

AI-TPACK Theory Perspective: Development of a Model for Enhancing Teacher Trainees' Intelligent Education Literacy

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Abstract: With the advancement of artificial intelligence (AI) technology, the integration of intelligent technologies into traditional education has emerged as a significant trend. However, the intelligent education literacy of teacher trainees who represent the core force in shaping future education still requires enhancement. Grounded in AI-TPACK theory, this study initially constructs a theoretical framework for teacher trainees' intelligent education literacy through an extensive literature review. This theoretical model encompasses three primary dimensions, eight secondary dimensions, and nineteen tertiary dimensions. It delineates a clear pathway for teacher trainees to gain a comprehensive understanding of the components constituting intelligent education literacy and provides valuable insights and references for normal universities aiming to cultivate such literacy among the teacher trainees.

Keywords: AI-TPACK Theory; Teacher Trainees; Intelligent Education Literacy; Artificial Intelligence in Education; Education Informatization

1. Introduction

With the advent of the intelligent era, "Intelligence + Education" has become an inevitable trend in educational transformation, and educational intelligence increasingly plays a significant role in the development of contemporary education. Artificial Intelligence in Education (AIED) has become as a specialized interdisciplinary research field. Consequently, this transformation causes new challenges for the professional development of teacher trainees. In recent years, government departments have published multiple documents aimed at enhancing teachers'

intelligent educational literacy, including the "Education Informatization 2.0 Action Plan" and the "Notice on Carrying Out Pilot Programs to Boost the Construction of the Teaching Staff with Artificial Intelligence." These documents emphasize the importance of strengthening the information literacy and information-based teaching abilities of teacher trainees. However, the development of intelligent education in China commenced relatively late and exhibits significant regional disparities. Consequently, there is a generally low level of intelligent educational literacy among both pre-service and in-service teachers.

Enhancing the intelligent educational literacy of teacher trainees is an inevitable trend to promote the development of intelligent education. Based on the aforementioned background, this study will employ the AI-TPACK theoretical framework and incorporate the specific requirements delineated in the pertinent documents issued by the Ministry of Education to construct a model of intelligent educational literacy for teacher trainees. The objectives of this study are to enrich and deepen the development theory of intelligent educational literacy, provide a new perspective for the professional development of teacher trainees, and promote the improvement of the training system for intelligent educational literacy among teacher trainees. This research aims to enhance and deepen the theoretical framework surrounding intelligent educational literacy. It seeks to provide a fresh perspective on the professional development of students in normal schools, while also promoting advancements in the cultivation system for intelligent educational literacy among these students. Furthermore, this study will provide theoretical guidance for the training practices of teacher trainees, thereby fostering innovation and development

in educational practice.

2. Overview of Related Research on the Model of Intelligent Educational Literacy for Teacher Trainees

2.1 Related Research on Intelligent Educational Literacy for Teachers

This study focuses on the dual identity of teacher trainees as learners in the current educational environment and potential teachers in the future field of education, which includes a close connection and common characteristics between learning and teaching. To develop a precise and comprehensive model of intelligent educational literacy for teacher trainees, this study systematically reviews and incorporates existing research findings on intelligent educational literacy for educators. It also closely integrates the unique perspectives and needs of teacher trainees for thorough analysis and discussion.

Although research on teachers' intelligent educational literacy in China started relatively late, it has developed rapidly and a number of influential models and frameworks have emerged. By meticulously sorting out these research findings, this study adopts an inductive and integrative approach to categorize dimensions with similar meanings and names into unified categories (as shown in Table 1), ultimately refining 9 core dimensions: intelligent knowledge, intelligent abilities, intelligent attitude, intelligent ethics, intelligent thinking, intelligent awareness, and intelligent innovation, among others. Subsequently, through statistical analysis of the frequency of occurrence of each dimension, it is found that dimensions with higher frequencies tend to highlight their core position and crucial role in the system of teachers' intelligent educational literacy. This analysis result is intuitively displayed in the following table, providing clear data support and visual representation for this study to deeply understand the composition of intelligent educational literacy for teacher trainees.

After sorting through the results, it is found that intelligent knowledge, intelligent abilities,

intelligent ethics, intelligent thinking, and intelligent awareness have higher frequencies, indicating that they can serve as relatively stable core elements of teachers' intelligent educational literacy.

2.2 Related Research on the Model of Intelligent Educational Literacy for Teacher Trainees

When reviewing the literature on intelligent educational literacy for teacher trainees, it becomes evident that many scholars have adopted the model of teachers' intelligent educational literacy as a blueprint for constructing models for teacher trainees, while innovating and extending this framework. The study systematically organizes and summarizes the pertinent aspects of the intelligent educational literacy model for teacher trainees. It conducts a thorough analysis, categorizes similar dimensions, and ultimately identifies 10 core dimensions. In further frequency statistics and analysis (as shown in Table 2), the higher the frequency of a dimension, the higher the degree of academic recognition it reflects. These high-frequency dimensions play a crucial role in the framework of the model of intelligent educational literacy for teacher trainees.

Through sorting through the results, this study finds that the three dimensions of intelligent learning, intelligent abilities, and intelligent ethics have the highest frequencies of occurrence, indicating that they are the core elements in constructing the model of intelligent educational literacy for teacher trainees. This finding emphasizes that these three aspects should be focused on in the construction of the model. In summary, this study integrates the essential components of teachers' intelligent educational literacy into the model for teacher trainees, emphasizing the core dimensions found in existing frameworks. Based on this, the basic framework of the research model is established, covering the core elements of intelligent learning, intelligent abilities, as well as key aspects such as professional ethics literacy related to intelligent ethics.

Table 1. Frequency of Core Dimensions in the Model of Intelligent Educational Literacy for Teachers

Research target	Scholars	Model name	Major dimension							
			Intelligent	Intelligent	Intelligent	Intelligent	Intelligent	Intelligent	Intelligent	Development

			knowledge	abilities	attitude	ethics	thinking	awareness	innovation	Teaching and Research	capacity
Principals	Xu Jiaxin [1] (2019)	The Connotation of Teachers' Intelligent Literacy in the Age of Artificial Intelligence				√	√		√		
	Xu Yafeng, Peng Xian, Cao Yue [2] (2020)	A Conceptual Framework for Teachers' Mathematical Literacy	√	√		√	√				
	Liu Bin [3] (2020)	Components of Intelligent Educational Literacy for Teachers	√	√	√	√				√	√
	Hu Xiaoyong, Xu Huanyun [4] (2021)	Intelligent Educational Literacy Structures for K-12 Teachers	√	√		√	√		√		
	Li Xiang[5] (2021)	The "Iceberg Structural Model" of Intelligent Educational Literacy of Teachers	√	√		√					
	Guo Jiong, Hao Jianjiang [6] (2021)	Teachers' Intelligent Educational Literacy Framework	√	√		√	√	√	√		
	Yang Jie [7] (2024)	Teacher Intelligence Educational Literacy Pyramid Model	√	√	√	√	√	√	√	√	√
Information technology teachers in primary and secondary schools	Peng Yulan [8] (2022)	A Framework for Intelligent Literacy for Information Technology Teachers in Primary and Secondary Schools	√	√		√		√			
Art teacher	Zheng Zhiyong, Li Jian [9] (2024)	Intelligent Educational Literacy Model for Art Teachers	√	√		√		√			
Frequency			8	8	2	9	5	4	4	2	2

Table 2. Frequency of Core Dimensions in the Model of Intelligent Educational Literacy for Teacher Trainees

Research target	Scholars	Model name	Major dimension									
			Intelligent knowledge	Intelligent ability	Intelligent attitude	Intelligent ethics	Intelligent thinking	Intelligent awareness	Intelligent innovation	Moral quality	Intelligent foundational literacy	Practical ability
Teacher Trainees	Ma Lin [10] (2020)	A model of pre-service core literacy for teacher trainees	√	√		√		√				
	Chen Fanli [11]	Model of Intelligent Educational Literacy	√	√		√	√	√				

	(2021)	for Teacher Trainees										
	Xing Zhende [12] (2022)	Model of Intelligent Educational Literacy for Teacher Trainees	√	√	√	√	√					√
	Li Wanyu [13] (2022)	"Three-dimensional pyramid" model	√	√		√	√		√			
	Liu Junjie, Li Xiangdong [14] (2023)	Intelligent Educational Literacy for Physical Education Teacher Trainees	√	√		√		√		√		√
	Wang Pengjiao, Wang Yuer, Wang Shuang [15] (2023)	A Framework for Artificial Intelligence Literacy for Teacher Trainees	√	√	√	√		√			√	
	Zhu Jingying, Xu Shiyun, Liu Chuyi [16] (2024)	A Framework for Intelligent Educational Literacy for Teacher Trainees	√	√	√	√		√	√		√	
	Sun Min [17] (2024)	A Framework for Intelligent Educational Literacy for Teacher Trainees	√	√		√	√		√			√
Frequency			8	8	3	8	4	5	3	1	2	3

2.3 AI-TPACK Theoretical Framework

The AI-TPACK theoretical framework has evolved from the TPACK theory, which was originally proposed by American university scholars Koehler and Mishra in the early 21st century [18]. Building on the PCK theory and incorporating technological developments, they presented the TPACK framework that integrates technology into teachers' knowledge structures. With the advent of the artificial intelligence era, Yan Zhiming and his colleagues introduced the AI-TPACK framework in 2020 (illustrated in Figure 1) [19]. This framework integrates artificial intelligence technology with pedagogical content knowledge. This framework encompasses four core dimensions: AI-CK (Artificial Intelligence-Content Knowledge), AI-TK (Artificial Intelligence-Technological Knowledge), AI-TPK (Artificial Intelligence-Technological Pedagogical Knowledge), and AI-TPACK (Artificial Intelligence-Technological Pedagogical Content Knowledge).

Ng et al. (2021) proposed the AI literacy TPACK framework (as shown in Figure 2) [20]. This theory encompasses an understanding of artificial intelligence, the ethical application of AI, and other fundamental concepts intrinsic to the field. These include five core principles: perception,

representation and reasoning, learning, natural interaction, and social impact.

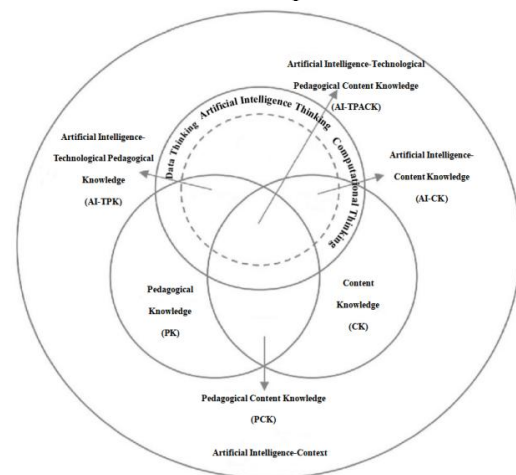
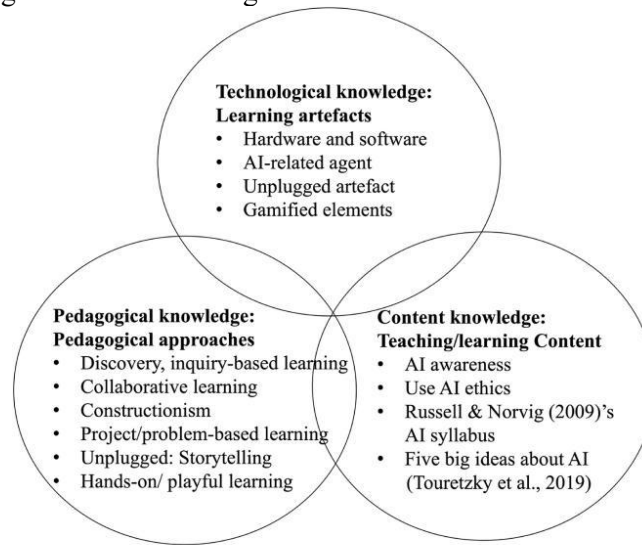


Figure 1. Diagram of the AI-TPACK Theoretical Framework

Currently, the conceptual definition and interpretation of AI-TPACK (i.e., teachers' technical pedagogical content knowledge integrated with artificial intelligence technology) remain in a phase of ongoing exploration and development, primarily centered around macro-level theoretical discourse. Chinese scholars have primarily concentrated on the fundamental concepts and connotative frameworks of AI-TPACK. Building upon the existing research findings of TPACK theory, they have proposed comprehensive strategies and recommendations aimed at advancing teachers'

AI-TPACK capabilities. This not only lays a theoretical foundation for this study but also provides valuable insights for constructing a

model of intelligent educational literacy for teacher trainees.



AI Literacy TPACK Framework

Figure 2. Research Areas of the AI Literacy TPACK Theory

3. Theoretical Model of Intelligent Educational Literacy for Teacher Trainees from the Perspective of AI Theory

By organizing and summarizing the content related to competencies and literacy, this study has derived an overview diagram of the core elements of competencies and literacy for both teachers and teacher trainees (as shown in Figure 3). On the left side of the diagram are

the elements of teacher literacy, and on the right side are the elements of teacher candidate literacy. The intersection represents the shared elements between the two, including discipline-specific professionalism, teaching literacy, innovative literacy, information literacy, communication literacy, and literacy in nurturing students.

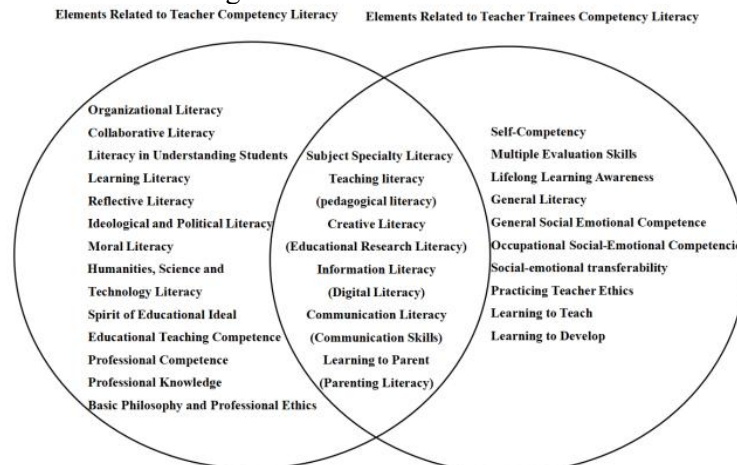


Figure 3. Relevant Elements of Competencies and Literacy

These shared elements are crucial for constructing a model of intelligent educational literacy for teacher trainees. Compared to experienced teachers, teacher trainees show certain deficiencies in the development of their competencies. These deficiencies mainly manifest in two aspects: first, the system tends to emphasize theoretical instruction while neglecting the cultivation of learning abilities,

resulting in teacher trainees having weak problem-solving skills in practical situations; second, inadequate training in teaching skills and professional ethics affects their professional literacy and sense of responsibility. These shortcomings hinder the comprehensive development of teacher trainees, making it difficult for them to meet the established standards of competencies and

graduation requirements (Ministry of Education of the People's Republic of China, 2017) (as shown in Table 3). In contrast, teachers equipped with their exceptional professional literacy are more skilled at

identifying students' needs and delivering targeted educational support. This insight offers a fresh perspective for developing the model of intelligent educational literacy for teacher trainees.

Table 3. Graduation Requirements for Teacher Trainees in Ordinary Colleges of Higher Learning

Graduation Requirements for Teacher Trainees	Concrete Content
Practicing Teacher Ethics	This includes the norms of teacher ethics and the sentiment of education. This requires teacher trainees to practice educational values, abide by the professional code of ethics, and identify with the significance of teacher education work.
Learning to Teach	This includes knowledge integration, pedagogical competence and technology integration. This requires Teacher Trainees to have a solid knowledge base and the ability to guide and evaluate learning, and to be able to use information technology to optimize instruction.
Learning to Parent	This includes classroom guidance and comprehensive parenting. This requires teacher trainees to acquire the ability to organize classroom activities and to effectively educate and guide students in their multifaceted development.
Learning to Develop	This includes independent learning, international perspective, reflective research, and communication and cooperation. This requires teacher trainees to establish a sense of lifelong learning, actively learn about the cutting-edge of education reform, develop critical thinking, and utilize the spirit of teamwork.

Meanwhile, drawing on the perspectives of scholars such as Yan Zhiming on AI-TPACK theory and combining the competencies and literacy of teacher trainees, teacher competencies, and graduation requirements, this study has constructed a model of intelligent educational literacy for teacher trainees (as shown in Figure 4). This model clarifies the key competencies and knowledge structure required for teacher trainees as both educators and learners.

3.1 Intelligent Learning Literacy

Intelligent learning literacy primarily encompasses enhancing teacher trainees' own learning awareness, deepening their understanding through the application of acquired knowledge or skills, and adapting to various difficulties and challenges encountered during the learning process (as shown in Table 4).

3.2 Intelligent Teaching Literacy

Intelligent teaching literacy refers to the ability to comprehend fundamental knowledge of artificial intelligence, seamlessly integrate AI technology into subject-specific instruction, design and implement effective intelligent teaching strategies, reflect upon and enhance the educational process, and engage in research and training related to intelligent teaching. The ultimate goal is to foster the healthy mental development of students while remaining at the forefront of educational advancements. This study, combining the AI-TPACK framework with the requirements for teachers' teaching competence in the new era, has formulated the components and requirements of intelligent teaching literacy (as shown in Table 5).

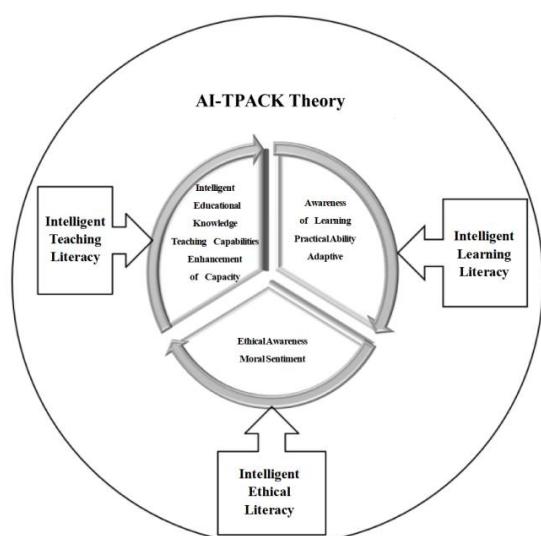


Figure 4. Intelligent Educational Literacy Model for Teacher Trainees

Table 4. Dimensions of Intelligent Learning Literacy

Primary dimensions	Secondary dimensions	Tertiary dimensions	Explanation
Intelligent Learning Literacy	Awareness of Learning	Understand Positioning	1. Understand the trend of artificial intelligence and contemporary social values. 2. Recognize the role of AI and the role it plays in their own learning and educational practices.
		Value Identity	Recognize the value of AI in education and learning and are willing to actively use smart tools in their own learning and teaching practices.
	Practical Ability	Operational Use	1. Have a comprehensive and detailed knowledge base of AI product functions and operations. 2. Have a certain degree of hands-on ability to use intelligent products.
		Evaluation Reflections	Have a creative and critical thinking to think dialectically about the pros and cons of the AI learning process.
	Adaptive	Digital Toughness	Demonstrate a certain degree of motivation and adaptability when encountering technical difficulties or challenges in applying digital technologies to educational teaching and learning practices.
		Lifelong Learning	Be able to establish the concept of lifelong learning, progress with social development and follow the trend of the times.

Intelligent teaching literacy is the core foundation of education and teaching, and it is one of the vital competencies, which teacher trainees must master. It demands that teacher trainees not only possess solid subject

knowledge and teaching skills but also have a deep understanding of the principles and applications of artificial intelligence technology, as well as the ability to effectively integrate it into instructional design.

Table 5. Dimensions of Intelligent Teaching Literacy

Primary dimensions	Secondary dimensions	Tertiary dimensions	Explanation
Intelligent Teaching Literacy	Intelligent Educational Knowledge Incorporating AI Technology	Artificial Intelligence-Technological Knowledge (AI-TK)	1. Understand the core concepts and development history of artificial intelligence and its technical principles, and master the basic technical architecture of artificial intelligence. 2. Knowledge of the technical operation of artificial intelligence tools in practical applications.
		Artificial Intelligence-Content Knowledge (AI-CK)	Effectively characterize, transform and summarize subject matter knowledge with the help of artificial intelligence technology, and the ability to present subject matter clearly.
		Artificial Intelligence-Technological Pedagogical Knowledge (AI-TPK)	Based on the understanding of the roles and limitations of AI technology, organically integrate AI technology into the process of learning and teaching interactions, and based on this understanding, design appropriate teaching methods and activities to optimize teaching strategies.
		Artificial Intelligence-Technological Pedagogical Content Knowledge (AI-TPACK)	1. Accurately and systematically characterize and present key concepts in the discipline through AI technology and help students gain a deeper understanding of the subject matter. 2. Creative use of artificial intelligence technology for classroom instructional design. 3. Use artificial intelligence techniques to identify and

			promptly resolve confusions and problems encountered in the conceptual learning process. 4. Promote the development of new epistemologies or strengthen existing pedagogical theories through the application of artificial intelligence technologies.
	Teaching capabilities that incorporate AI technology	Devise	Ability to design teaching strategies and methods that are beneficial to the healthy development of students' minds based on the general laws of students' psychological development and the principles of teaching science.
		Realize	1. The ability to model correct processes and explain principles for intelligent instruction. 2. Predicting the direction of national education reform and education development trends through artificial intelligence technology, so as to play a positive leading role in teaching and learning.
	Enhancement of capacity	Teaching Enhancement	1. Reflecting on and evaluating the process of using smart tools in the teaching and learning process. 2. Obtaining unique evaluation and feedback on the teaching and learning process through intelligent functions.
		Research on Teaching and Learning	Proactive participation in intelligent teaching theory research activities and teaching practice learning.
		Intelligent Training	Proactively participate in intelligent teaching training activities to keep abreast of developments at the forefront of education.

3.3 Intelligent Ethical Literacy

Intelligent ethical literacy encompasses a comprehensive understanding of ethical considerations in the appropriate application of AI technology. This includes evaluating potential risks and safeguarding privacy, adapting to evolving roles, and guiding students in its responsible use. Furthermore, it

involves nurturing moral sentiments through the cultivation of virtues and establishing normative responsibility by exemplifying ethical behavior. To better understand this concept, this study has formulated the following table (as shown in Table 6), summarizing various key aspects of intelligent ethical literacy and their applications in education.

Table 6. Dimensions of Intelligent Ethical Literacy.

Primary dimensions	Secondary dimensions	Tertiary dimensions	Explanation
Intelligent Ethical Literacy	Ethical Awareness	Posture	1. Correct and reasonable use of artificial intelligence technology in accordance with laws, regulations and relevant provisions. 2. Assessment of potential risks and vulnerabilities of AI products. 3. Grasp the right to privacy of educational data and have a sensitive awareness of data security.
		Values	1. Grasp the transformation of the roles of teachers and students in the age of artificial intelligence, and establish a correct view of education and teachers. 2. Focus on students' personalized needs, pay attention to individual differences, and guide students to use smart tools correctly.
	Moral Sentiment	Moral Education	1. Combining educational values and traditional virtues with the use of artificial intelligence to cultivate students' moral literacy and ideological connotation needed for intelligent ageing.

		Obligations	2. Coordinate multiple parties, lead by example and establish solid and effective guidelines for the use of student smart tools.
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Intelligent ethical literacy is a core competency that teacher trainees must master. The focus is not only on the responsible use of intelligent technology in teaching within the digital age but also on ensuring that such technology is employed to foster educational equity, respect individual rights, and uphold social ethical standards. It concerns not only how to use intelligent technology responsibly in teaching in the digital age but also how to ensure that technology is utilized to promote educational equity, respect individual rights, and uphold social ethical standards.

4. Conclusion

In this era of rapid transformation, intelligent education has become an important force driving educational progress. Building on the foundation of traditional teaching methods, future educators must cultivate and enhance their literacy in intelligent education. To better explore the components of teacher trainees' intelligent educational literacy, this study draws on the AI-TPACK framework, references existing literature, and constructs a model for teacher trainees' intelligent educational literacy. This not only boosts teacher trainees' grasp and application of modern information technology but also sharpens their innovative and critical thinking, and other key competencies. In the future, as emerging technologies like artificial intelligence and big data continue to develop, this model will continue to play a significant role in guiding teacher trainees to grow into a new generation of teachers with high-level intelligent educational literacy. It will also lay a solid foundation for nurturing future citizens and high-quality talent.

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