

Bridging the Gap, Creating Equity through Wisdom: The Sustainable Development of Inclusive Preschool Education in the Era of Artificial Intelligence

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Abstract

Artificial intelligence (AI) significantly advances sustainable inclusive early childhood education through three interconnected pathways: (1) personalized learning enabling equitable development foundations; (2) resilient safety systems via real-time monitoring; and (3) enhanced home-school collaboration through data-driven communication. These innovations collectively optimize teacher effectiveness and foster socio-emotional skills. However, critical challenges threaten system sustainability: data privacy risks, disparities in teachers' AI competencies, and the widening "intelligence gap" exacerbating inequities. To address these barriers, human-centered strategies are imperative: establishing robust data governance frameworks, promoting lifelong teacher professional development, and bridging the intelligence divided through policy-technology synergy. Only through such integrated approaches can inclusive early education achieve its goals of quality, equity, and sustainability aligned with global commitments (SDG 4, SDG 9c.).

Keywords

Artificial Intelligence, Pre-school Inclusive Education, Sustainable Development, Educational Equity

Introduction

AI holds significant potential for advancing sustainable inclusive preschool education. This paper examines AI's enabling roles in promoting equity: facilitating personalized learning, building safe environments, cultivating socio-emotional skills, optimizing teacher resources, and deepening home-school collaboration—key to achieving SDG 4. However, integration faces critical challenges: data privacy/ethical risks, disparities in teachers' technological capabilities, and the emerging "intelligence gap" threatening to exacerbate inequities. We analyze these dual dimensions (empowerment vs. obstacles) and propose human-centered strategic pathways—robust

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data governance, teacher lifelong learning, and collaborative intelligence gap bridging—essential for realizing high-quality, inclusive, sustainable preschool education in the AI era.

Methodology

This study employs qualitative literature analysis to systematically explore the role of artificial intelligence (AI) in promoting sustainable inclusive preschool education. Sources comprised peer-reviewed articles (2018–2024) on adaptive learning and emotion-recognition systems (e.g., Kaška-Porayska-Pomsta et al., 2018; Zhou, 2018), policy documents such as UNESCO’s (2024) AI competency framework, and empirical cases including Shenzhen’s “Smart Kindergarten” and the Knewton and Seesaw platforms (Sun & Xu, 2025). A three-phase thematic coding procedure was applied: (1) categorising affordances (e.g., personalised learning for equity) and challenges (e.g., data-privacy risks); (2) cross-context comparison of implementations to expose resource-related variations in effectiveness; and (3) mapping findings onto SDG 4 and SDG 9.c policy targets (UNESCO, 2024). Methodological triangulation integrated educational-technology insights, child-development theory, and inclusive-education policy principles (Wu & Sun, 2024). Although rapid AI iteration constrains any literature-based review, prioritising policy-relevant cases published within the last three years - especially the 2024 UNESCO framework - enhances timeliness and validity.

Results and Discussion

The Empowering Role of Artificial Intelligence in the Sustainable Development of Inclusive Preschool Education

AI generates adaptive learning paths via real-time analytics, advancing equity by dynamically calibrating task difficulty and content modality for every learner, including children with special educational needs (SEN) (Zhou, 2018). The Knewton platform, for instance, supplies individualized activity sequences that reduce attainment gaps and resource wastage, operationalising SDG 4.5 from the earliest stage (Sun & Xu, 2025).

AI-enabled surveillance (facial recognition, barrier-free access control) strengthens kindergarten safety infrastructures, protecting mobility-limited and SEN children (Wu & Sun, 2024). Shenzhen’s “Smart Kindergarten” illustrates how intelligent monitoring coupled with universal-design principles lowers accident risk while creating an inclusive physical space (UNESCO, 2024).

Emotion-recognition algorithms (facial/vocal analysis) allow teachers to detect and regulate pupils’ affective states, optimising classroom climate (Kaška-Porayska-Pomsta et al., 2018). Tools such as the ECHOES system provide safe, simulated scenarios in which children with autism spectrum disorder practise pragmatic language, fostering social-emotional learning competencies essential for lifelong inclusion (Gao & Yang, 2023).

Automated courseware generation and data-driven reporting relieve teachers of routine tasks, reallocating professional time to high-value interactions—individualised feedback, exploratory dialogue and behavioural observation (Zhou, 2018). AI-generated lesson summaries

rapidly flag instructional blind spots, improve differentiation, curb educator burnout and thereby sustain workforce quality (Sun & Xu, 2025).

AI-mediated portals (e.g., Seesaw) translate learning analytics, behaviour logs and emotion metrics into visualisable progress reports for parents, offering evidence-based guidance on socio-emotional support and behaviour management (Luo, 2024). Push notifications, video conferencing and one-to-one chat functions diminish communication latency, align family–school objectives and construct a durable support network promoting holistic development (Wu & Sun, 2024).

The core challenges faced by artificial intelligence in promoting the sustainable development of early childhood inclusive education

The sensitive data of children—health, behavior, and emotions—on which AI systems rely entail systemic risks. Absent ethically regulated data collection, such practices infringe privacy and erode school–family trust, the cornerstone of educational-ecosystem resilience (Wu & Sun, 2024). Over-dependence on algorithmic decisions (e.g., AI-generated learning paths) can diminish children's autonomous exploration and stunt critical-thinking competencies vital for sustainable development (UNESCO, 2024). Without a full-life-cycle stewardship framework governing collection, storage, sharing, and destruction of pupil data, technology deployment drifts from the “people-oriented” mandate of sustainable development and may provoke social resistance, rendering innovations unsustainable (Sun & Xu, 2025).

The UNESCO Teachers' AI Competency Framework (2024) defines five core competencies: human-centered AI awareness, AI ethics understanding, basic/applied AI knowledge, effective AI-teaching integration, and AI for professional development. However, significant disparities persist in teachers' acceptance and adaptability. Many educators, particularly non-tech-savvy ones, exhibit resistance or discomfort towards AI tools. This psychological barrier and adaptation difficulty limit their effective utilization of AI, dampening teaching innovation and effectiveness, and ultimately compromising technology's classroom efficacy. Addressing this capability gap is critical for realizing AI's potential in inclusive education.

The landmark UN Global Digital Compact (2024) reveals the digital divide has evolved into a more complex and concealed “intelligence gap.” While AI-assisted teaching thrives in developed urban kindergartens, central/western rural areas face critical barriers: inadequate network infrastructure and outdated equipment prevent even basic online tools. Compounding this, teachers with insufficient training often over-reliance on algorithmic outputs, overshadowing individual child observation. If unaddressed, this disparity risks transforming AI—intended as a “bridge for educational equity”—into an “invisible wall” exacerbating urban-rural educational inequities and undermining SDG 9.c's goal of universal technological access.

Technology in preschool inclusive education must prioritize a human-centered approach, built on three pillars. First, robust privacy protection is essential: policymakers must strengthen regulations for transparent, lawful data handling, especially for sensitive children's data, and developers must implement rigorous security. Second, technology should actively foster children's subjective initiative and agency, providing personalized support and equitable opportunities for exploration and potential development. Third, it must catalyze creativity for both teachers (designing inclusive activities) and children (expressing imagination through digital tools). Achieving this balance requires collaborative efforts among policymakers (ethical frameworks),

educators (implementation), and developers (responsible design) to cultivate a fair, inclusive, and sustainable educational environment.

To achieve sustainable and inclusive AI-enabled preschool education, it is imperative to address the dual challenges of individual teacher capacity deficits and structural resource inequalities. The AI Competency Framework for Teachers (UNESCO, 2024) outlines five core competencies, including human-centered AI literacy, ethical understanding, and pedagogical integration. However, significant disparities persist in teachers' technological acceptance and applied competencies. Particularly in rural and underserved regions, many educators possess only basic digital literacy, lacking a deeper understanding of AI's pedagogical logic (Sun & Xu, 2025). This often results in superficial adoption of AI tools or overreliance on algorithmic outputs, undermining professional judgment and child-centered observation (Wu & Sun, 2024).

To overcome these barriers, a lifelong, progressive teacher capacity-building system must be established, spanning both pre-service and in-service professional development. At the pre-service level, teacher training institutions should integrate compulsory modules on data ethics in early childhood education, AI-assisted instructional design, and foundational algorithmic literacy (Xue et al., 2024). This will support the transition of teachers from passive technology users to reflective instructional designers (UNESCO, 2024).

At the in-service level, kindergartens should implement tiered professional development programs. Teachers with lower technological proficiency should receive targeted training in AI tool operation, troubleshooting, and basic content creation. Those with stronger digital skills should engage in advanced training on human-AI collaborative teaching, intelligent assessment strategies, and adaptive learning design (Sun & Xu, 2025). A mentorship mechanism should be introduced to foster peer learning and sustainable capacity growth across teaching teams (Zhou, 2018).

Crucially, teacher capacity development must be synchronized with efforts to bridge the emerging "intelligence divide." This divide extends beyond infrastructural gaps (e.g., network access and hardware availability) to encompass disparities in algorithmic accessibility, data literacy, and instructional support systems (Fang & Zhong, 2024). If left unaddressed, AI risks becoming an invisible barrier that exacerbates existing educational inequities, rather than a tool for inclusion (UNESCO, 2024).

Therefore, policy-technology synergy is essential. On the technological front, there is an urgent need to develop low-bandwidth AI tools and offline intelligent resource kits tailored to resource-constrained environments, ensuring functional usability in low-connectivity settings (Wu & Sun, 2024). On the policy front, governments and educational authorities should establish a Special Fund for AI Equity in Early Childhood Education, dedicated to upgrading digital infrastructure, delivering targeted teacher training, and supporting collaborative research and development in underserved regions (Sun & Xu, 2025).

Only by integrating individual professional growth with systemic structural reform can AI truly serve as a catalyst for equitable, inclusive, and sustainable preschool education—aligned with the global commitments of SDG 4 (Quality Education) and SDG 9.c (Universal and Affordable Access to Information and Communications Technology) (UNESCO, 2024).

Conclusion

AI can personalise learning, strengthen safety and deepen home–school collaboration, advancing inclusive preschool provision in line with SDG 4 and SDG 9.c. Yet weak data governance, uneven teacher AI competence and an emerging “intelligence divide” threaten to deepen inequities. A sustainable, human-centred strategy is therefore essential: embed AI ethics and algorithmic literacy in pre-service curricula; deliver tiered in-service training; and pair policy funds with low-bandwidth, offline-compatible tools to ensure rural and disadvantaged centres are not left behind. By integrating lifelong teacher development with systemic equity reforms, AI can function as a bridge—rather than a barrier—to high-quality, inclusive early childhood education for every child.

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