 23 | The course has sparked an interest in continuing to learn about artificial intelligence technology | Likert Five-point Scale |
| | | | Sense of gain | Question 24 | The current training program can help acquire sufficient knowledge and skills in artificial intelligence | Likert five-point scale |
| | | Overall feedback | Overall satisfaction | Question 25 | Satisfied with the current training program | Likert five-point scale |
| | | | Insufficient feedback | Question 26 | In what ways does the current training program fail to help address the challenges of artificial intelligence (insufficient development of technical skills, insufficient innovation in instructional design, lack of practical experience with artificial intelligence tools, lack of data analysis skills, lack of education on ethics and artificial intelligence risks, etc.)? | Multiple Choices |

**Continued**

| | | | | | | |
|---|---|---|---|---|---|---|
| Evaluation side | Effect evaluation and improvement expectations | Overall feedback | Improving expectations | Question 27 | Which courses or practices do you hope schools will add (Artificial Intelligence Tools Practice, AI-based student data analysis methods, human-machine collaborative instructional design, educational ethics and AI risks, etc.)? | Multiple choices |

2) Interview Outline Design

The interview protocol adopts a semi-structured format and is developed around the three analytical dimensions of the supply-demand alignment framework. While ensuring comprehensive coverage of the core questions, the protocol allows for flexible probing and follow-up inquiries when necessary **(See Table 3)**.

**Table 3.** Interview outline design.

| Analysis level | First-level dimension | Secondary Dimensions | Corresponding interview questions | Interview Objectives |
|---|---|---|---|---|
| Demand side | AI awareness | Value cognition | Question 3 | Get respondents' understanding of the nature of the teaching profession without presetting an AI context |
| | | Value cognition | Question 4 | Gain a deeper understanding of respondents' perception of the impact of AI education |
| | | Role positioning | Question 6 | Understand the respondents' awareness of their own shortcomings |
| | AI Ethics | Risk regulation awareness | Question 5 | Dig into respondents' attitudes and ethical judgments about "human-machine relationships" |
| | AI capabilities | Teaching integration ability | Question 11 | Understand the self-directed learning behavior and intrinsic motivation of the respondents |
| Supply-side | Curriculum teaching | Teacher demonstration | Question 7 | Understand the infiltration of AI awareness in the classroom in the training program |
| | | Teacher demonstration | Question 9 | Verify the implementation of AI tool teaching in the training program |
| | | Teacher demonstration | Question 10 | Find out if the training program is systematic in training AI capabilities |
| | Practice Platform | Access Opportunities | Question 8 | Get the specific context and insights from the AI experience in the practice session |
| | | The platform offers | Question 12 | Obtain the actual description beyond the text of the training program system |
| Evaluation side | Effect perception | Sense of gain | Question 13 | Obtain respondents' subjective evaluations of the effectiveness of the training program |
| | Overall feedback | Improvement expectations | Question 14 | Collect specific suggestions for improvement from the respondents |

### 3.1.2. Data Collection

1) Research Participants

The participants of this study were current students and graduates enrolled in

teacher education programs at higher normal universities and comprehensive universities. Their academic programs fall within the broader field of education and encompass a curriculum system covering educational theory, psychology, subject-specific pedagogy, educational technology, and teaching practicum. Through systematic professional training and educational internships, these students acquire foundational educational theories, instructional skills, and classroom management competencies.

2) Questionnaire Survey

The questionnaire was distributed through the Wenjuanxing online survey platform. A pilot study was conducted in May 2025 with 27 participants to refine the questionnaire items. The formal survey was conducted from mid-June to late July 2025. The questionnaire was purposively distributed through channels such as class groups and alumni groups of teacher education institutions, using a combination of snowball sampling and convenience sampling methods. Based on the distribution channels and self-reported information, valid responses were obtained from preservice teachers enrolled in teacher education programs across six higher education institutions, including three provincial key normal universities, two local normal colleges, and one comprehensive university. As the questionnaire was collected anonymously online, institution-specific response numbers were not tracked, preventing precise reporting of sample distribution across institutions. After conducting reverse-scoring verification, response-time screening, and duplicate-response checks, a total of 125 questionnaires were collected, of which 112 were identified as valid, resulting in an effective response rate of 89.6%. The demographic distribution of the sample is presented in Table 4.

Table 4. Distribution of survey samples.

| Variables | Options | Frequency | Percentage |
|---|---|---|---|
| Grade | Freshman | 17 | 15.2 |
| | Sophomore | 54 | 48.2 |
| | Junior | 19 | 17.0 |
| | Senior year | 8 | 7.1 |
| | Graduate student | 14 | 12.5 |
| Professional | Liberal arts | 74 | 66.1 |
| | Science | 29 | 25.9 |
| | Arts and Sports | 3 | 2.7 |
| | Others | 6 | 5.4 |
| Do you have any internship or apprenticeship experience in primary or secondary schools | is | 27 | 24.1 |
| | no | 85 | 75.9 |

After excluding non-scale items, the standardized Cronbach's alpha coefficients for the overall questionnaire and its respective dimensions were 0.906,

0.848, 0.822, and 0.891, respectively. These results indicate that the questionnaire demonstrated good reliability and high internal consistency among the items. The validity of the questionnaire was examined using exploratory factor analysis. The Kaiser-Meyer-Olkin measure of sampling adequacy was 0.842, and Bartlett's test of sphericity yielded a significance level approaching zero ($p < 0.05$), indicating that the data were suitable for factor analysis. Principal component analysis was employed to extract common factors, followed by orthogonal rotation using the varimax method. Five factors with eigenvalues greater than 1 were extracted, accounting for 70.608% of the cumulative variance. The factor loadings of all items ranged from 0.426 to 0.761, exceeding the acceptable threshold of 0.4, demonstrating that the questionnaire possessed satisfactory construct validity **(See Table 5)**.

It should be noted that the five factors extracted from the EFA do not completely correspond to the first-order dimensions proposed in the theoretical framework but reflect different latent dimensions underlying the questionnaire structure. Factor 1 mainly represents preservice teachers' AI teaching application competence and technological awareness, including AI tool use, understanding of AI-related educational applications, and technology application in teaching contexts. Factor 2 primarily reflects preservice teachers' perceived effectiveness of teacher education programs, including curriculum relevance, acquisition of AI-related knowledge and skills, and learning motivation. Factors 3 and 4 correspond to practical support and curricular integration of AI within program provision, respectively. Factor 5 contains items related to AI application judgment and ethical evaluation; however, due to the limited number of indicators, it was not treated as an independent theoretical dimension in subsequent analyses. Overall, the factor structure was broadly consistent with the proposed AI literacy development needs-program provision alignment framework.

**Table 5.** Exploratory factor analysis results of the questionnaire.

| Item | Factor 1 | Factor 2 | Factor 3 | Factor 4 | Factor 5 |
|---|---|---|---|---|---|
| Q17 | 0.849 | | | | |
| Q16 | 0.799 | | | | |
| Q15 | 0.705 | | | | |
| Q21 | 0.632 | | | | |
| Q19 | 0.555 | | | | |
| Q14 | 0.459 | | | | |
| Q25 | | 0.842 | | | |
| Q22 | | 0.834 | | | |
| Q24 | | 0.810 | | | |
| Q23 | | 0.682 | | | |
| Q12 | | | 0.846 | | |
| Q13 | | | 0.839 | | |

**Continued**

| | | | |
|---|---|---|---|
| Q10 | 0.763 | | |
| Q11 | 0.512 | | |
| Q9 | | 0.822 | |
| Q8 | | 0.719 | |
| Q7 | | 0.639 | |
| Q20 | | | −0.829 |
| Q18 | | | 0.594 |

a. Extraction method: Principal Component Analysis. Rotation method: Varimax rotation. Only factor loadings with absolute values greater than 0.40 are presented.

3) Interview Study

Building upon the preliminary analysis of the questionnaire data, this study simultaneously conducted in-depth interviews in June 2025.Using information searches and personal referrals, the study employed purposive sampling to recruit 15 participants with diverse backgrounds in terms of gender, age, institutional type, and disciplinary fields. Data saturation was reached by the 13th participant. The interviews adopted a semi-structured format and were conducted through one-to-one online sessions via Tencent Meeting and WeChat voice calls. Each interview lasted approximately 30 minutes, was audio-recorded with participants' consent, and was subsequently transcribed verbatim, resulting in approximately 80,000 Chinese characters of interview transcripts.

To enhance the trustworthiness of the qualitative research, several quality control procedures were implemented. First, during the data collection phase, interviews and preliminary coding were conducted concurrently to dynamically monitor the emergence of new concepts. No substantial new concepts emerged after the 13th interview, and the subsequent two participants did not provide additional information beyond the existing categories, indicating that theoretical saturation had been achieved. Second, during the data organization phase, the preliminary analytical results were returned to five participants for member checking to ensure that the findings accurately represented their perspectives. Third, during the coding analysis phase, the researcher conducted intra-coder reliability checks by recoding the same text segments after a two-week interval. The coding consistency rate reached 87%, exceeding the generally accepted threshold of 70%.

For data analysis, thematic analysis was employed to analyze the interview transcripts. The coding process adopted a combination of deductive and inductive approaches. First, an initial coding framework was developed based on the AI literacy supply-demand alignment framework proposed in this study, including core dimensions such as AI awareness, AI knowledge, AI competencies, AI ethics, and teacher education program provision. Subsequently, additional codes were generated inductively during the analysis of interview transcripts to identify emerging themes and contextual factors underlying the formation of supply-demand gaps.

Specifically, the researcher first conducted line-by-line reading and initial cod-

ing of the interview transcripts to identify meaningful units related to the research questions. Related codes were then grouped into broader thematic categories to explain the supply-demand gaps in preservice teachers' AI literacy development. Finally, the qualitative findings were integrated with the questionnaire results to provide contextual explanations for the supply-demand mismatches identified through quantitative analysis and to further explore their underlying mechanisms **(See Table 6)**.

**Table 6.** Coding framework for interview data.

| Core Themes | Sub-Themes | Relationship with Survey Findings |
|---|---|---|
| AI awareness gap | Lack of systematic AI education exposure; traditional understanding of teacher competencies | Explains the discrepancy between positive expectations toward AI-enabled education and limited recognition of AI-related teacher competencies |
| AI knowledge gap | Superficial understanding of AI tools; insufficient understanding of AI principles and application boundaries | Explains why preservice teachers can identify AI applications but lack systematic conceptual understanding |
| AI competence gap | Insufficient practical training opportunities; limited integration of AI into teaching practice; lack of institutional support | Explains the mismatch between AI application needs and the practical training provided by teacher education programs |
| AI ethics gap | Lack of guidance on evaluating AI-generated content; insufficient ethical reflection and judgment ability | Explains the gap between preservice teachers' ethical awareness and their practical evaluation abilities |
| Program provision gap | Insufficient curriculum integration; limited practice platforms and training opportunities | Explains the structural imbalance identified from the supply-side analysis |

## 3.2. Results Analysis

### 3.2.1. Demand Side: Current Status of Artificial Intelligence Literacy among Normal School Students

Regarding AI awareness, preservice teachers demonstrated positive expectations toward the role of artificial intelligence in empowering education. Specifically, 89.3% of respondents believed that AI could improve teaching efficiency, while 77.7% agreed that AI-driven data analytics could support more precise and targeted instruction **(See Table 7)**. However, preservice teachers' perceptions of teacher professional competencies remained largely shaped by traditional frameworks. More than 80% of preservice teachers identified subject knowledge (92%), pedagogical knowledge (90.2%), and teaching competence (88.4%) as the most essential teacher competencies, whereas the recognition rate of "digital literacy" was only 57.10%, ranking lowest among all competency categories **(See Table 7)**. Further analysis of preservice teachers' perceptions of teachers' unique advantages compared with AI revealed significant differences across different dimensions, as indicated by repeated-measures ANOVA ($F(3.42, 379.20) = 47.58$, $p < 0.001$, $\eta^2 = 0.30$).Among these dimensions, "Emotional guidance" ranked first ($M = 4.13$), with significantly higher ratings than all other options ($p < 0.01$). "Classroom adaptability" ranked second ($M = 3.42$), receiving significantly higher ratings than "interpersonal communication ability," "innovative thinking," and "interdiscipli-

nary design" ($p < 0.001$), but significantly lower ratings than "emotional guidance" ($p = 0.007$). No significant differences were found among "interpersonal communication ability" ($M = 2.63$), "innovative thinking" ($M = 2.13$), and "interdisciplinary design" ($M = 1.89$) ($p > 0.05$) **(See Figure 1)**. This distribution suggests that although preservice teachers recognize the irreplaceable emotional and educational value of teachers in human-AI collaboration, they have insufficient awareness of the key extended competencies required of teachers in the AI era, such as interdisciplinary integration, pedagogical adaptability, and innovative design. Consequently, they have not yet developed a role orientation that is responsive to technological transformation. During the interviews, when participants were not explicitly prompted to consider artificial intelligence, many respondents primarily associated the competencies of a "qualified teacher" with instructional ability and professional knowledge, with few mentioning technology-related competencies. These qualitative findings further corroborated the quantitative results.

**Table 7.** Artificial intelligence awareness among normal school students.

| | | Responses | | Percentage of cases |
|---|---|---|---|---|
| | | Number of cases | Percentage | |
| How is AI changing the classroom (Value Cognition) | Improving teaching efficiency | 100 | 28.6% | 89.3% |
| | Increase interactivity and fun | 82 | 23.4% | 73.2% |
| | Help with precision teaching | 87 | 24.9% | 77.7% |
| | Enrich teaching resources | 81 | 23.1% | 72.3% |
| The qualities a qualified teacher should have (Professional Awareness) | Solid academic knowledge | 103 | 13.4% | 92.0% |
| | Rich knowledge of education and teaching | 101 | 13.1% | 90.2% |
| | Teaching ability | 99 | 12.9% | 88.4% |
| | Communication skills | 90 | 11.7% | 80.4% |
| | Teaching wit | 66 | 8.6% | 58.9% |
| | Caring for students | 89 | 11.6% | 79.5% |
| | Love your job and be dedicated | 77 | 10.0% | 68.8% |
| | Emotional stability | 81 | 10.5% | 72.3% |
| | Digital literacy | 64 | 8.3% | 57.1% |

a. Tabulating two groups using the value 1.

Regarding AI knowledge, preservice teachers achieved a mean score of 7.21 out of 10, indicating a moderately high level of AI-related knowledge **(See Table 8)**. Most participants were able to identify common educational application scenarios of artificial intelligence and distinguish the basic functional differences among mainstream AI tools. However, they demonstrated limited systematic understanding of the underlying principles, applicable conditions, and limitations of AI technologies.

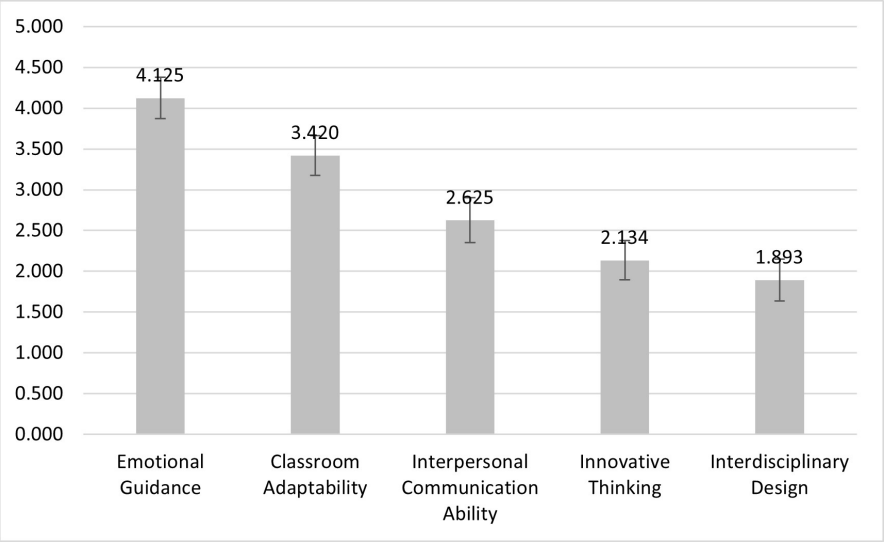


Figure 1. The role positioning of teachers by normal school students.

Regarding AI competencies, preservice teachers achieved a mean score of 14.43 out of 20. Among the four dimensions, information acquisition competency (Item 16, M = 3.89) and instructional design competency (Item 17, M = 3.86) received relatively higher scores, whereas classroom management competency (Item 18, M = 3.27) and learning analytics competency (Item 19, M = 3.41) showed comparatively lower performance **(See Table 8)**. These findings indicate that preservice teachers have developed a certain foundation in using AI to support basic tasks such as information retrieval and lesson plan design; however, their ability to extend AI applications to core instructional processes, including classroom management and learning diagnosis, remains notably insufficient.

Regarding AI ethics, preservice teachers achieved a mean score of 7.40 out of 10; however, their performance exhibited a noticeable gap between ethical awareness and practical application. More than 60% of respondents believed that AI-generated content should not be directly applied to teaching, suggesting that preservice teachers have developed a basic level of critical awareness. However, the mean score for

Table 8. Knowledge, competence and ethics of artificial intelligence.

| First-level dimension | Secondary Dimensions | Mean | Full marks | Score rate | Overall mean | Overall scoring rate |
|---|---|---|---|---|---|---|
| AI knowledge | Application scenario knowledge | 3.58 | 5 | 71.60% | 7.21/10 | 72.10% |
| | Knowledge of Tool functionality | 3.63 | 5 | 72.60% | | |
| AI capabilities | Information acquisition ability | 3.89 | 5 | 77.80% | 14.43/20 | 72.15% |
| | Instructional design ability | 3.86 | 5 | 77.20% | | |
| | Classroom management skills | 3.27 | 5 | 65.40% | | |
| | The ability to analyze students' situations | 3.41 | 5 | 68.20% | | |
| AI Ethics | Content critical consciousness | 3.78 | 5 | 75.60% | 7.40/10 | 74.00% |
| | Content discrimination ability | 3.63 | 5 | 72.60% | | |

the ability to identify the accuracy and applicability of AI-generated content was only 3.63, indicating that preservice teachers' ethical awareness has not yet been fully translated into practical evaluative competence **(See Table 8)**.

### 3.2.2. Supply Side: Current Status of Curriculum Training

The overall score rate of curriculum-based training provision was 61.86%, indicating a relatively low-to-moderate level of AI-related curriculum development. Regarding curriculum and instruction, the supply indicators demonstrated substantial internal variation. Among these indicators, "instructors' demonstration of AI tool usage" (M = 3.37) and "AI-integrated course assignments" (M = 3.56) received relatively higher scores. In contrast, the indicator "professional courses incorporating AI-related modules" received a lower score of 3.05, with only 37.5% of respondents confirming the existence of such modules. Regarding practical platforms, "institution-organized AI practice activities" (M = 2.54) and "institution-provided opportunities for practicing AI educational technologies" (M = 2.54) ranked lowest among all items **(See Table 9)**. These findings suggest that the current integration of AI-related content relies largely on individual instructors' spontaneous initiatives rather than systematic program-level design. Moreover, areas requiring sustained institutional investment, such as practical activities and structural support mechanisms, remain notably underdeveloped.

**Table 9.** Status of curriculum development.

| First-level dimensions | Secondary Dimensions | Mean | Full marks | Score rate | Overall mean | Overall scoring rate |
|---|---|---|---|---|---|---|
| Course instruction | Course Modules | 3.05 | 5 | 61.00% | 9.98/15 | 66.53% |
| | Teacher's demonstration | 3.37 | 5 | 67.40% | | |
| | Assignment Requirements | 3.56 | 5 | 71.20% | | |
| Practice Platform | The platform offers | 3.10 | 5 | 62.00% | 11.67/20 | 58.35% |
| | Contact opportunities | 3.50 | 5 | 70.00% | | |
| | Technical practice | 2.54 | 5 | 50.80% | | |
| | Practical activities | 2.54 | 5 | 50.80% | | |

### 3.2.3. Evaluation Dimension: Perceived Effectiveness and Satisfaction with Teacher Education Programs

Regarding perceived effectiveness, the overall mean score for the evaluation of teacher education programs was 9.46 out of 15, corresponding to a score rate of 63.07%, which indicates a moderate level of perceived effectiveness. Among the evaluated dimensions, "courses stimulating interest in AI learning" (M = 3.19) received the highest score, followed by "alignment between course content and AI development" (M = 3.16), while "acquisition of sufficient AI knowledge and skills" (M = 3.12) received the lowest score. This pattern suggests that preservice teachers possess strong intrinsic motivation to engage in AI learning, and that existing courses have achieved some effectiveness in stim-

ulating learning interest. However, teacher education programs remain insufficient in facilitating the practical transformation of AI knowledge acquisition into skill development. The gap between interest stimulation and competency acquisition indicates that effective connections have not yet been established between the advancement of course content and the effectiveness of pedagogical implementation.

Regarding overall feedback, "lack of hands-on experience with AI tools" (79.5%) and "insufficient development of technical competencies" (70.5%) were identified as the most prominent deficiencies, representing the major shortcomings of current teacher education programs. "Lack of innovation in instructional design" (57.1%) and "lack of training in data analytics competencies" (51.8%) ranked second in terms of perceived deficiencies. Although "lack of education on educational ethics and AI-related risks" was reported by 46.4% of respondents, it ranked relatively lower among the identified deficiencies **(See Table 10)**. This pattern corresponds with the findings from the supply-side analysis: practical platforms and competency training represent the weakest components of current program provision. Meanwhile, the urgency of ethics education is relatively underestimated at this stage, as AI ethics has not yet become a salient concern within the explicit awareness of most preservice teachers.

**Table 10.** Feedback on insufficient training programs.

| | | Responses | | Percentage of cases |
|---|---|---|---|---|
| | | Number of cases | Percentage | |
| Deficiencies in the culture program | Insufficient cultivation of technical capabilities | 79 | 23.1% | 70.5% |
| | Lack of innovation in instructional design | 64 | 18.7% | 57.1% |
| | Lack of hands-on experience with AI tools | 89 | 26.0% | 79.5% |
| | Lack of data analysis skills development | 58 | 17.0% | 51.8% |
| | Lack of education ethics and AI risk education | 52 | 15.2% | 46.4% |

a. Tabulating two groups using the value 1.

### 3.2.4. Analysis of the Current Situation and Causes of Supply and Demand Matching

By comparing the current status of preservice teachers' AI literacy across different dimensions on the demand side with the corresponding levels of program provision on the supply side, four types of supply-demand alignment gaps were identified **(See Table 11)**. Systematic coding of the interview data provided a contextualized interpretive pathway for understanding the underlying mechanisms contributing to the formation of these gaps. It should be noted that this study conducted an interpretive analysis of the factors associated with supply-demand gaps based on questionnaire and interview data. These factors primarily reflect participants' perceptions and experiential interpretations rather than empirically established causal relationships.

Table 11. Analysis of supply and demand matching of artificial intelligence literacy among normal school students.

| Analysis Dimensions | Demand side (literacy level of normal school students) | Supply-side (training program supply level) | Matching status |
|---|---|---|---|
| Ai consciousness | high (89.30 percent approve of efficiency improvement) | Course Module (61.00%) Practical activities (50.80%) | Serious gap |
| Knowledge of artificial intelligence | Moderate level (Scoring rate 72.10%) | Teacher demonstration (67.40%) Assignment requirements (71.20%) | There is a gap |
| Ai capabilities | Medium level (Scoring rate 72.15%) | Technical practice (50.80 percent) Practical activities (50.80 percent) | Serious gap |
| Ai Ethics | Medium level (Scoring rate 74.00%) | Ethics education selection rate 46.4% (lowest) | Serious gap |

First, Interview findings indicated that preservice teachers generally perceived that AI literacy development had not yet been systematically integrated into the curriculum. Several interviewees reported that their AI-related knowledge was primarily acquired through self-directed learning on social media platforms or peer recommendations rather than through formal coursework. One fourth-year undergraduate student stated: "There is no course at our university related to the educational applications of artificial intelligence. We can only search online and learn from what others are doing." This lack of systematic curriculum support was perceived by participants as an important factor associated with fragmented exposure to AI-related educational knowledge and limited recognition of AI-related teacher competencies.

Second, Interview findings suggested that preservice teachers perceived current AI-related educational content as primarily focusing on tool introduction rather than systematic methodological guidance and pedagogical integration. Most preservice teachers encountered AI primarily through brief verbal references made by instructors during classes. As one participant explained, "The teacher mentioned Wenxin Yiyan in class and said that it could help us prepare lessons, but that was all—there was no specific demonstration of how to use it." This form of knowledge provision was perceived as limiting preservice teachers' development of transferable AI-related educational understanding, resulting in fragmented awareness of tools and functions rather than comprehensive knowledge structures.

Third, Interview findings revealed that preservice teachers perceived a gap between their demand for AI-integrated teaching competencies and the practical opportunities provided by teacher education programs. Although some participants had completed AI-related assignments, these activities were mainly conducted through individual exploration rather than systematic practical training. Meanwhile, even when preservice teachers expressed willingness to apply AI during teaching internships, their attempts were often restricted by schools and supervising teachers due to concerns such as "potential technical problems" or "lack of necessary conditions." One fourth-year student with internship experience stated: "I wanted to try using AI to facilitate classroom interaction, but my super-

vising teacher said that the school did not have the necessary conditions and was concerned that technical problems might disrupt the class, so I was not allowed to use it." These factors were perceived by participants as being associated with insufficient development of AI application competence.

Fourth, Interview findings suggested that preservice teachers perceived insufficient systematic support for AI ethics education within current teacher education programs. Several interviewees reported that when instructors assigned AI-related tasks, they rarely provided guidance on how to evaluate the accuracy and applicability of AI-generated content. One third-year student accurately summarized this dilemma: "The teacher assigned us a task to use AI to create teaching materials, but never taught us how to judge whether the AI-generated outputs were accurate or appropriate. We were required to use AI, but we were not taught how to use it critically and responsibly." Without structured ethical training embedded in coursework and teaching practice, preservice teachers may find it difficult to transform their initial awareness of AI-related risks into practical judgment abilities.

## 4. Recommendations for Improvement

### 4.1. Developing a Progressive AI Curriculum Framework

The awareness gap primarily stems from the lack of systematic curricular responses to preservice teachers' high expectations regarding the educational value of AI. Therefore, a progressive AI curriculum framework can be developed across three stages: foundational general education, disciplinary integration, and pedagogical innovation.

First, at the stage of general education, compulsory introductory AI courses should be offered to all preservice teachers. These courses should cover fundamental AI principles, an overview of educational application scenarios, and familiarity with mainstream AI tools, thereby enabling preservice teachers to develop a foundational understanding of AI technologies and transforming their initially abstract positive expectations into structured cognitive foundations.

Second, at the stage of professional education, discipline-specific courses integrating AI with subject teaching should be developed for different disciplinary areas, such as AI-enhanced Chinese reading instruction and AI-supported mathematical problem solving. These courses should establish substantive connections between AI knowledge and the subjects that preservice teachers are preparing to teach, preventing AI-related knowledge from becoming detached from disciplinary contexts and remaining merely theoretical.

Third, at the advanced stage of teacher education, higher-level courses on human-AI collaborative instructional design should be offered. Through workshop-based or project-based learning approaches, preservice teachers can be guided to develop AI integration plans within specific subject teaching contexts, facilitating the transition from knowledge understanding to innovative instructional design. Meanwhile, preservice teachers should be required to complete a comprehensive

human-AI collaborative lesson design plan and implement and reflect upon it through microteaching or simulated classroom activities. Such authentic or near-authentic teaching experiences enable them to evaluate and refine their understanding of AI application in educational contexts.

### 4.2. Strengthening Immersive Practical Training

The core issue underlying the competency gap is that advanced training in pedagogical AI integration, which preservice teachers need most urgently, represents the weakest area of current program provision. To address this challenge, improvements should be pursued through two interconnected dimensions: platform-based support and integration into teaching internships.

First, at the level of platform-based support, teacher education institutions should establish AI application training platforms equipped with representative AI-enabled educational applications, such as intelligent assessment systems, virtual simulation classrooms, and learning analytics tools. These platforms can provide preservice teachers with low-risk environments for technological practice, enabling them to acquire foundational operational skills before entering authentic classroom settings. Meanwhile, the development of training platforms should extend beyond the procurement and installation of hardware facilities. It should also include the design of progressive training task frameworks and operational guidelines, enabling preservice teachers to gradually transition from isolated skill acquisition to integrated application practice through clearly defined, task-driven learning processes.

Second, at the level of internship integration, the pedagogical application of AI tools should be incorporated as a mandatory requirement within teaching internships. Preservice teachers should be required to complete and implement at least one AI-supported instructional design project during their internships, enabling them to evaluate and reflect on the effectiveness of AI application in authentic classroom contexts and transform operational skills into situated pedagogical judgment. Before internships, supervising teachers should provide preservice teachers with specific guidance and exemplary cases regarding the application of AI in teaching. During internships, they should offer targeted feedback on AI-integrated instruction through classroom observations and teaching evaluations, thereby preventing the formalistic tendency of using AI merely for the sake of application.

### 4.3. Embedding Integrated and Continuous AI Ethics Education

The distinctive feature of the ethics gap lies in the fact that, although preservice teachers have developed preliminary critical awareness, the absence of systematic ethics education within teacher preparation programs prevents them from transforming such awareness into practical evaluative competencies. To address this issue, AI ethics education should be embedded throughout the entire teacher preparation process, forming a progressive pathway consisting of three intercon-

nected stages: conceptual introduction, contextual judgment, and reflective internalization.

First, at the stage of general education, teacher education programs should establish the foundation of preservice teachers' ethical awareness by introducing fundamental principles related to privacy protection, algorithmic fairness, and data security in educational contexts. Such instruction can help preservice teachers understand the underlying rationale behind the responsible and cautious use of AI.AI ethics instruction should not be limited to the presentation of regulations or the enumeration of ethical principles. Instead, it should employ historical cases and contemporary events to reveal the complexity and urgency of AI-related ethical issues, fostering preservice teachers' deeper reflection and sustained engagement with ethical considerations.

Second, at the stage of professional education, task-based activities involving the critical analysis of AI-generated content should be incorporated into subject courses. Preservice teachers should be guided to practice evaluating the accuracy and applicability of AI outputs within specific disciplinary contexts, accumulate methodological tools, and develop practical approaches for the responsible and cautious use of AI.

Third, during the teaching internship stage, preservice teachers should be guided to systematically reflect on the ethical boundaries of AI tool use and strengthen their understanding of and commitment to teacher agency in human-AI collaboration. Dedicated reflection topics can be incorporated into internship journals, requiring preservice teachers to document and analyze AI-related ethical dilemmas encountered during their teaching practice. This process can help them develop independent judgment and decision-making abilities through engagement with authentic ethical situations.

## 5. Limitations and Future Directions

This study has several limitations. First, the cross-sectional design and self-reported nature of the questionnaire data limit the ability to establish causal relationships between teacher education program provisions and preservice teachers' AI literacy development. Although the findings provide a comprehensive understanding of preservice teachers' AI literacy status and their perceptions of current training programs, the factors associated with supply-demand gaps should be interpreted as participants' perceived explanations rather than empirically established causal effects. Future research could employ longitudinal, quasi-experimental, or intervention-based designs to further examine the mechanisms through which different teacher education approaches influence preservice teachers' AI literacy development.

Second, this study primarily focused on the alignment between AI literacy development needs and teacher education program provisions. Although the interview findings revealed contextual factors related to curriculum design, practical training, and institutional support, the dynamic development process of AI liter-

acy across different stages of teacher preparation was not fully examined. Future studies could adopt longitudinal approaches to investigate how preservice teachers' AI literacy evolves from initial teacher education to professional practice.

Finally, although participants were recruited from multiple types of higher education institutions and different disciplinary backgrounds, the sample size and sampling scope remain limited, which may constrain the generalizability of the findings. Future research could expand the sample across diverse regions, institution types, and in-service teacher groups to further validate the findings and contribute to the development of more comprehensive teacher education frameworks for the AI era.

## Conflicts of Interest

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

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