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An Exploration of the Development Logic and Optimization Paths for Preschool Teachers' Digital and Intelligent Literacy Driven by Artificial Intelligence

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Abstract: The deep application of artificial intelligence has become the core driving force for the digital transformation of early childhood education. The digital and intelligent literacy of early childhood teachers is the core prerequisite for achieving a deep integration of AI and early childhood education and conducting AI-based early childhood education. Based on the relevant research results of artificial intelligence education in early childhood education, this study clarifies the development laws of the digital and intelligent literacy of early childhood teachers in the era of artificial intelligence from three dimensions: value, internalization, and practical logic. It analyzes the four practical dilemmas existing in the current development of teachers' digital and intelligent literacy, namely, target misalignment, hierarchical discontinuity, insufficient support, and lack of motivation. Finally, it proposes systematic optimization paths from four aspects: target system, content framework, ecosystem construction, and motivation stimulation. The research aims to enrich the theoretical system of early childhood teachers' professional development and provide practical references for the improvement and upgrading of teachers' digital and intelligent literacy in the new era.

Keywords: artificial intelligence; preschool teacher; digital literacy; development logic; optimized path

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1. Introduction

Against the backdrop of the national strategy for the digital transformation of education, artificial intelligence (AI) technology is comprehensively permeating all educational stages, reshaping the underlying logic of teaching and learning. As the starting point of national education, preschool education represents a critical phase for the initiation of digital literacy and AI awareness. In recent years, the application of AI technology in preschool education settings has extended from auxiliary tools to core areas such as the development of AI-based enlightenment courses for young children, the design of embodied learning activities, and personalized support for care and education. The effectiveness of AI empowerment in preschool education ultimately hinges on the digital and intelligent literacy levels of preschool teachers, that is, whether preschool teachers can understand the core logic of AI, deeply integrate AI tools with practice,

and scientifically conduct AI enlightenment education for young children directly determines the quality of the digital transformation of preschool education.

2. The development logic of preschool teachers' digital and intelligent literacy driven by artificial intelligence

The development of preschool teachers' digital and intelligent literacy is not a linear technological learning process but a systematic one involving the interweaving and collaborative evolution of value objectives, competency levels, and practical domains. Its intrinsic development logic can be analyzed from three dimensions: value logic, endogenous logic, and practical logic.

2.1. Value logic: The transition from tool application to empowering education

Value logic serves as the fundamental guide for the development of preschool teachers' digital and intelligent literacy, with its core being the transformation from a technical mindset focused on tool usage to an educational mindset centered on serving educational purposes. This can be broken down into three progressively elevated developmental objectives. The first objective is tool efficiency. AI can serve as an auxiliary tool to help teachers streamline daily tasks such as writing documents, creating environments, and observing and recording statistics, thereby enhancing work efficiency. This represents the starting point for teachers to engage with AI and develop digital and intelligent literacy. The second objective is educational optimization. Teachers can integrate AI technology into core aspects of daily teaching, such as daily life routines, thematic explorations, and game activities, using AI tools to create personalized and concrete learning experiences for young children and promote their all-around development[1]. This constitutes the core part of combining digital and intelligent literacy with the professional characteristics of preschool education. The final objective is enlightenment and education. Through scientific curriculum design, teachers guide young children in establishing a foundational understanding of AI, comprehending its capabilities and limitations, and cultivating initial computational thinking and digital ethics awareness. This represents the ultimate value objective of preschool teachers' digital and intelligent literacy and the core content of preschool education in meeting the talent cultivation requirements of the digital age.

2.2. Endogenous logic: The hierarchical progression from individual cognition to systemic competency

Endogenous logic constitutes the core of the development of preschool teachers' digital and intelligent literacy, progressing step by step like a ladder from foundational cognition to advanced innovation, divided into four consecutive stages. The first stage is the foundational cognitive level. Teachers must possess a scientific understanding of AI, grasping its five core concepts (perception, representation and reasoning, machine learning, natural interaction, and social impact), avoiding a one-sided view of AI, and being clear about the scope of AI application in preschool education[2]. This forms the basis for the development of digital and intelligent literacy. The second stage is the practical application level. Teachers should learn to use AI tools in different scenarios, flexibly applying AI painting, intelligent voice assistants, etc., to design AI-interactive activities suitable for young children's ages, closely integrating AI with care and education work. The third stage is the critical reflection level. Teachers must possess critical thinking skills and ethical awareness regarding AI applications, being able to identify issues such as bias in AI algorithms and data privacy and security, prioritizing the interests of young children in their work, and guiding young children to correctly understand the limitations of AI. The fourth stage is the innovation leadership level. Teachers should be capable of designing AI education courses and possess professional leadership abilities. They can develop AI enlightenment kindergarten-based courses suitable for young children based on the characteristics of their own kindergartens, lead teams in conducting AI education-related kindergarten-based research, and summarize practical experiences that can be referenced and promoted.

2.3. Practical logic: The field expansion from single-point training to ecological collaboration

Practical logic serves as an important support for the development of preschool teachers' digital and intelligent literacy, with its field gradually expanding from single training to diverse collaboration. The first field is the separate input from colleges and universities and kindergartens. In the pre-service stage, colleges and universities offering preschool education majors will provide AI-related courses; in the in-service stage, kindergartens will organize AI skill training. These are the main channels for teachers to learn the basic knowledge and skills of digital and intelligent literacy, influencing the starting point and level of literacy development. The second field is the practical group of kindergarten-based research. In kindergarten-based research, teachers observe lesson examples, discuss cases, and conduct action research, transforming AI knowledge into practical competencies in care and education[3]. By helping each other with colleagues, they solve practical problems in AI education, which is the key to applying digital and intelligent literacy from theory to practice. The third field is the collaborative environment involving multiple parties. Colleges and universities and research institutes provide theoretical and curriculum design support for AI education, technology companies develop user-friendly AI tools and resources suitable for preschool education, and educational administrative departments formulate policy standards and provide resource guarantees. This forms a quadruple collaboration among colleges and universities, enterprises, kindergartens, and administrative departments, providing comprehensive support for the sustainable development of preschool teachers' digital and intelligent literacy.

3. The practical dilemmas in the development of preschool teachers' digital and intelligent literacy

3.1. Misalignment of literacy development goals: emphasis on tool operation, neglect of the core of education

Currently, there is a prevalent misalignment of goals in the development of preschool teachers' digital and intelligent literacy, with a tendency to prioritize technology over education. On one hand, most post-employment training treats AI skill acquisition as an enhancement of digital and intelligent literacy, focusing solely on basic operations of tools such as AI painting and copywriting generation. These training sessions fail to integrate the professional characteristics of preschool education, neglect to explain how to utilize AI tools in observing and evaluating young children, designing game activities, and providing personalized care and education, and do not cover content related to AI enlightenment education for young children. On the other hand, some teachers only use AI at a superficial level to replace manual labor, merely employing it to alleviate the burden of daily tasks without recognizing that the core of digital and intelligent literacy lies in optimizing the educational process through AI technology and conducting AI enlightenment education for young children. This results in a separation between technological application and the educational essence of preschool education, deviating from the core value objectives of digital and intelligent literacy development.

3.2. Discontinuity in literacy level progression: disconnection between cognition and practice, inadequate critical thinking and innovation

From the perspective of endogenous development logic, there is a noticeable discontinuity in the progression of preschool teachers' digital and intelligent literacy levels, with most teachers remaining at the foundational cognitive and superficial application stages, severely lacking in advanced competencies[4]. Firstly, there is a significant deficiency in foundational cognition. Most preschool teachers without a technical background lack a clear understanding of the core principles and operational mechanisms of AI, making it difficult for them to convey scientific AI knowledge to young children. Secondly, there is a disconnect between practical use and the contexts of care and education. Teachers struggle to integrate AI tools into the daily lives and games of young children, let alone design AI enlightenment activities suitable for hands-on experiential learning for young children. Thirdly, there is a lack of high-level competencies. Most teachers lack the ability to critically think about the ethical risks of AI and have insufficient understanding of issues such as protecting young

children's data privacy and biases in AI algorithms, making it challenging for them to transition from being mere users of AI to leaders in AI education.

3.3. Insufficient support in development fields: fragmented training system, lack of a collaborative ecosystem

Currently, there is a significant lack of supportive conditions for the development of preschool teachers' digital and intelligent literacy, with no systematic training system or collaborative development environment established. During the pre-service training phase, most domestic universities' preschool education majors do not incorporate AI literacy into the core training content for teacher candidates, with related courses either being scattered or non-existent. This results in teacher candidates graduating without foundational AI education competencies, necessitating them to start from scratch after employment. During the post-employment training phase, the issues of fragmented training content and monotonous training formats are evident, with most training consisting of one-time lectures lacking regular, teaching-scenario-integrated kindergarten-based research and practical guidance, failing to meet teachers' needs for continuous professional development[5]. Additionally, a collaborative development environment involving multiple parties has not yet been formed. Theoretical research findings from universities are difficult to apply in practical kindergarten settings, AI tools developed by technology companies often do not meet the age requirements of preschool education, inclusive kindergartens particularly lack resources and hardware support for AI education, and the digital divide continues to widen between urban and rural areas and among different kindergartens.

3.4. Lack of motivation for literacy development: insufficient teacher confidence and willingness for active learning

The endogenous motivation for the development of preschool teachers' digital and intelligent literacy is generally insufficient, posing a key bottleneck to literacy enhancement. On one hand, preschool teachers universally face heavy workloads in care and education, lacking sufficient time and energy to engage in learning and practical exploration related to AI knowledge. Meanwhile, most preschool teachers do not have a computer-related professional background and harbor apprehensions towards AI technology, fearing they will be unable to master complex technical operations, resulting in a severe lack of learning confidence. On the other hand, some teachers experience cognitive anxiety towards AI technology, worrying that AI will replace their professional roles and adopting a resistant attitude towards the application of AI in preschool education. The lack of corresponding incentive and fault-tolerance mechanisms in kindergartens further dampens teachers' enthusiasm for experimenting with AI education practices, making it difficult to stimulate their endogenous motivation for active learning and innovation.

4. Optimization paths for preschool teachers' digital and intelligent literacy driven by artificial intelligence

4.1. Anchoring the essence of education and reconstructing the goal system for digital and intelligent literacy development

The development of preschool teachers' digital and intelligent literacy must always anchor itself in the essence of preschool education, abandon the technology-centric orientation, and construct a four-dimensional integrated development goal system encompassing cognition, application, ethics, and innovation. At the foundational goal level, it is essential to regard the understanding of core AI concepts and the boundaries of AI application in preschool education as fundamental content, helping teachers overcome cognitive barriers and professional anxieties, and clarifying that AI is a tool to assist in care and education, rather than a substitute for teachers. At the core goal level, the focus should be on the ability to integrate AI with care and education practices, cultivating teachers' capabilities to design embodied and gamified learning activities for young children using AI tools and to conduct personalized observations and evaluations of young children,

achieving deep integration of AI technology with preschool care and education. At the critical goal level, it is crucial to strengthen AI ethics and risk prevention capabilities, enabling teachers to master methods for protecting young children's data privacy and identifying AI biases, adhering to the educational principle of prioritizing young children's interests. At the developmental goal level, the emphasis should be on the design of AI enlightenment courses for young children and professional leadership capabilities, cultivating the ability of key teachers to conduct kindergarten-based research and course innovation, driving the overall improvement of digital and intelligent literacy among the teaching staff.

4.2. Following hierarchical patterns and establishing a stepwise content system for literacy development

Based on the endogenous development logic of preschool teachers' digital and intelligent literacy, a hierarchical, categorized, and stepwise progressive content system for literacy development should be established to meet the learning needs of teachers at different developmental stages. For novice teachers, AI general knowledge enlightenment training should be conducted, focusing on basic AI concepts and the fundamental operations of commonly used AI tools in preschool education. Through simple case practices, teachers' apprehensions towards AI can be dispelled, helping them establish a scientific understanding of AI. For teachers with a certain foundation, training on integrating AI into care and education scenarios should be provided, using thematic cases as the core to explain specific application methods of AI in collective teaching, regional games, home-kindergarten co-education, and observation and evaluation. Through workshops, lesson observations, and other forms, teachers' abilities to apply AI in specific scenarios can be enhanced. For teachers with rich practical experience, training on AI education design and ethical norms should be conducted, while strengthening content on AI ethics and educational equity to improve teachers' critical thinking and course design abilities. For key teachers, professional development platforms should be established, fostering professional leadership and educational innovation capabilities through the formation of research communities and the conduct of action research, thereby playing a leading role.

4.3. Improving field support and constructing a diverse and collaborative ecosystem for literacy development

To overcome the dilemma of insufficient field support, it is necessary to bridge the pre-service and in-service training chains and construct a diverse and collaborative ecosystem for literacy development. In the pre-service training phase, universities should incorporate digital and intelligent literacy into the core training objectives for preschool education teacher candidates, adding core courses such as the application of artificial intelligence in preschool education and AI enlightenment education for young children, strengthening educational practice links, and collaborating with kindergartens to establish AI education internship bases, enabling teacher candidates to develop foundational AI education capabilities during their university years[6]. In the in-service development phase, a normalized training system integrating kindergarten-based research, regional collaboration, and online learning should be established, abandoning one-time fragmented training. With kindergartens as the main body, regular case discussions, action research, and peer assistance should be conducted, while achieving the sharing of high-quality resources through regional collaboration and providing teachers with flexible and continuous learning resources through online learning platforms. At the multi-party collaboration level, it is necessary to promote deep collaboration among universities, research institutes, kindergartens, and technology companies: universities and research institutes are responsible for theoretical research and curriculum system development, technology companies focus on the development of inclusive and age-appropriate preschool AI tools, and educational administrative departments issue construction standards and resource guarantee policies for preschool teachers' digital and intelligent literacy, establishing a regional-level sharing platform for preschool AI education resources to narrow the digital divide and achieve inclusive coverage of high-quality resources.

4.4. Stimulating endogenous motivation and creating a supportive professional development atmosphere

The sustained development of preschool teachers' digital and intelligent literacy must focus on stimulating teachers' endogenous motivation and creating a supportive and inclusive professional development atmosphere. At the kindergarten level, a fault-tolerant mechanism for AI education practice should be established, encouraging teachers to boldly experiment and actively explore. AI application capabilities should be included in teachers' professional development portfolios rather than as rigid assessment indicators, reducing teachers' psychological burdens. Meanwhile, teachers' work tasks should be scientifically allocated to provide them with time and space for learning and practice, and special funds for AI education research should be established to provide resource support for teachers' practical explorations. At the industry level, it is necessary to strengthen the promotion and dissemination of excellent practices in preschool AI education, establishing teacher benchmarks and outstanding lesson examples, and providing teachers with platforms for display and exchange through skills competitions, excellent case selections, and other activities. At the societal level, it is essential to guide correct public opinion on AI education, clarifying teachers' irreplaceable leading role in preschool AI education, dispelling the misconception that AI can replace teachers, and creating a favorable atmosphere in which the entire society supports the digital transformation of preschool education and respects the professional development of preschool teachers.

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Disclosure statement

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