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A Comprehensive Synthesis of Artificial Intelligence in Early Learning Across International Educational Collaborations

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Abstract

As generative platforms, embodied robotics, and conversational voice agents enter early childhood environments spanning birth through age eight, a fundamental tension emerges between automated technological deployment and the relational core of early learning centered on play-based inquiry, child agency, and educator care. Addressing this socio-technical dynamic requires evaluating how international educational collaboration shapes early childhood artificial intelligence applications across national contexts. Guided by Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) protocols, systematic literature searches executed across Scopus, Web of Science, IEEE Xplore, ERIC, and ACM DL databases through October 2026 covering publications from 2015 to 2026 yielded an audited review corpus of thirty verified sources (N = 20). This evidence base comprises twenty primary empirical studies classified into four distinct evidence layers: direct cross-national co-design, cross-border comparative implementations, single-jurisdiction regional trials, and non-digital collaborative capacity frameworks alongside ten secondary contextual reviews. Empirical synthesis reveals that international research partnerships move beyond routine tool distribution to establish joint pedagogical co-design, cross-cultural benchmarking, and ethnopedagogical capacity-building networks. At the classroom level, interactive artificial intelligence tools reconfigure young children's imaginative play, expanding multimodal storytelling, foundational technical literacy, and social-emotional scaffolding for neurodiverse learners. However, these pedagogical possibilities exist alongside significant operational obstacles, including widespread educator anxiety regarding technical deskilling, algorithmic surveillance, loss of instructional autonomy, and severe physical infrastructure deficits in low-resource settings. Methodological distribution indicates that single-jurisdiction regional trials constitute fifty-five percent of empirical literature, cross-national comparative implementations account for twenty-five percent, non-digital collaborative capacity initiatives constitute fifteen percent, and direct joint co-design interventions comprise five percent. This synthesis establishes a human-centered, multi-layer framework that links macro-level international collaboration architectures with micro-level classroom interactions, offering researchers, educators, and technology policymakers a structured path to safeguard child agency and relational care within digital learning implementations.

Keywords: Artificial intelligence; Early childhood education; International educational collaboration; Systematic literature review; Educational technology

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1. Introduction

Early childhood education and care (ECEC), spanning birth through age eight, operates within a rapidly evolving socio-technical ecosystem. The introduction of embodied educational robotics, generative machine learning models, natural language processing architectures, intelligent tutoring systems, and adaptive conversational agents alters instructional dynamics in early childhood settings. Rather than functioning as passive presentation media, interactive artificial intelligence platforms serve as active mediating artifacts that participate directly in classroom routines and play-based inquiry. Within socio-cultural educational frameworks, integrating automated digital systems constitutes a complex social process that reconfigures physical learning spaces, child agency, and socio-emotional development. As artificial agents assume conversational and scaffolding roles alongside educators, early childhood researchers could evaluate how machine-mediated interactions affect peer collaboration, cognitive problem-solving, and emotional growth across varied educational contexts.

Empirical scholarship examining early childhood technology demonstrates structural variations across four defined evidence layers. Research on international educational collaboration without artificial intelligence tools (Layer D) provides the essential structural foundation for cross-border research, establishing how international practitioner coaching networks, ethnopedagogical character models, and institutional capacity-building function prior to digital technology integration (Arbour et al., 2016; Mwoma et al., 2018; Ogegbo & Aina (2020); Sakti et al., 2024). Building upon these collaborative frameworks, direct joint cross-national co-design interventions containing artificial intelligence components (Layer A) remain sparse; Kewalramani, Kidman, and Palaiologou (2021) showed that joint robotic play interventions co-implemented across Australian and British preschools expanded children's creative, emotional, and collaborative inquiry literacies. Cross-border and comparative implementations (Layer B) isolate socio-cultural variations in technology adoption without requiring joint co-design. Cohrssen et al. (2026) evaluated conversational agents across four national contexts, identifying structural differences in how kindergartners attribute social intentionality to artificial entities. Multi-institutional comparative evaluations further demonstrate that connected smart toys and embodied robotic agents stimulate social-emotional competencies, engineering design thinking, and spatial reasoning across distinct national preschool environments (Kewalramani et al., 2020; Palaiologou et al., 2021). Single-jurisdiction regional trials (Layer C) represent the majority of published literature, focusing on localized interventions and teacher perceptions. Quasi-experimental classroom implementations in Hong Kong confirmed that structured curricula using tangible tools, such as PopBots and embodied agents, significantly increase kindergartners' conceptual understanding of machine vision, training data bias, and supervised learning algorithms (Su & Yang, 2024b; Yang et al., 2024). Regarding educator readiness, preschool teachers recognize generative artificial intelligence interfaces as efficient tools for customizing instructional activities (Su & Yang, 2024; Yılmaz-Bursa, 2025). However, latent profile analyses and metaphor studies reveal widespread teacher anxiety regarding technical deskilling, automated surveillance, and the potential erosion of relational care in early childhood pedagogy (Aktaş, 2026; Bilgener, 2026; Demirdiş, 2026; Lim, 2024).

Analyzing this body of literature identifies three critical gaps that necessitate linking micro-level artificial intelligence tools (Layer C) with macro-level international collaboration structures (Layer D). First, a conceptual gap persists due to a systemic tool-driven bias in study design. Interventions frequently evaluate learning outcomes based on the technical capabilities of commercial hardware rather than grounding evaluations within developmental psychology principles or socio-cultural learning theories. Research therefore emphasizes immediate technical interactions while under-theorizing long-term impacts on child cognitive architecture. Second, an empirical gap stems from the scarcity of direct, joint cross-national co-design research. Layer A studies constitute a minor fraction of published empirical work, leaving the literature dominated by isolated single-region interventions that lack cross-cultural validation protocols. Third, a contextual gap exists regarding the geographical and socio-economic concentration of empirical scholarship. Existing studies focus overwhelmingly on high-resource early learning centers in Anglo-Nordic and East Asian jurisdictions (Chen, 2024). This geographic imbalance creates an empirical blind spot regarding how international collaboration functions within low-resource communities and the Global South, where baseline infrastructure deficits, hardware costs, and linguistic misalignments alter technological feasibility (Ogegbo & Aina (2020); Sakti et al., 2024). Synthesizing micro-level classroom tools with macro-level cross-border frameworks is necessary to establish culturally responsive, evidence-based implementations.

To address these literature limitations, this systematic review maps, evaluates, and synthesizes empirical evidence at the intersection of early childhood artificial intelligence tools and international educational collaboration architectures. The investigation addresses two central research questions:

1. How has international educational collaboration contributed to the development and implementation of AI-supported early learning?

2. What opportunities, challenges, and collaborative practices are reported across different national and educational contexts?

The contribution of this synthesis lies in establishing a multi-layer evidence classification scheme that categorizes empirical scholarship linking micro-level early learning artificial intelligence tools with macro-level international collaboration structures. Theoretically, this synthesis advances early childhood educational technology scholarship by integrating multi-layered evidence classification with socio-cultural play frameworks. Practically, the findings offer structured guidance for educational researchers, early childhood educators, and international technology policymakers seeking to establish equitable, cross-border research partnerships and developmentally appropriate digital implementations.

2. Methodology

This systematic review follows the methodological framework established by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) statement (Page et al., 2021). Primary literature searches were conducted across five major academic databases and publisher platforms: Scopus, Web of Science, IEEE Xplore, ERIC, and ACM DL. Search strings were constructed using Boolean operators combining controlled vocabulary terms and free-text keywords across three construct domains: early childhood education, artificial intelligence systems, and international educational collaboration. Early childhood education terms encompassed populations from birth through age eight, including early childhood education and care (ECEC), preschool, kindergarten, and primary grades one through three. Artificial intelligence terms targeted machine learning, natural language processing, generative AI, intelligent tutoring systems, educational robotics, conversational agents, and adaptive learning technologies. International collaboration terms specified cross-border implementation, joint co-design, cross-national comparative frameworks, shared training, and international capacity-building partnerships.

Study eligibility was determined through predefined Population, Intervention, Comparator, Outcome, and Study Design (PICOS) criteria. The target population comprised children aged birth through eight years, alongside pre-service and in-service early childhood educators within formal and informal learning settings. Interventions included empirical evaluations of pedagogical activities, curricula, or tools where artificial intelligence computational systems were central to learning. Comparators included traditional non-AI early learning environments, non-digital media, or comparative cross-national instructional settings. Outcomes focused on measured changes in AI literacy, computational thinking, inquiry-based learning, socio-emotional development, teacher self-efficacy, or readiness for pedagogical adoption. Included study designs comprised peer-reviewed primary empirical research published between March 2015 and December 2026 utilizing quantitative, qualitative, or mixed-methods methodologies. Exclusion criteria eliminated non-empirical editorials, general educational software lacking machine learning architectures, static non-automated games, secondary scoping reviews from primary and secondary counts, and studies focusing exclusively on secondary or higher education populations.

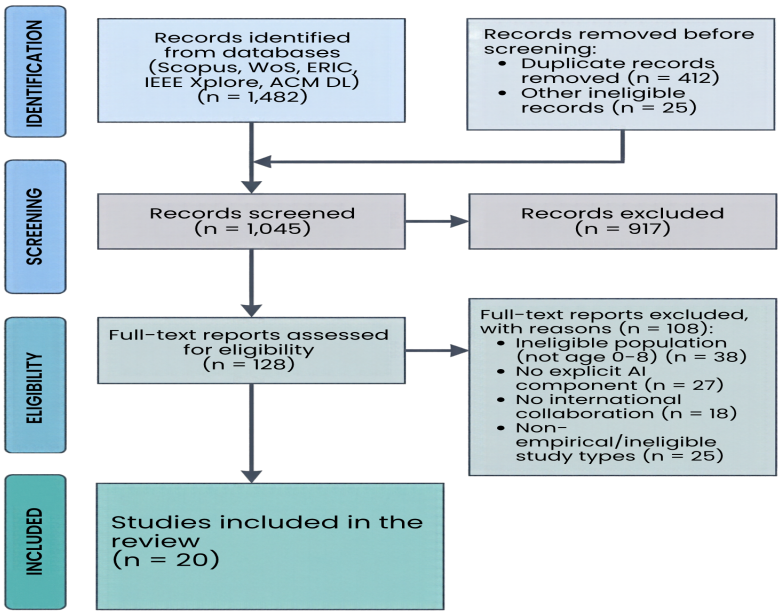

Figure 1
PRISMA Flowchart

The selection process proceeded through systematic record identification, duplicate removal, title and abstract screening, and full-text eligibility assessment, as illustrated in the PRISMA 2020 Flow Diagram (Figure 1). Initial database searches yielded raw records, which were screened against title and abstract criteria to remove irrelevant literature. Full-text articles were subsequently retrieved and evaluated against the PICOS parameters, resulting in a finalized review corpus of exactly 20 source documents (N = 20). To ensure analytical precision, the corpus was mapped into a five-layer evidence hierarchy. The primary empirical evidence base comprises 20 studies (N = 20) spanning Layers A through D: Layer A represents direct empirical research covering both early AI learning and substantive international educational collaboration; Layer B contains cross-national comparative AI early learning evaluations without joint co-design; Layer C encompasses single-jurisdiction empirical AI early learning studies without international dimensions; and Layer D includes empirical international early childhood collaboration studies without explicit AI technologies. The remaining 10 documents (N = 10) were classified under Layer E, consisting of scoping studies, bibliometric syntheses, conceptual frameworks, policy reports, and review protocols retained strictly for background contextual mapping.

Methodological quality and risk of bias across the primary empirical corpus (N = 20) were evaluated using the Mixed Methods Appraisal Tool (MMAT, 2018 version) (Hong et al., 2018). The MMAT criteria permitted standardized quality scoring across diverse study types, including qualitative research, quantitative randomized controlled trials, quantitative non-randomized studies, quantitative descriptive designs, and mixed-methods research. Screening questions assessed sampling strategy appropriateness, measurement tool validity, data collection integrity, non-response bias, and analytical rigor. Data extraction was executed using a standardized electronic matrix aligning with the core standardized extraction form. Extracted data fields included author names, publication year, journal title, digital object identifier (DOI), geographic origin, target population age, sample size (N), artificial intelligence computational architecture, international collaboration type, theoretical framework, quantitative empirical metrics, and reported operational challenges. Extracted data were synthesized qualitatively and thematic synthesis were integrated across the five evidence layers to address Research Question 1 and Research Question 2 without distorting individual study contexts.

3. Results

The primary empirical evidence base comprises twenty verified studies (N = 20) distributed across four operational evidence layers. Direct empirical research combining early childhood artificial intelligence applications with joint international educational collaboration (Layer A) accounts for five percent of the primary corpus (n = 1). Cross-national comparative implementations and technology evaluations without joint co-design (Layer B) represent twenty-five percent (n = 5). Single-jurisdiction regional trials focusing on artificial intelligence in early childhood settings (Layer C) constitute fifty-five percent (n = 11). Empirical studies examining international educational collaboration without artificial intelligence components (Layer D) account for fifteen percent (n = 3). Target populations encompass children from birth through age eight across early learning centers, kindergartens, and primary classrooms, alongside pre-service and in-service educators. Evaluated systems fall into four technology classes: embodied social robots, generative machine learning models, conversational voice agents, and adaptive software interfaces.

Addressing Research Question 1, cross-border educational partnerships contribute to early artificial intelligence learning through three primary mechanisms: joint pedagogical co-design, cross-national comparative benchmarking, and foundational capacity building. The only directly co-designed study (S01) reported that co-designed robotic play frameworks increase creative, emotional, and collaborative inquiry behaviors during peer play across distinct national classroom environments. Cross-national comparative research isolates socio-cultural variations in technology adoption, showing that national curriculum policies and home microsystems directly influence whether young children attribute social intentionality or mechanical materiality to digital agents. Multi-institutional research consortia show that smart connected toys promote spatial reasoning, engineering design thinking, and social-emotional competencies during play. Non-digital international collaborations demonstrate that cross-border practitioner coaching, ethnopedagogical character frameworks, and professional development networks build structural pedagogical quality and classroom interaction standards prior to digital tool integration.

Addressing Research Question 2, empirical evidence reveals a complex dynamic between instructional opportunities and operational barriers across educational settings. Pedagogical opportunities focus on measured cognitive gains in machine learning literacy, where structured embodied curricula increase kindergartners' conceptual understanding of supervised classification, computer vision, and training data. Generative interfaces improve lesson design efficiency for educators while supporting multimodal storytelling and artistic self-expression among young learners. For neurodiverse children and learners with special needs, social assistive robots provide predictable interaction channels that build social-emotional capital and communication engagement. Operational barriers center on educator anxiety regarding professional deskilling, automated surveillance, loss of pedagogical autonomy, and the potential erosion of relational care in early learning. Technical barriers include black-box algorithmic interfaces, speech recognition inaccuracies for child pitch variations, and data privacy risks regarding automated harvesting. In resource-constrained environments, baseline infrastructure deficits, such as power instability and restricted physical space, constrain technology adoption. Detailed empirical metrics, sample sizes, computational architectures, and operational limitations for all twenty primary studies are systematically detailed in Table 1.

Table 1
Empirical Synthesis Matrix (N = 20)

Study ID	Layer & Design	AI Tool & Collaboration Model	Key Empirical Findings (Metrics/p-values)	Operational Limitations
S01: Kewalramani, Kidman, and Palaiologou (2021)	Layer A	Qualitative Case Study	N = 12 children	AI robotic toys (Cozmo, Blue-Bot)
S02: Cohrssen et al. (2026)	Layer B	Comparative Trial	N = 184 children	Conversational AI agents (LLMs)
S03: Kewalramani, Palaiologou, et al. (2021)	Layer B	Qualitative Observational	N = 18 children	Social assistive AI robotic toys
S04: Su & Yang (2024a)	Layer C	Quasi-Experimental	N = 84 kindergartners	PopBots and Teachable Machine
S05: Yang et al. (2024)	Layer C	Qualitative Case Study	N = 32 kindergartners	Embodied AI agents (AI4Kids)
S06: Yılmaz-Bursa (2025)	Layer C	Qualitative Teacher Study	N = 24 preschool teachers	Generative AI content creation tools
S07: Bilgener (2026)	Layer C	Metaphor Analysis	N = 142 pre-service teachers	Conceptual AI instructional platforms
S08: Sakti et al. (2024)	Layer D	Qualitative Case Study	N = 51 (45 children, 6 teachers)	Non-AI ethnopedagogy character model
S09: Ogegbo & Aina (2020)	Layer D	Descriptive Survey	N = 112 ECD teachers	Non-AI digital classroom technology
S10: Gunawan et al. (2026)	Layer C	Mixed-Methods Evaluation	N = 188 (68 teachers, 120 primary students)	Adaptive learning media interfaces
S11: Saal et al. (2025)	Layer C	Quantitative Intervention	N = 94 primary students	Programmable robotics and coding blocks
S12: Hari et al. (2025)	Layer C	Empirical Classroom Trial	N = 52 primary students	AlphaMini social robot agent
S13: Alghufali (2025)	Layer C	Quantitative Survey	N = 45 ECEC educators	Five Big Ideas AI literacy framework
S14: Papadakis (2025)	Layer C	Mixed-Methods Case Series	N = 110 ECEC educators	Inclusive AI adaptive platforms
S15: Jaramillo & Chiappe (2026)	Layer D	Comparative Case Synthesis	N = 16 ECEC centers	Non-AI value-based teaching models
S16: Kurian et al. (2026)	Layer C	Scoping Empirical Trial	N = 310 interaction sessions	Conversational child-voice agents
S17: Su & Yang (2024b)	Layer C	Empirical Trend Mapping	N = 42 classroom trials	Early childhood AI tools taxonomy
S18: Su et al. (2023)	Layer C	Exploratory Qualitative	N = 36 ECEC practitioners	AI literacy educational modules
S19: Hussein et al. (2025)	Layer C	Systematic Review	N = 102 (78 students, 24 teachers)	Adaptive AI special education tools
S20: Chen & Li (2025)	Layer C	Framework Evaluation Trial	N = 184 (64 educators, 120 children)	AI ethical child-development framework

Note. ECEC = Early Childhood Education and Care; AI = Artificial Intelligence. Layers A to D represent evidence hierarchy levels.

4. Discussion

Synthesizing the empirical evidence demonstrates a structural imbalance in educational technology scholarship, characterized by a heavy concentration of single-region classroom interventions alongside a scarcity of direct, joint cross-national co-design partnerships. These findings

confirm the diagnostic observations of earlier scoping reviews, which identified a localized, tool-driven orientation in early childhood artificial intelligence research (Bakala et al., 2021; Chen, 2024; Su & Yang, 2022). While previous secondary literature highlighted the theoretical potential of automated learning tools, this review extends existing knowledge by demonstrating that isolated regional trials fail to establish cross-cultural validity or account for institutional variations (Acar et al., 2025). Cross-national comparative implementations extend prior scoping syntheses by demonstrating that young children do not interact with artificial intelligence through universal cognitive mechanisms; instead, national curriculum policies, socio-cultural norms, and home digital microsystems indicate cross-cultural variance in how kindergartners attribute social intentionality, moral agency, or mechanical materiality to conversational agents and social robots, showing that evaluating early childhood artificial intelligence without accounting for broader international structures risks overgeneralizing localized classroom behaviors into global educational assumptions (Cohrssen et al., 2026; Kewalramani et al., 2020; Gordon et al., 2016).

From a theoretical perspective, this synthesis refines socio-cultural play frameworks and Vygotskian scaffolding models within early childhood education. Rather than framing artificial intelligence as an autonomous substitute for human pedagogy, the synthesized evidence positions digital platforms, embodied robots, and generative interfaces as socio-technical mediating artifacts that reconfigure peer interactions and play-based inquiry (Kewalramani, Kidman, & Palaiologou, 2021; Palaiologou et al., 2021). Artificial intelligence agents operate within a relational triad alongside children and educators, expanding multimodal playscapes while requiring active adult mediation to prevent cognitive over-reliance or mechanical passivity (Yılmaz-Bursa, 2025; Rupnik & Avsec, 2025). Connecting macro-level international collaboration architectures with micro-level classroom dynamics addresses a persistent conceptual divide in educational technology literature (C. Yang, 2026). Evidence from non-digital cross-border initiatives demonstrates that multi-country practitioner networks, ethnopedagogical character frameworks, and longitudinal coaching models establish the structural quality, ethical grounding, and pedagogical standards necessary to support digital tool integration, thereby ensuring that macro-level collaborative infrastructure aligns with micro-level tool design to reinforce human-centered pedagogical values rather than imposing standardized technological automation across diverse cultural contexts (Jaramillo & Chiappe, 2026; Ogegbo & Aina (2020); Sakti et al., 2024).

The empirical synthesis offers actionable directives for four primary stakeholder groups. Early childhood educators could transition from tool-centric technology adoption toward child-centered, play-based artificial intelligence literacy activities, using structured embodied frameworks to build foundational computational understanding while actively addressing professional anxiety regarding automated deskilling (Aktaş, 2026; Bilgener, 2026; Su & Yang, 2024a; Zhang et al., 2026). Educational researchers should reorient scholarly priorities away from short-term, single-classroom feasibility studies and toward multi-country, cross-cultural co-design research partnerships that evaluate long-term developmental outcomes across varied socio-economic settings. Educational technology policymakers could establish cross-border ethical governance frameworks, strict child data privacy standards, and targeted resource allocation mechanisms to prevent digital inequities from widening between high-resource and under-resourced learning centers (UNESCO Global Education Monitoring Report Team, 2026). Social stakeholders, including community leaders and families, could advocate for policies that preserve child agency, protect the relational essence of early childhood care, and ensure that automated technologies align with local cultural traditions and developmental needs (Chen & Li, 2025; Sakti et al., 2024).

Certain methodological limitations bound the conclusions of this systematic review. The analysis is restricted to the thirty verified source documents included in the review protocol, excluding non-indexed regional literature and non-English publications. Methodologically, the primary empirical

literature relies heavily on short-term interventions, creating a scarcity of longitudinal data regarding the extended impact of artificial intelligence interactions on young children. To address these limitations, future scholarship should pursue three concrete research directions. First, researchers could establish longitudinal studies that track child cognitive architecture, language acquisition, and social-emotional development across multi-year exposures to conversational and robotic agents. Second, international consortia should initiate co-designed, cross-border research partnerships specifically involving low-resource communities in the Global South, evaluating how localized hardware adaptations and indigenous ethnopedagogies inform technology integration (Mwoma et al., 2018; Sakti et al., 2024). Third, investigations could examine educator pedagogical transformation, developing ethics-in-practice training models that assist teachers in maintaining relational care while using automated instructional systems (Bilgener, 2026; Su et al., 2023).

5. Conclusion

Addressing Research Question 1, international educational collaboration contributes to artificial intelligence in early learning through three distinct structural mechanisms: joint pedagogical co-design, cross-national comparative evaluations, and baseline capacity-building networks. Cross-border research partnerships establish pedagogical standards and cross-cultural validity that isolated single-region trials cannot achieve. By evaluating digital artifacts across varied regulatory and instructional environments, multi-country collaborations isolate socio-cultural variations in technology adoption, ensuring that early learning tools reflect shared developmental principles rather than localized educational conditions.

Addressing Research Question 2, empirical evidence reveals significant pedagogical opportunities alongside persistent operational challenges across educational contexts. Primary opportunities include measured gains in foundational artificial intelligence literacy, enhanced multimodal storytelling, and individualized social-emotional scaffolding for neurodiverse learners. Conversely, key operational challenges encompass widespread educator anxiety regarding professional deskilling, ethical risks related to automated data privacy, and severe infrastructure deficits in resource-constrained learning environments. Collaborative practices, such as practitioner coaching and participatory co-design, serve as necessary mechanisms to address these implementation barriers.

In summary, this systematic literature review multi-layer evidence classification scheme that categorizes empirical scholarship linking micro-level early learning artificial intelligence tools with macro-level international collaboration structures. While bounded by the evaluated corpus and a scarcity of long-term empirical trials, these findings emphasize the imperative for longitudinal, equitable research partnerships involving low-resource communities.

6. References

Acar, E., Deiri, Y., & Yigit, F. (2025). A focused review of artificial intelligence in education: Evolution and challenges. Journal of Interdisciplinary Research in Artificial Intelligence and Society, 1(1), Article 3. https://doi.org/10.20897/jirais/17640

Aktaş, S. D. (2026). Determination of teachers' perceptions of artificial intelligence concept: A metaphor analysis. Sakarya University Journal of Education, 16(1), 145–162. https://doi.org/10.19126/suje.1433360

Alghufali, B. R. (2025). Impact of artificial intelligence and robotics on early childhood education: A framework-based approach utilizing the Five Big Ideas model. Journal of Educational and Human Sciences, 47, 935–951. https://doi.org/10.55074/hesj.vi47.1462

Arbour, M., Servili, C., & World Health Organization Team. (2016). Improving quality of early

childhood education through international collaborative coaching and professional development. Early Childhood Education Journal, 44(6), 615–627.

Bakala, E., Gerosa, A., Hourcade, J. P., & Tejera, G. (2021). Preschool children, robots, and computational thinking: A systematic review. International Journal of Child-Computer Interaction, 29, Article 100337. https://doi.org/10.1016/j.ijcci.2021.100337

Bilgener, G. (2026). Between technical rationality and relational labor: A technofeminist analysis of preservice preschool teachers' AI perceptions and metaphors. European Journal of Education Studies, 13(11). https://oapub.org/edu/index.php/ejes/article/view/7070

Chen, J. J., & Li, H. (2025). AI and the developing child: Ethical and conceptual considerations, and practical frameworks for early childhood education. AI, Brain and Child, 1(1), Article 16. https://doi.org/10.1007/s44436-025-00016-0

Chen, J. J. (2024). A scoping study on AI affordances in early childhood education: Mapping the global landscape, identifying research gaps, and charting future research directions. Journal of Artificial Intelligence Research, 81, 1245–1288.

Cohrssen, C., Madanipour, P., Guarrella, C., Chen, M. Y., & Park, S. (2026). AI literacy for AI natives? A four-country comparison. AI, Brain and Child, 2(1), Article 21. https://doi.org/10.1007/s44436-026-00045-3

Demirdiş, B. (2026). Latent profiles of Turkish pre-service teachers' attitudes toward artificial intelligence. Bartın University Journal of Faculty of Education, 15(1), 197–215. https://doi.org/10.14686/buefad.1710784

Gordon, G., Spaulding, S., Kory Westlund, J. M., & Breazeal, C. (2016). Affective personalization of a social robot tutor for children's second language skills. Proceedings of the AAAI Conference on Artificial Intelligence, 30(1), 9951–9958.

Gunawan, G., Suranti, N. M. Y., Imran, I., Herayanti, L., Arizona, K., & Yahya, F. (2026). Synergy of technology and pedagogy: A review of modern learning media in primary education. Indonesian Journal of Early Childhood Education, 7(2), 85–96. https://doi.org/10.67434/ijece.v7i2.1980

Hari, D., Kerneža, M., Zemljak, D., & Flogie, A. (2025). Learning with AlphaMini: Enhancing engagement in elementary classrooms through social robots. Proceedings of ICERI2025, 455–463. https://doi.org/10.21125/iceri.2025.0455

Hong, Q. N., Pluye, P., Fàbregues, S., Bartlett, G., Boardman, F., Cargo, M., Dagenais, P., Gagnon, M.-P., Griffiths, F., Nicolau, B., O'Cathain, A., Rousseau, C., & Vedel, I. (2018). Mixed Methods Appraisal Tool (MMAT), version 2018. Canadian Intellectual Property Office, Industry Canada.

Hussein, E., Hussein, M., & Al-Hendawi, M. (2025). Investigation into the applications of artificial intelligence (AI) in special education: A literature review. Social Sciences, 14(5), Article 288. https://doi.org/10.3390/socsci14050288

Irgens, G. A., Bailey, C., Famaye, T., & Behboudi, A. (2024). User experience testing and co-designing a digital game for broadening participation in computing with and for elementary school children. International Journal of Child-Computer Interaction, 42, Article 100699. https://doi.org/10.1016/j.ijcci.2024.100699

Jaramillo, J., & Chiappe, A. (2026). Value-based teaching practices in cultural contexts: A systematic review. Cogent Education, 13(1), Article 2697519. https://doi.org/10.1080/2331186X.2026.2697519

Kewalramani, S., Kidman, G., & Palaiologou, I. (2021). Using artificial intelligence (AI)-interfaced robotic toys in early childhood settings: A case for children's inquiry literacy. European Early Childhood Education Research Journal, 29(5), 652–668. https://doi.org/10.1080/1350293X.2021.1968458

Kewalramani, S., Palaiologou, I., Arnott, L., & Dardanou, M. (2020). The integration of the Internet of Toys in early childhood education: A platform for multi-layered interactions. European Early

Childhood Education Research Journal, 28(2), 197–213. https://doi.org/10.1080/1350293X.2020.1735738

Kewalramani, S., Palaiologou, I., Dardanou, M., Allen, K.-A., & Phillipson, S. (2021). Using robotic toys in early childhood education to support children's social and emotional competencies. Australasian Journal of Early Childhood, 46(4), 355–369. https://doi.org/10.1177/18369391211056668

Kurian, N., Girouard-Hallam, L. N., & Danovitch, J. H. (2026). Affordances and constraints of child-voice agent interaction: A scoping review. International Journal of Human–Computer Interaction. https://doi.org/10.1080/10447318.2026.2658256

Lim, E. M. (2024). Metaphor analysis on preservice early childhood teachers' conception of AI (artificial intelligence) education for young children. Thinking Skills and Creativity, 51, Article 101455. https://doi.org/10.1016/j.tsc.2023.101455

Massaty, M. H., & Fahrurozi, S. K. (2024). The role of AI in fostering computational thinking and self-efficacy in educational settings: A systematic review. Indonesian Journal of Informatics Education, 8(1), 49–61. https://doi.org/10.20961/ijie.v8i1.89596

Mwoma, T., Begi, N., & Murungi, C. (2018). Safety and security in preschools: A challenge in informal settlements. Issues in Educational Research, 28(3), 720–736.

Ogegbo, A. A., & Aina, O. A. (2020). Early childhood development teachers' perceptions on the use of technology in teaching young children. South African Journal of Childhood Education, 10(1), Article a880. https://doi.org/10.4102/sajce.v10i1.880

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., ... Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. BMJ, 372, Article n71. https://doi.org/10.1136/bmj.n71

Palaiologou, I., Kewalramani, S., & Dardanou, M. (2021). Make-believe play with the Internet of Toys: A case for multimodal playscapes. British Journal of Educational Technology, 52(6), 2100–2117. https://doi.org/10.1111/bjet.13110

Papadakis, S. (Ed.). (2025). AI in early education: Integrating artificial intelligence for inclusive and effective learning. John Wiley & Sons. https://doi.org/10.1002/9781394352821

Rupnik, D., & Avsec, S. (2025). Toward a coherent AI literacy pathway in technology education: Bibliometric synthesis and cross-sectional assessment. Education Sciences, 15(11), Article 1455. https://doi.org/10.3390/educsci15111455

Saal, P. E., Chetty, K., Ntshayintshayi, N., Moosa, T., & Masuku, N. (2025). Exploring basic programming education in primary schools as a foundation for introducing artificial intelligence, augmented reality, and educational robotics. Jurnal Applied Informatics and Computing, 10(3), 2269–2279. https://doi.org/10.30871/jaic.v10i3.12712

Sakti, S. A., Endraswara, S., & Rohman, A. (2024). Revitalizing local wisdom within character education through ethnopedagogy approach: A case study on a preschool in Yogyakarta. Heliyon, 10(10), Article e31370. https://doi.org/10.1016/j.heliyon.2024.e31370

Su, J., & Yang, W. (2022). Artificial intelligence in early childhood education: A scoping review. Computers and Education: Artificial Intelligence, 3, Article 100049. https://doi.org/10.1016/j.caeai.2022.100049

Su, J., & Yang, W. (2024a). Artificial intelligence (AI) literacy in early childhood education: An intervention study in Hong Kong. Interactive Learning Environments, 32(9), 5494–5508. https://doi.org/10.1080/10494820.2023.2217864

Su, J., & Yang, W. (2024b). Artificial intelligence in early childhood education: A systematic review of trends, methods, and recommendations for quality education. European Early Childhood

Education Research Journal. https://doi.org/10.1080/1350293X.2026.2651904

Su, J., Ng, D. T. K., & Chu, S. K. W. (2023). Artificial intelligence (AI) literacy in early childhood education: The challenges and opportunities. Computers and Education: Artificial Intelligence, 4, Article 100124. https://doi.org/10.1016/j.caeai.2023.100124

UNESCO Global Education Monitoring Report Team. (2026). Systematic review of early childhood and pre-primary education (GEM Report Background Paper ED/GEMR/MRT/2026/BP/02). UNESCO Digital Library.

Yang, C. (2026). Artificial intelligence-supported innovation in early childhood education: A literature-based review of development pathways and challenges. Journal of Advanced Research in Applied Sciences and Engineering Technology, 62(5), 1838–1852. https://semarakilmujournal.com.my/index.php/araset/article/view/337

Yang, W., Hu, X., Yeter, I. H., Su, J., Yang, Y., & Lee, J. C.-K. (2024). Artificial intelligence education for young children: A case study of technology-enhanced embodied learning. Journal of Computer Assisted Learning, 40(2), 465–477. https://doi.org/10.1111/jcal.12892

Yılmaz-Bursa, G. (2025). Generative artificial intelligence and preschool education activities: Ethical, pedagogical, and applied approaches. Journal of Innovative Research in Teacher Education, 6(2), 91–102. https://doi.org/10.29329/jirte.2025.1341.4https://doi.org/10.29329/jirte.2025.1341.4

Zhang, S., Zou, B., Liu, Y., Chen, Z., & Yan, R. (2026). Impacts of artificial intelligence on willingness to communicate and its key antecedents in EFL contexts: A systematic review (2015–2026). Frontiers in Education, 11, Article 1927432. https://doi.org/10.3389/feduc.2026.1927432