**AI Literacy among Chinese Preschool Teachers: Empirical Status, Barriers and Cultivation Strategies**

**Abstract**

The transformative rise of artificial intelligence (AI) is propelling education systems into a new era, yet empirical research on AI literacy among preschool teachers remains scarce, particularly in China. This study investigates the current status, obstacles, and cultivation strategies for AI literacy among Chinese preschool teachers through a three-dimensional framework encompassing AI Knowledge, AI Ability, and AI Awareness. Using a mixed-methods sequential explanatory design, we collected data from 152 preschool teachers through stratified random sampling across eastern, central, and western regions of China, ensuring representation from both public and private institutions. The quantitative phase employed a validated questionnaire (Cronbach's *α*=0.93), while the qualitative phase involved in-depth interviews with 16 purposively selected participants. Results reveal that teachers' overall AI literacy is moderate, with self-reported awareness (*M*=3.44) surpassing both technical knowledge (*M*=3.34) and application ability (*M*=3.28). Notable gaps are found in technical knowledge application and system understanding. A "degree-inverse phenomenon" emerged: teachers with postgraduate qualifications reported lower AI literacy than their peers, attributed to limited practical exposure and heightened critical standards. Public-private disparities and gender differences further exacerbate inequities. Multi-level barriers include policy ambiguity at the macro level, insufficient institutional support and theory-heavy training at the organizational level, and entrenched reliance on traditional pedagogies at the individual level. Addressing these challenges requires systemic, multi-tiered strategies, including establishing national AI literacy standards tailored to preschool education, implementing dynamic monitoring systems, providing sustained institutional resources and hands-on professional development, and ensuring equitable access that values both technical competencies and ethical awareness.

***Keywords:*** *AI literacy, preschool teachers, China, mixed-methods, three-dimensional framework, policy recommendations*

**Introduction**

The era of artificial intelligence (AI) is profoundly reshaping human society, with education at the forefront of this transformation (Lee & Jang, 2020; Selwyn, 2019). AI is rapidly redefining the skills, knowledge, and pedagogies required for success in the digital age, compelling global education systems to respond with curriculum reform and policy innovation (Cambridge et al., 2024; Chen et al., 2022). Among these responses, the development of teacher AI literacy is widely recognized as a cornerstone for effective and sustainable educational change(Kasneci et al., 2023; Ng et al., 2022).

Since its introduction in 2016, the concept of AI literacy has evolved into a multidimensional construct, encompassing not only technical knowledge and operational skills, but also critical thinking, problem-solving, and ethical awareness (Long et al., 2021; Ng et al., 2022; Tan et al., 2024). For teachers, AI literacy means the ability to understand, apply, and reflect on AI tools and concepts within pedagogical practice—an ability seen as essential for fostering future-ready learners in an increasingly intelligent learning environment (Akgun & Greenhow, 2022; Kim, 2024).

Despite growing global attention, a notable research gap remains at the preschool level. Most empirical investigations focus on K-12 or higher education, while studies addressing preschool teachers are exceptionally scarce. This scarcity is critical, as early childhood teachers play a foundational role in children's development (Li et al., 2023; Lim, 2023), yet face unique challenges in integrating AI due to developmental appropriateness concerns and limited tailored training (Yao & Wang, 2024; Zhao et al., 2022).

The urgency is further heightened by generative AI tools like ChatGPT, which place new ethical and practical demands on educators (Kasneci et al., 2023; Yan et al., 2024). However, many preschool teachers acquire only foundational AI knowledge and often lack confidence in translating this into practice (Lim, 2023; Younis, 2024).

This study targets Chinese preschool teachers, addressing three research questions:

What is the current status of AI literacy among Chinese preschool teachers across the three dimensions of Knowledge, Ability, and Awareness?

What are the main challenges and root causes contributing to AI literacy deficiencies among this group, at policy, organizational, and individual levels?

What targeted and feasible strategies could be proposed for promoting AI literacy in the preschool education sector?

By integrating quantitative survey data and qualitative interviews, this study aims to bridge a critical empirical gap and provide an evidence-based, nuanced understanding of AI literacy among preschool teachers in China. The anticipated findings offer practical insights and actionable recommendations for policymakers, educational leaders, and teacher educators seeking to foster equitable, high-quality early childhood education in the age of artificial intelligence.

**Literature Review: A Three-Dimensional Framework for AI Literacy in Teacher Education**

The literature on teacher AI literacy is best understood through a three-dimensional framework: AI Knowledge, AI Ability, and AI Awareness, shaped by macro-policies, institutional support, individual characteristics, and early childhood education contexts.

**AI Knowledge**The knowledge dimension focuses on teachers' conceptual and technical understanding of AI (Kong et al., 2024; Long & Magerko, 2020; Ng et al., 2022). Policy initiatives in leading economies highlight divergent development paths. The US and UK, for instance, have moved to incorporate AI and digital literacy into curricular standards and teacher professional development, but report fragmentation of practical knowledge delivery and uneven resource allocation, leading to inconsistent outcomes(Bhimdiwala et al., 2022; Brandão et al., 2024; Chen et al., 2022; Will, 2023; Chen, Fan, & Liao, 2025; Chen & Fan, 2025a; Chen & Fan, 2025b). Policy initiatives show divergent paths: the US and UK report fragmentation in knowledge delivery (Cambridge et al., 2024; Chen et al., 2022). China's strategy has increased teacher upskilling but persistent regional disparities undermine equal access (Brandão et al., 2024; Li et al., 2023; Zhao et al., 2022).

Empirical studies indicate that solid AI knowledge among teachers is not solely a function of policy but also linked to individual characteristics such as digital experience, higher academic qualification, and openness to innovation—demographics more likely to foster strong literacy outcomes (Ayanwale et al., 2024; Cheng et al., 2024; Hur, 2024; Karataş & Yüce, 2024; Li et al., 2023; Lim, 2023; Stolpe & Hallström, 2024). However, teachers in under-resourced or early childhood environments are less likely to have access to developmentally appropriate AI concepts and teaching materials (Brandão et al., 2024; Lim, 2023; Sperling et al., 2024). Even the best-designed national policies may fail to ensure meaningful AI knowledge development if training is inaccessible or not tailored to authentic classroom needs (Nazaretsky et al., 2022; Ng et al., 2022)(Nazaretsky et al., 2022; Ng et al., 2022).

Effective AI literacy requires more than static understandings: teachers need to critically engage with the societal role of AI, identify potential algorithmic biases, and foster collaborative, creative classroom practices (Braun & Clarke, 2006; Cambridge et al., 2024; Long & Magerko, 2020). Yet, foundational knowledge-building remains particularly weak for preschool and early elementary educators, with limited research and resource support for these developmental stages (Lim, 2023; Sperling et al., 2024).

**AI Ability**Ability encompasses a teacher’s capacity to apply AI concepts and tools in authentic pedagogical practice, translating knowledge into effective classroom action. Building this competency has proven even more challenging than imparting knowledge alone.

Singapore’s context-specific, tiered professional development—complete with government support and clear milestones—has set a benchmark for helping teachers develop practical AI skillsets (Cambridge et al., 2024; Chen et al., 2022). Other settings like the US and UK often fall short, as professional development tends to be overly theoretical, sporadic, or disconnected from the day-to-day realities of classroom practice (Bhimdiwala et al., 2022; Brandão et al., 2024). In China, support is concentrated in primary and secondary sectors, leaving preschool teachers with limited guidance or hands-on opportunities (Brandão et al., 2024; Li et al., 2023; Zhao et al., 2022).

Research consistently shows that teachers who engage in ongoing, collaborative, hands-on professional development—such as coaching, peer learning, and communities of practice—are more adept at translating AI concepts into teaching strategies and demonstrate stronger self-efficacy (Cambridge et al., 2024; Chounta et al., 2022; Fang et al., 2023; Roshan et al., 2024; Tan et al., 2024; Wilton et al., 2022; Younis, 2024). However, teacher demographics such as gender, professional background, and digital experience play a strong role—male and digitally experienced teachers tend to report greater efficacy and enthusiasm for AI integration (Ayanwale et al., 2024; Cheng et al., 2024; Li et al., 2023; Stolpe & Hallström, 2024).

At the systemic level, persistent organizational barriers—including inadequate infrastructure for early childhood contexts, insufficient ongoing support, and lack of alignment with early childhood pedagogies—frustrate attempts to build lasting AI ability (Brandão et al., 2024; Cambridge et al., 2024; Lim, 2023). The emergence of generative AI (e.g., LLM-powered chatbots, advanced tutoring systems) places additional demands on teachers to not only utilize but also critically appraise the ethicality and reliability of these tools (Alsafari et al., 2024; Carrasco Ramírez & Islam, 2024; Guo & Lee, 2023; Kasneci et al., 2023). Where organizational vision and leadership are lacking, even skilled educators may struggle to adapt (Brandão et al., 2024; Cambridge et al., 2024; Zhao et al., 2022).

A key concern remains the misalignment between most existing AI resources and the realities of early childhood and preschool teaching. Curriculum, training, and digital tools are most often developed for older students, leaving early childhood educators with few developmentally appropriate options for practice (Lim, 2023; Nazaretsky et al., 2022; Yao & Wang, 2024).

**AI Awareness**AI awareness refers to teachers’ ability to recognize and address the wider ethical, social, and professional implications of AI in education. This dimension is increasingly critical as generative AI and algorithmic teaching tools become more embedded in classroom settings.

Some national strategies—most notably in the UK—explicitly integrate digital ethics into their understanding of AI literacy (Akgun & Greenhow, 2022; Brandão et al., 2024). However, most international and local efforts have struggled to translate broad ethical aspirations into actionable classroom guidance, particularly in early childhood education where data privacy, bias, and fairness have acute relevance but little concrete policy response (Akgun & Greenhow, 2022; Brandão et al., 2024; Yan et al., 2024; Chen, Fan, & Liao, 2025; Chen & Fan, 2025a; Chen & Fan, 2025b).

Teachers’ capacity for ethical and critical reflection is strongly mediated by institutional context and professional community. Where schools cultivate reflection, discussion, and open debate, teachers are more likely to feel confident navigating the uncertain ethical terrain of AI (Cambridge et al., 2024; Nazaretsky et al., 2022; Wilton et al., 2022). In contrast, educators in under-resourced settings—especially in early childhood—often report increased hesitation, concern, and resistance in the absence of proper guidance (Lim, 2023; Miniankou & Puptsau, 2023).

The fast evolution of AI (including powerful LLMs and data-driven assessment tools) has further heightened the urgency of reflecting on issues such as data security, student privacy, and professional identity (Akgun & Greenhow, 2022; Alsafari et al., 2024; Nazaretsky et al., 2022; Yan et al., 2024). Without sustained attention to these ethical considerations and the specific needs of marginalized or early childhood educators, the gap between policy and meaningful, responsible uptake is set to widen (Brandão et al., 2024; Lim, 2023; Miniankou & Puptsau, 2023).

**Research Methods and Design**

This study employed a mixed-methods sequential explanatory design to investigate AI literacy among Chinese preschool teachers. The quantitative phase surveyed 152 in-service teachers with valid teaching certificates through stratified random sampling across eastern, central, and western regions, and public and private institutions. This sample provided a ±7.9% margin of error at the 95% confidence level.

The self-developed questionnaire, grounded in international AI literacy frameworks (Kong et al., 2024; Ng et al., 2022) and adapted for China's context , contained 35 items across three subscales: AI Knowledge (10 items), AI Ability (12 items), and AI Awareness (13 items). Items used a 5-point Likert scale (1=strongly disagree to 5=strongly agree), with scores interpreted as: 1.00-2.49=low, 2.50-3.49=moderate, 3.50-5.00=high.

Content validity was established through expert review and pretesting. Construct validity was confirmed via exploratory factor analysis (pilot *n*=80; *KMO*=0.91; Bartlett's *χ²*=1056.23, *df*=171, *P*<0.001) with all items showing strong factor loadings (>0.50). Confirmatory factor analysis supported the scale structure (*χ²/df*=2.38; CFI=0.96; TLI=0.95; RMSEA=0.059). Internal reliability was high for both the full scale (Cronbach's *α*=0.93) and subscales (0.89–0.93).

For the qualitative phase, semi-structured interviews were conducted with 16 teachers representing diverse backgrounds. The interview guide explored teachers' experiences with AI integration, challenges, and recommendations for improving AI literacy at policy, organizational, and individual levels. Interviews lasted 30–40 minutes, were recorded, transcribed in Mandarin, and analyzed using NVivo 14.0.

Qualitative data were analyzed following Braun and Clarke’s (2006) thematic approach . Two researchers independently performed open and focused coding of transcripts, identifying emerging themes and then reaching consensus through discussion (Cohen’s *κ*=0.84). For example, responses such as “I’m used to my current methods and rarely try new tech” and “Training is mostly theoretical and not practical” were coded under “low motivation” and “insufficient practical training,” which were further synthesized around policy, organizational, and individual-level factors.

The study received institutional ethics approval, with informed consent obtained from all participants. Participation was voluntary, and anonymity and confidentiality were strictly maintained. Survey data were collected online; interviews were conducted via secure video call or telephone and securely de-identified. Quantitative analyses (SPSS 26.0) included descriptive statistics and group comparisons (T-tests, ANOVA). Qualitative findings were used to supplement quantitative results, particularly in explaining the underlying barriers and identifying potential cultivation strategies. The integration of both datasets provided comprehensive insights into the challenges and solutions for AI literacy development among Chinese preschool teachers.

**Results**

**1. Current Status of AI Literacy Among Chinese Preschool Teachers**

Table 1 shows that preschool teachers generally possess moderate levels of AI knowledge, ability, and awareness, with the highest mean score in awareness (*M=*3.44) and the lowest in ability (*M=*3.28). All scores remain below the high” threshold, suggesting that while teachers recognize the importance of AI, their practical skills to integrate AI effectively into teaching are still lacking.

**Table 1. Overall AI Literacy of Preschool Teachers (*N* = 152)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Dimension** | **Mean** | **SD** | **Min** | **Max** | **Interpretation** |
| Knowledge | 3.34 | 0.95 | 1 | 5 | Moderate |
| Ability | 3.28 | 0.88 | 1 | 5 | Moderate |
| Awareness | 3.44 | 0.87 | 1 | 5 | Moderate |

*\*Score interpretation was as follows:Low (1.00-2.49), Moderate (2.50-3.49), High(3.50-5.00).*

To provide granular insights, Table 2 identifies specific strengths and weaknesses within each dimension. Items were selected based on mean scores, with the two highest-scoring items representing strengths and the two lowest-scoring items indicating weaknesses for each dimension:

**Table 2. Representative High and Low Scoring Items by Dimension (*N* = 152)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Dimension** | **Item Category** | **Item** | **Mean (SD)** |
| **AI Knowledge** | High-scoring items | Q4: Understanding of AI essence | 3.41 (0.086) |
| Q6: Understanding of learning classification methods | 3.40 (0.099) |
| Low-scoring items | Q7: Understanding of matching AI tools with learning needs | 3.30 (0.095) |
| Q2: Understanding of AI systems | 3.24 (0.095) |
| **AI Ability** | High-scoring items | Q19: Ability to use AI technology to discover problems | 3.36 (0.93) |
| Q17: Using AI technology to search learning resources | 3.35 (0.94) |
| Low-scoring items | Q16: Ability to use AI tools to customize learning plans | 3.21(0.92) |
| Q12: Ability to use AI products for translation | 3.20 (0.89) |
| **AI Awareness** | High-scoring items | Q28: AI products can assist personalized learning | 3.52 (0.88) |
| Q25: Awareness of AI technology as educational tool | 3.49 (0.90) |
| Low-scoring items | Q30: Awareness that AI products reduce independent thinking | 3.35 (0.88) |
| Q34: Ethical review of AI data | 3.36 (0.91) |

Table 2 shows most teachers are confident in understanding AI essence, learning classification methods, and recognizing AI's potential for personalized learning, but struggle with technical matching of tools to needs, system understanding, and specific AI tool applications such as customizing learning plans. While teachers demonstrate understanding of AI's role in education and can discover problems using AI, concerns about independent thinking reduction and data ethics review remain areas needing improvement.

**Table 3 reveals significant group differences in AI literacy. Males scored higher than females across all dimensions. Welch's ANOVA showed educational level differences (*P* < 0.001): Bachelor's/Diploma > High school > Junior high, with postgraduates scoring lowest. Preschool education majors and public kindergarten teachers also demonstrated higher AI literacy than their counterparts.**

**Table 3. Group Comparisons of AI Literacy Scores (*N* = 152)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Group/Variable** | **N** | **Knowledge (M ± SD)** | **Ability  (M ± SD)** | **Awareness (M ± SD)** | **Statistical Results** |
| **Gender** |  |  |  |  | **T-test** |
| Female | 112 | 3.16 ± 0.91 | 3.12 ±0.85 | 3.21 ± 0.83 | All dimensions: *P* < 0.01 |
| Male | 40 | 3.85 ± 1.02 | 3.75 ±0.92 | 3.77 ± 0.94 |
| **Education Level** |  |  |  |  | **Welch's ANOVA** |
| Junior high/below | 8 | 2.11 ± 0.62 | 2.14 ±0.44 | 2.40 ± 0.56 | All dimensions: *P* < 0.001 |
| High school | 21 | 3.25 ± 0.70 | 2.98 ±0.65 | 3.21 ± 0.83 | Post-hoc: Bachelor's/Diploma >High school > Junior high; Postgraduate < all others |
| Diploma | 53 | 3.43 ± 0.83 | 3.41 ±0.64 | 3.70 ± 0.73 |
| Bachelor | 52 | 3.77 ± 0.95 | 3.64 ±1.03 | 3.80 ± 0.74 |
| Postgraduate | 18 | 2.46 ± 0.57 | 2.73 ±0.68 | 2.43 ± 0.57 |
| **Major** |  |  |  |  | **Welch's ANOVA** |
| Preschool education | 93 | 3.59 ± 0.96 | 3.56 ±0.90 | 3.71 ± 0.85 | All dimensions: *P* < 0.001 |
| Other education | 39 | 3.13 ± 0.67 | 2.91 ±0.57 | 3.13 ± 0.76 | Post-hoc: Preschool education >Other education > Non-education |
| Non-education | 20 | 2.57 ± 0.89 | 2.75 ±0.86 | 2.81 ± 0.65 |
| **Kindergarten Type** |  |  |  |  | **T-test** |
| Public | 93 | 3.60 ± 0.91 | 3.40 ±0.79 | 3.56 ± 0.89 | Knowledge: ***P*** < 0.05 |
| Private | 59 | 3.16 ± 0.99 | 3.20 ±0.95 | 3.36 ± 0.81 | Ability and Awareness: *ns* |

*\*****Significance Levels. P <0 .05; P< 0.01;*** *P* ***<0 .001; ns = not significant.***

**2. Challenges Underpinning Deficiencies in AI Literacy**

Table 4 summarizes that shortcomings in AI literacy arise from multiple sources. Policymakers have not issued clear guidance or incentives; organizations often fail to provide practical training and up-to-date digital resources; and many teachers themselves lack motivation to move beyond traditional methods, which together perpetuate gaps in both proficiency and confidence regarding AI in preschool education.These multi-level challenges reveal surface manifestations of deeper systemic issues.

**Table 4. Systemic Barriers to AI Literacy Development: A Multi-Level Analysis**

|  |  |  |  |
| --- | --- | --- | --- |
| **System Level** | **Key Challenges** | **Manifestations** | **Representative Evidence from Interviews** |
| Macro-level: Policy System | Absence of unified AI literacy framework and standards | • No national AI literacy standards for preschool teachers • Lack of systematic curriculum guidelines • Absence of incentive mechanisms • Missing accountability structures | "There is no unified standard or reward system for AI learning. We don't even have clear guidelines on what AI competencies we should develop" (XQJS-3). "The policy documents mention AI in education, but there's no specific framework for preschool teachers. We're left to figure it out ourselves" (XQJS-1). |
| Meso-level: Organizational System | Insufficient institutional support and resource allocation | • Theory-heavy training lacking practical application • Limited access to AI- enabled teaching tools • Inadequate professional development opportunities • Weak inter-institutional collaboration | "The training we receive is mostly theoretical lectures. We sit and listen but never get hands-on practice with actual AI tools" (XQJS-2). "Our kindergarten has basic projectors and computers, but no smart interactive screens or AI teaching assistants that we hear about in conferences" (XQJS-4). "I attended one AI workshop, but when I returned to my classroom, I had no resources or support to implement what I learned" (XQJS-16). |
| Micro-level: Individual System | Low self- efficacy and resistance to technological change | • Preference for traditional pedagogical methods • Technology anxiety and fear of replacement • Limited awareness of AI's educational potential • Insufficient intrinsic motivation for professional development | "I've been teaching for 15 years using traditional methods. Why should I change now? These AI tools seem complicated and time-consuming" (XQJS-5). "Honestly, I'm worried that if I become too dependent on AI, I might lose my teaching skills or even my job" (XQJS-3). "I don't see how AI relates to early childhood education. Young children need human interaction, not machines" (XQJS-10). |

*\*****Interview codes represent individual participants (XQJS = Xueqian Jiaoshi/Preschool Teacher).***

In summary, while Chinese preschool teachers demonstrate moderate AI literacy, clear weaknesses remain—especially in higher-order knowledge, integration, and ethical/data awareness. These are reinforced by gaps at the policy level, insufficient organizational support, and teachers’ own attitudes and habits. Addressing these barriers will require coordinated interventions at all three levels.

1. **Strategies for Promoting AI Literacy: Teacher Perspectives**

**Regarding the third research question, we analyzed teachers' recommendations for overcoming the identified barriers and promoting AI literacy development.  
Table 5. Teacher-Proposed Strategies for AI Literacy Development**

|  |  |  |  |
| --- | --- | --- | --- |
| **Strategy Level** | **Proposed Strategies** | **Representative Evidence** | **Frequency (n=16)** |
| **Macro-level: Policy Strategies** | Establish national AI literacy standards for preschool teachers | "We need clear benchmarks, like those for English proficiency. Without standards, we don't know what level to aim for" (XQJS-1) | 14/16 |
| Integrate AI literacy into teacher qualification frameworks | "AI literacy should be part of our teaching certificate requirements, not an optional add-on" (XQJS-7) | 12/16 |
| Create incentive mechanisms for AI skill development | "If mastering AI tools could lead to career advancement or salary increases, teachers would be more motivated" (XQJS-13) | 11/16 |
| Develop age-appropriate AI curriculum guidelines | "We need specific guidance on what AI concepts are suitable for 3-6 year olds, not just general K-12 frameworks" (XQJS-9) | 10/16 |
| **Meso-level: Organizational Strategies** | Provide hands-on, practice-oriented training | "Less theory, more practice. Let us actually use AI tools with children and see what works" (XQJS-2) | 15/16 |
| Establish professional learning communities | "Creating teacher groups to explore AI together would be more effective than individual learning" (XQJS-11) | 13/16 |
| Ensure equitable resource distribution | "Private kindergartens need subsidies for AI tools. The gap with public schools is too wide" (XQJS-6) | 11/16 |
| Implement mentorship programs | "Pairing tech-savvy teachers with beginners would accelerate learning and reduce anxiety" (XQJS-14) | 9/16 |
| **Micro-level: Individual Strategies** | Start with simple, practical AI applications | "Begin with tools we can immediately use, like AI-assisted lesson planning, not complex programming" (XQJS-5) | 14/16 |
| Connect AI to existing pedagogical practices | "Show us how AI enhances what we already do well, rather than replacing our methods" (XQJS-8) | 12/16 |
| Address emotional and psychological barriers | "We need support groups to discuss our fears about AI replacing teachers or harming children's development" (XQJS-3) | 10/16 |
| Promote reflective practice and action research | "Encourage teachers to document and share their AI integration experiences, learning from successes and failures" (XQJS-15) | 8/16 |

The interview data revealed that teachers not only identified problems but also possessed practical insights into potential solutions. Notably, the most frequently mentioned strategies directly addressed the barriers identified in Table 4. For instance, to counter the absence of unified standards (macro-level barrier), 87.5%（14/16） of teachers advocated for national AI literacy benchmarks. Similarly, to address insufficient practical training (meso-level barrier), 93.8%（15/16） emphasized hands-on workshops over theoretical lectures.

**Discussion**

This study offers a nuanced portrait of AI literacy among Chinese preschool teachers, revealing moderate overall competency (with individual dimension means ranging from 3.28 to 3.44) with significant variations across dimensions. Item-level analysis shows teachers demonstrate relative strength in understanding AI concepts yet struggle with technical depth, pedagogical integration, and ethical considerations, as evidenced by the moderate scores across all measured items.

This pattern of surface-level familiarity coupled with implementation deficits echoes findings from Lim (2023), Ayanwale et al. (2024), and Kong et al. (2024),who document similar discrepancies globally. The pronounced weakness in data ethics awareness and cognitive degradation concerns, as reflected in the lower-scoring items within the awareness dimension, corroborates frameworks positioning AI literacy as encompassing not merely technical proficiency, but critical ethical reasoning (Akgun & Greenhow, 2022; Ng et al., 2022; Chen, Fan, & Liao, 2025; Chen & Fan, 2025a; Chen & Fan, 2025b). These findings suggest that despite policy rhetoric and reform initiatives, the translation of AI awareness into meaningful pedagogical transformation remains severely constrained—a phenomenon extensively documented in broader educational contexts.

The data reveal striking demographic and institutional disparities. The persistent gender gap, with male teachers significantly outperforming female colleagues (*P*<0.01), aligns with international research on gendered technology adoption patterns (Hur, 2024; Karataş & Yüce, 2024). Given preschool education's female-dominated nature, this disparity signals urgent equity concerns. Similarly, teachers with preschool education majors outperforming those from other backgrounds reinforces the importance of discipline-specific AI literacy development, consistent with Stolpe and Hallström's (2024) argument for contextualized technology education.

Most intriguingly, the "degree-inverse" phenomenon persists: postgraduate-qualified teachers scored significantly lower than bachelor's or diploma-holding peers across all dimensions. This counterintuitive result challenges conventional assumptions about educational attainment and technological sophistication. Explanatory mechanisms include: postgraduate teachers often occupying administrative positions with limited classroom exposure, creating theory-practice disconnect (Li et al., 2023)); and advanced training potentially cultivating heightened critical awareness manifesting as conservative self-assessments (Kong et al., 2024; Ng et al., 2022). This finding suggests that credentialism alone cannot drive authentic AI literacy development without sustained practical engagement.

Delving into the multilevel barriers underlying these deficiencies reveals deeply embedded, mutually reinforcing obstacles. At the policy level, the absence of unified national AI literacy standards for preschool education creates cascading uncertainty throughout the system. Recent research demonstrates that Chinese provincial digital education policies concentrate predominantly on supply-side interventions (technological infrastructure) while neglecting demand-side considerations (stakeholder needs and pedagogical guidance), resulting in poor coordination and persistent technology-pedagogy gaps(Cao et al., 2024). Teachers' repeated emphasis on policy ambiguity and evaluation vacuum as fundamental impediments resonates strongly with findings from Akgun and Greenhow (2022), UNESCO (2021), and Zhao et al. (2022). Without clear benchmarks linking AI competencies to career progression, superficial compliance replaces genuine capacity-building.

Organizationally, data expose critical resource disparities and professional development inadequacies. Theory-heavy training divorced from practical application leaves teachers stranded between rhetoric and reality (Alsafari et al., 2024; Brandão et al., 2024). This phenomenon can be characterized as 'performative compliance'—whereby institutions fulfill regulatory mandates without fostering genuine pedagogical capacity, a practice that contrasts sharply with Bazhenkov's (2022) advocacy for substantive compliance frameworks. The performance gap between public and private kindergarten teachers underscores how institutional support and infrastructure shape competency development (Li et al., 2023; Miniankou & Puptsau, 2023). Private institutions face "cascading disadvantage" where those serving vulnerable populations receive least support (Guleva, 2022). These findings strongly support calls for sustained, practice-oriented professional learning communities as documented by Bhimdiwala et al. (2022)and Cambridge et al.(2024).

At individual level, methodological conservatism, technology anxiety, and motivational deficits emerge as constraining forces—patterns consistently identified by Hur (2024), Lim (2023), and Younis (2024). Research examining anxiety among Chinese preschool teachers revealed that stress, uncertainty, and inadequate support systems contribute to risk-averse behaviors in pedagogical decision-making (Wang et al., 2024). The intersection of gender, specialization, and institutional type reflects structural inequities requiring systemic intervention (Ayanwale et al., 2024; Karataş & Yüce, 2024). These findings demonstrate AI literacy development as a complex social-ecological phenomenon emerging from dynamic interactions among policy frameworks, organizational conditions, and individual agency (Cambridge et al., 2024; Ng et al., 2022; Tan et al., 2024).

Comprehensive intervention strategies become imperative. Policy reforms must establish explicit AI literacy standards tailored to preschool education, incorporating successful international models integrating competencies into teacher accreditation with accountability mechanisms (Brandão et al., 2024; Cambridge et al., 2024). Standards must recognize AI literacy's multidimensional nature, encompassing technical knowledge, critical awareness, and ethical reflection(Kong et al., 2024; Ng et al., 2022)

Organizationally, sustainable investment in technological infrastructure and collaborative professional development is essential. Nordic collaborative training models demonstrate how peer mentorship and experiential learning bridge theory-practice divides (Bhimdiwala et al., 2022; Chounta et al., 2022). Addressing resource imbalances requires targeted policy incentives ensuring equitable access (Li et al., 2023; Nazaretsky et al., 2022).

Individual strategies must foster professional reflection, ethical reasoning, and innovative engagement with AI tools. Project-based inquiry, action research, and blended learning show promise in democratizing access across demographic boundaries (Ayanwale et al., 2024;; Tan et al., 2024). Professional learning communities and collaborative lesson design incorporating AI tools demonstrate effectiveness in supporting sustained change (Fang et al., 2023; Kasneci et al., 2023).

In conclusion, this study advances understanding of AI literacy development in early childhood education by revealing its multilevel, contingent nature. Rather than assuming linear progression from training to competency, findings illuminate a complex landscape shaped by structural constraints and cultural ambivalence. Future research must employ longitudinal designs tracing developmental trajectories (Sperling et al., 2024), develop culturally responsive assessment frameworks (Kong et al., 2024), and investigate ethical and generative AI integration in preschool contexts (Nazaretsky et al., 2022; Yan et al., 2024). Only through comprehensive inquiry can we navigate AI's transformative potential for early childhood education.

**Conclusion and limitations**

This study reveals that Chinese preschool teachers possess only moderate AI literacy, with awareness exceeding both technical knowledge and practical ability. Persistent gaps at the policy, organizational, and individual levels signal an urgent need for unified national standards, ongoing institutional support, and professional development that integrates both technical and ethical dimensions. To keep pace with the rapid evolution of AI, we recommend dynamic monitoring and periodic literacy assessment systems to enable continuous adaptation. The cross-sectional design, reliance on self-reported data, underrepresentation of rural and male teachers, and the fast-changing AI landscape limit the generalizability and causal inference of our results. Nonetheless, these findings provide a foundation for promoting educational equity, resource allocation, and targeted training—aligned with SDG4—and support the integration of AI literacy into teacher qualification frameworks. Future research should adopt longitudinal and intervention-based designs, expand sample diversity, and focus on evaluating the actual classroom impact of new AI technologies to guide more effective and responsive policy and practice.

**Ethics Approval and Consent:**

This study was approved by the relevant ethics committee, and all participants provided informed consent prior to their participation.

**Disclaimer (Artificial intelligence)**

The author(s) hereby declare that no generative AI technologies, including but not limited to Large Language Models (e.g., ChatGPT, Copilot) or text-to-image generation tools, were utilized in the writing or editing of this manuscript.

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