ROLE OF TECHNOLOGY IN TEACHING EARLY MATHEMATICS: A CONCEPTUAL FRAMEWORK FOR PRESCHOOL EDUCATION

Shafinaz Binti Shapie*
Faculty of Human Development, Universiti Pendidikan Sultan Idris, Tanjung Malim, Perak, Malaysia
p20232002865@siswa.upsi.edu.my

Norly Binti Jamil
Faculty of Human Development, Universiti Pendidikan Sultan Idris, Tanjung Malim, Perak, Malaysia

Jamilah Binti Mohd Basir
Faculty of Human Development, Universiti Pendidikan Sultan Idris, Tanjung Malim, Perak, Malaysia

Abstract: In early childhood education, the rapid advancement of digital technology has significantly influenced the pedagogical practises, learning environment and also student's achievement. The increasing exposure of preschool learners to digital tools presents new opportunities for developing foundational mathematical competencies. This conceptual paper determines the roles and uses of the technology in teaching early mathematics and proposes a comprehensive conceptual framework to guide the effectiveness of the digital tools in early childhood education. The use of technology in teaching is a critical concern in education amid technological shifts and paradigm changes. Drawing from the established empirical studies and the relevant papers synthesis literature to identify the roles of the digital tools by integrated the technology in teaching mathematics for the preschool children in the range age below 6 years old. The frameworks also highlighted the contextual factors that influenced successful implementation of technology in preschool mathematics instruction. Through a systematic analysis of scholarly articles published between 2010 and 2026, this review identifies the roles technology plays in early mathematics education. Studies comprises of 106 papers were analysed across multiple databases, with 17 main papers studied accordingly. Results reveal four dominant roles of technology: (1) Enhancing Conceptual Understanding, (2) Promoting Engagement and Motivation, (3) Supporting Differentiated Learning and (4) Facilitating Teacher Instruction and Assessment. By conceptualising the interplay between technological tools, pedagogical strategies, and learning outcomes toward the children, this paper contributes to a clearer understanding of how technology can be purposefully utilised to enhance early mathematical learning and teaching.

Keywords: Mathematics, Early Childhood, Technology

1. Introduction

1.1 *Digital Technology Integration in Early Childhood Education*

Integration of the Digital Technology (DT) is the key to steering educational institutions to excellence lies in tech-teaching styles (Hwang et al., 2023). The pedagogically meaningful integration of digital technology has become a critical driver of educational innovation and institutional effectiveness. The introduction and expansion of technology in education have changed the educational environment especially in early childhood education (ECE) field. The integration of DT concepts includes computers, printers, telephones, smartphones, electronic toys, Internet connections, tablet computers, interactive whiteboards, digital cameras, facsimile machines, and voice recorders (Bolstad, 2004; Plowman & Stephen, 2005). These varied forms of DT may provide opportunities to support many aspects of ECE. In addition, Artificial Intelligence (AI, hereafter), sometimes called machine intelligence, is intelligence demonstrated by machines or computers (Solanki et al., 2021). AI is one of the integration uses of technology that has been increasingly showing significant contributions in ECE. From robotic instruction to the invention of an automated system for scoring answer sheets, for instance, AI has a role to play in facilitating teaching, learning, and assessment (Jiahong et. al, 2022).

1.2 *Roles of Technology in Teaching Mathematics in ECE*

Throughout these recent years, the rapid developments of Information Communication Technology (ICT,hereafter) had has brought significant developments in global education systems (Artemis et.al, 2021). In the present study, we aim to record preschool teachers' views on the use, benefits, and barriers of ICT for teaching mathematics in the classroom. Apart from these studies, they also seek to examine the roles of ICT and technology and other digital tools used as educational tools in teaching mathematics to preschool students.

Technology is an integral part of developing 21st-century skills among preschool students. The curriculum aims to help children expand their basic mathematical knowledge and practice new skills in an experiential, interdisciplinary context. Furthermore, toddlers who use the method of trying and testing can process new data and calculate simple mathematical equations. In addition, using modern technology, they can solve problems, recognise numbers on the keyboard, and understand the importance of calculators and digital tools in everyday life (KSPK, 2017). That has been comprehensively discussed in Malaysia's curriculum framework for developing 21st-century and other computational skills among preschoolers.

Trends among local Malaysian educators and researchers focus on the pillar stand in KSPK (2017), but recently, the new Kurikulum Prasekolah 2026 (KP2026) and Kurikulum Persekolahan 2027 will be implemented for Malaysian students soon. Thus, understanding the uses of the technology in implementing the KP2026 will assist teachers, educators, and researchers in enhancing pedagogy, especially in building digitally savvy characters among students. Digital literacy has been listed as one of the pillars in this new KP2026.

Various intelligent systems driven by information technologies have gained widespread adoption in ECE. Digital technologies such as the Internet of Things (IoT), data mining, and Machine Learning (ML), along with the acquisition and leveraging of diverse data, have been used for health diagnostics, developmental assessments, and behavioural pattern analysis, thereby providing robust support for early childhood development. For instance, smart toys integrated with sensors, actuators, and internet connectivity offer novel pathways for children's learning and development (Liu,J. et.al, 2025).

2. Methodology

2.1 *Research Objectives and Questions*

This concept paper is aimed to determine the role of DT in ECE especially in teaching mathematics to the preschool children age below 6 years old. In this study, we followed the principles established by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Moher, 2015). We gathered empirical researches, reviewed literature papers and also synthesized studies in ECE related with DT and ICT through the electronic database.

In view of the differences that may be caused by differences in research methods, participant characteristics, authors' country, digital tools and knowledge or activity evaluation found in the literature, this review aims to evaluate, synthesize and display the latest literature on the use in ECE, involving research design, AI tools, DT activities and research results. To achieve the objectives, we focused on articles on the application of AI in young children's learning and development and on studies on technology in ECE.

We also seek papers that explore any digital tools and review papers regarding the use of technology in preschool of Malaysia or outside Malaysia worldwide. In addition, the study proposes possible directions for future technology research, aiming to establish a strong theoretical foundation, clarify factors that hinder the efficient application of AI in ECE, and emphasise the digitalisation of digital

tools. Hence giving one systematically main framework on the concept of DT in ECE globally. Through this concept paper, the following Research Questions (RQs) will be answered:
RQ1: What technology has been used in ECE?
RQ2: What are the roles of DT in ECE?
RQ3: What are the roles of DT in teaching mathematics in ECE?

2.2 *Materials and Methods*

A systematic literature search includes papers from the electronic database likely Web of Science (WoS), Scopus, Springer, PMC, arXiv, MDPI, Institute of Electrical and Electronics Engineers (IEEE) and database Education Resources Information Centre (ERIC). All articles and papers are accessed from 2010 to January 2026. Stages of the search are shown as in Figure 1.

Initially, we entered search terms such as “technology in education,” “ digital tools use in ECE,” “artificial intelligence,” “AI,” and “early childhood education.” However, to narrow the results, we employed a similar approach to that of Toh et al. (2016). The search string used for technology in ECE review was: “AI” OR “Artificial Intelligence” OR “Deep learning” OR “Machine Learning” OR “Teaching Mathematics*” OR “computer- supported collaborative learning with technology” OR “DT Digital Tools*“AND “early childhood” OR “young child*” OR “preschool*” OR “kindergarten*” OR “pre-k*” OR “childcare” OR “child care” OR “day care” OR “children. Databse searched also includes ERIC, Scopus, WoS, JSTOR, ScienceDirect, and Google Scholar were searched using keywords like "technology in early math education," "preschool digital math tools," "interactive mathematics learning," and "ICT in preschool” in order to widen the literature search.

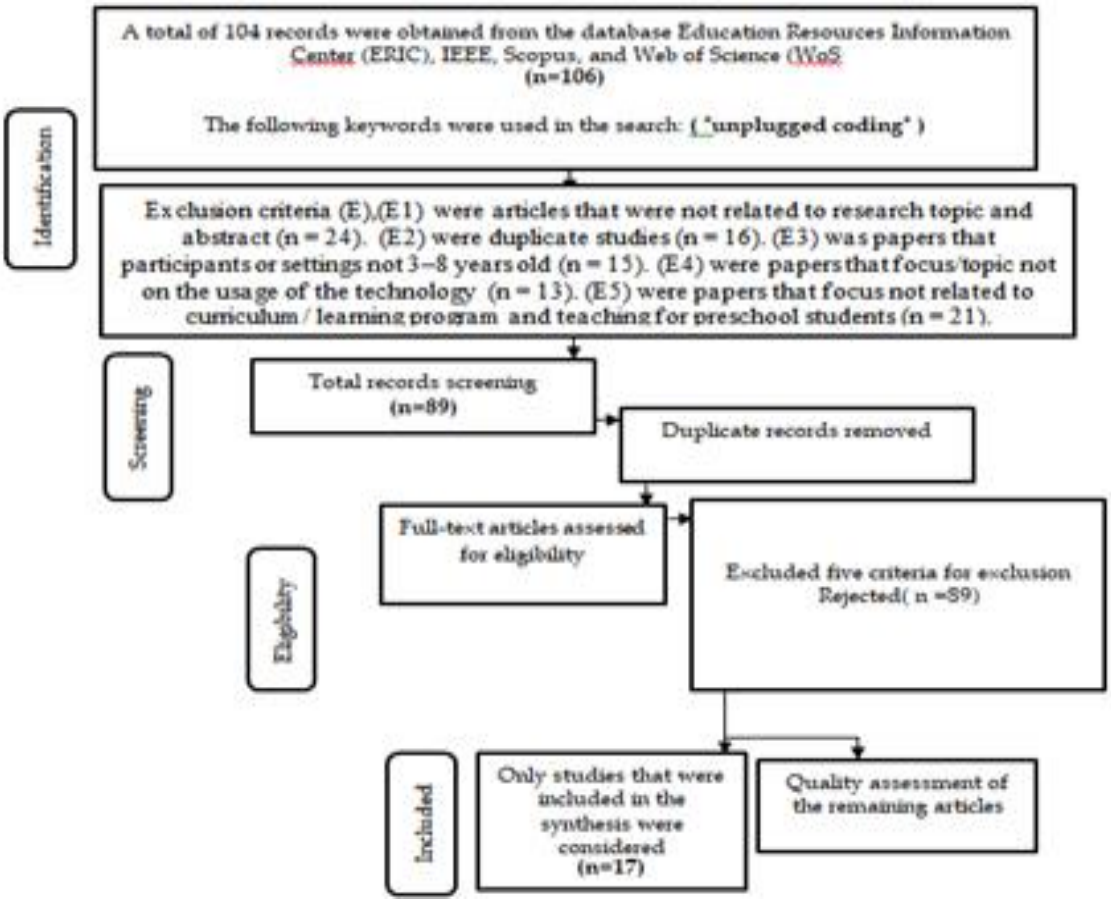

Figure 1: Flow Diagram of Research Selection Process using PRISMA Adapted from a Study by Moher et al. (2015)

3. Findings

A total of 106 papers were identified from the database search that can be considered for this research study on visualize the framework related with DT in ECE especially in teaching mathematics for the pre-schoolers in different countries across the globe. However, 89 of the articles and papers been excluded based on the five criteria for the exclusion. Thus only 17 papers found to be qualified based on the re-porting items indicated for the thematic review since they were found to be more relevant and fit with the research aims.

Corresponding to the RQ1 (What technology has been used in ECE?) and RQ2 (What are the role of DT in ECE?) of this concept paper, we presented the findings in Table 1 to answer RQ1 and RQ2 as follow:

Table 1: Charting the Data

Source	Paper (Author, Year)	Study Type	Technology Examined	Main Finding/Roles
ERIC	Aldhilan (2024)	Systematic review	ICT (computers, software)	ICT is widely used in early childhood classrooms to support interactive learning, but its effectiveness is constrained by teachers' limited digital preparedness and the need for pedagogically meaningful integration.
ResearchGate	Demeke et al. (2022)	Empirical	Interactive apps, e-learning, digital toys	Tech can enhance cognition & creativity. Interactive applications, e-learning platforms, and digital toys can enhance young children's cognitive development and creativity by supporting engaging, exploratory, and technology-mediated learning experiences.
ERIC	Eliot et al. (2023)	Systematic review	Various technologies	Key conceptual dimensions of technology integration in early childhood education, emphasising how diverse digital tools shape pedagogical practices, learning environments, and developmental outcomes.
ResearchGate	Hsin et al. (2014)	Empirical	Educational apps	Educational applications can support improvements in young children's language and early numeracy skills by providing interactive, engaging, and developmentally appropriate learning opportunities.
Springer	Lindeman et al. (2021)	Qualitative	Digital tools (tablets, cameras)	Preschool teachers demonstrate varied practices and levels of competence in using digital tools such as tablets and cameras, influencing the effectiveness of technology integration in classrooms.
Atlantis Press	Nurdiantami & Agil (2020)	Systematic review	PCs & tablets	Tablets offer better usability than PCs for young learners, but effective educational integration relies on consistent adult guidance to facilitate meaningful interaction and outcomes.
ResearchGate	Nirmala et al. (2024)	Literature review	Augmented Reality (AR)	Augmented Reality (AR) in early childhood education improves student engagement and academic performance through interactive, multisensory learning experiences. The review highlights that AR bridges abstract concepts with reality, acting as a powerful tool to enhance cognitive connection with the curriculum.
PMC	Pila et al. (2019)	Survey synthesis	Whiteboards,AR support learning activity, computers	AR integration significantly boosts student engagement and academic performance by providing immersive, interactive experiences that simplify complex concepts

				and increase learner motivation across diverse educational settings
journalofeducationalinformatics.ca	Plowman et al. (2012)	Empirical	Interactive media	Interactive media enhances early literacy in preschool children by fostering engagement and supporting active learning, particularly when integrated into a play-based curriculum. The research emphasizes a "guided interaction" model, where adult support ensures digital tools enrich rather than replace traditional learning interactions.
Springer	Eryigit et al. (2025)	Mixed methods	AR-supported learning	Integrating augmented reality (AR) into preschool geometry instruction significantly improves shape identification skills and boosts intrinsic motivation compared to traditional methods. The mixed-methods study suggests that interactive, AR-supported activities bridge the gap between physical and digital, enhancing student engagement and cognitive growth in early education.
MDPI	Neo.et al (2025)	Mixed methods	AR mobile app	The ARKiD study (2025) employed a mixed-methods approach to investigate an augmented reality (AR) app, finding that both preschoolers and teachers rated the tool positively for engagement and usability. The study, published in MDPI's Education Sciences, concludes that AR-based flashcards provide a viable, high-engagement pedagogical resource for modern preschool classrooms
PubMed	Eryiğit et al. (2025)	Systematic review	Multiple technologies	Integrating various instructional technologies into early childhood education significantly enhances children's academic achievement and social-emotional development, offering a versatile range of support for foundational skill acquisition.
PMC	Fleer et al. (2023)	National study	Apps, tablets, digital platforms	Digital technology integration facilitates quality enhancement in early childhood settings, yet its efficacy depends on holistic strategic planning, educator professional development, and alignment with national quality standards
Emerald	AM et al. (2025)	Conceptual	Interactive storytelling, AI	This research identifies interactive storytelling and artificial intelligence as transformative pedagogical tools, emphasizing that effective integration requires robust digital infrastructure, specialized teacher training, and strategic parental engagement.
arXiv	Silva et al. (2021)	Systematic review	Robots, coding tools	A systematic review demonstrates that robotic tools and coding environments effectively foster computational thinking in early learners by providing immersive, hands-on experiences that significantly increase classroom engagement
arXiv	Yi et al. (2023)	Review	AI & robots	Artificial intelligence and robotic systems facilitate personalized educational interactions, offering tailored pedagogical support that enhances learning outcomes for young children, including those with diverse neurodevelopmental needs
arXiv	Uriawan et al. (2025)	Developmental study	AR app	Developmental research indicates that augmented reality applications significantly elevate student engagement and conceptual understanding by transforming abstract

	educational content into immersive, interactive, and visually accessible learning experiences.

Figure 2 shows the key roles of technology in teaching mathematics in ECE. We categorized the findings in four subthemes to describe the roles of DT in teaching mathematics in ECE (RQ3: What are the roles of DT in teaching mathematics in ECE?) as follows:

3.1 *Enhancing Conceptual Understanding*

Digital manipulatives and visual-based applications like Number Rack (Starkey et al., 2016) allow pre-schoolers to visualize mathematical operations. Tools such as TouchMath and Montessori-inspired apps help children internalize abstract concepts through interaction.

3.2 *Promoting Engagement and Motivation*

Gamified platforms like Moose Math and DragonBox Numbers foster motivation and sustained attention (Neumann, 2018). Studies highlight that game-based learning environments enhance interest and retention (Papadakis et al., 2020).

3.3 *Supporting Differentiated Learning*

Adaptive systems, such as DreamBox and Mathseeds, adjust the level of difficulty based on individual performance, making them suitable for diverse learning needs (Kim et al., 2021).

3.4 *Facilitating Teacher Instruction and Assessment*

Technology assists teachers in planning lessons, tracking progress, and identifying misconceptions (Chen & Chang, 2017). Interactive whiteboards and formative assessment apps are widely used tools.

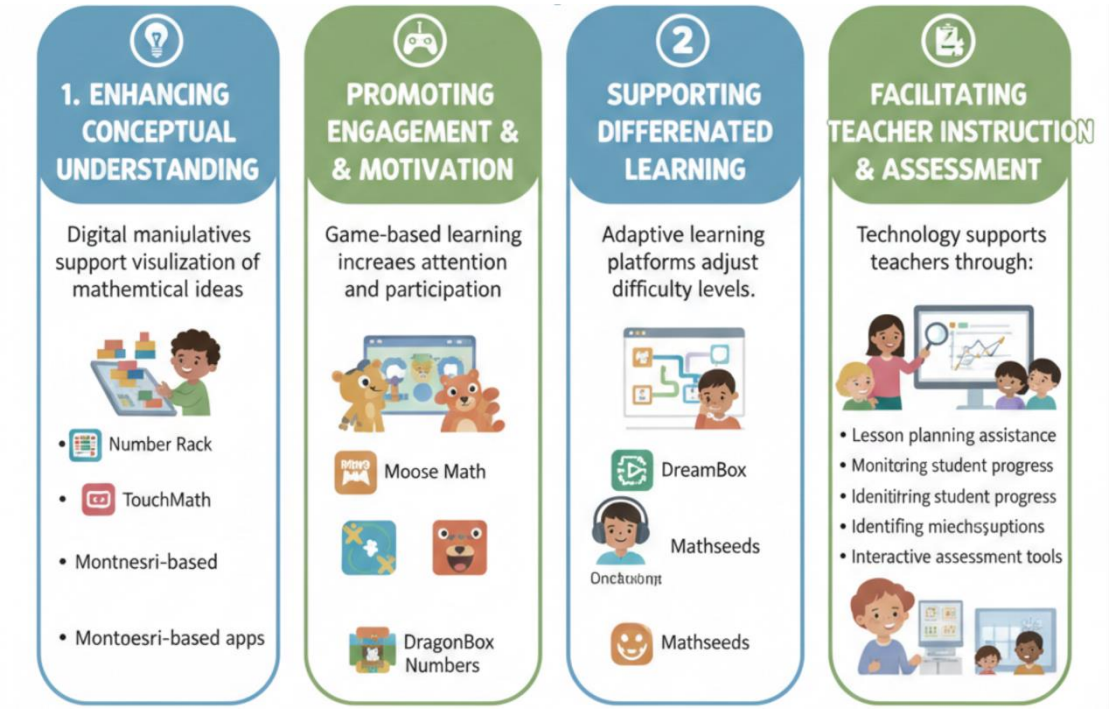

Figure 2: Key Roles of Technology in Teaching Early Mathematics (Sources : OpenAI,2026 generated images)

4. Conclusion

Based on the findings, the study demonstrates that the role of technology has been widely acknowledged in this modern era globally. Digital technologies play vital contribution as tools and resources in teaching and learning in ECE. The phenomenon of DT in ECE changed the learning environment and also multiple pedagogical in teaching mathematics in preschool level.

Indirectly DT play significant roles as pedagogical support tools for the teachers to support the mathematical instruction. Teacher preparedness toward the lesson using the integration of DT in the class. In addition, multimedia resources enrich the pedagogical support as teaching strategies and explanation.

DT provides chance to gain conceptual understanding to young learners through interactive activities such educational apps which promote learning through e-exploration journey. Apart, DT also play as learning resources to individual to learn through individualised learning with flexible access to DT. These resources include adjustability level of difficulties in learning through apps or e-module, immediate feedback during the learning session and scaffolding through repetition of learning using the DT. Hence we can conclude that DT plays major roles as tools and resources in teaching and learning to the young learners.

References

Aldhilan, D. (2024). The incidence of information and communication technologies in early childhood classrooms: A systematic literature review. *Pedagogical Research, 9*(2), em0190.

AM, M. A., Mirawati, M., Hopiani, A., & Despriliani, R. (2025). Future-ready instructional technology for early childhood education: A bibliometric and meta-synthesis analysis. *On the Horizon: The International Journal of Learning Futures, 33*(4), 418–443.

Chen, M., & Chang, Y. (2017). The roles of technology in supporting preschool mathematics learning. *Early Childhood Education Journal, 45*(4), 513–522.

Demeke, M. M., Gebremedhin, Z. A., & Yohannes, T. K. (2022). The role of technology in early childhood education: Enhancing learning experiences. *ICISTECH Proceedings*.

Eryiğit, Ç. D., Küçük, S., & Taşgın, A. (2025) .Impact of augmented reality technology on geometry skills and motivation of preschool children. *Education and Information Technologies*, 30, 22753–22778.

Eliot, S., Peterson, L., & Lantz-Andersson, A. (2023). A systematic literature review of empirical research on technology education in early childhood education. *International Journal of Technology and Design Education, 33*(3), 793–818.

Fleer, M., Rai, P., & Fragkiadaki, G. (2023). *The role of digital technologies in supporting quality improvement in ECEC.* Monash University; Australian Children's Education and Care Quality Authority (ACECQA). acecqa.gov.au

Hsin, C.-T., et al. (2014). Specific study on digital applications for early literacy and numeracy. In cited literature on technology tools and early learning outcomes.

Hwang, G.-J.; Tu, Y.-F. (2021). Roles and Research Trends of Artificial Intelligence in Mathematics Education: A Bibliometric Mapping Analysis and Systematic Review. *Mathematics*, 9, 584

Lindeman, S., Svensson, M., & Enochsson, A. B. (2021). Digitalisation in early childhood education: Teachers' experiences with digital tools. *Education and Information Technologies*.

Neo, H.-F., Law, K. A., Ng, W., Thye, Y. Y., & Teo, C.-C. (2025). Augmented reality technology in aiding preschoolers' education: A preliminary study. *Education Sciences, 15*(8), Article 1033. https://doi.org/10.3390/educsci15081033

Nurdiantami, Y., & Agil, H. M. (2020). *The use of technology in early childhood education: A systematic review.* Atlantis Press Proceedings.

Nirmala, B., Solihatin, E., & Sukardjo, M. (2024). Augmented reality in early childhood education: Trends, practices and insights from a literature review. *International Journal of Interactive Mobile Technologies, 18*(22), 50–67.

Papadakis, S., Kalogiannakis, M., & Zaranis, N. (2021). Teaching mathematics with mobile devices and the Realistic Mathematical Education (RME) approach in kindergarten. *Advances in Mobile Learning Educational Research, 1*(1), 5-18.

Papadakis, S., Alexandraki, F. & Zaranis, N. (2022). Mobile device use among preschool-aged children in Greece. *Educ Inf Technol, 27*, 2717–2750.

Paul, C. D., Hansen, S. G., Marelle, C., & Wright, M. (2023). Incorporating technology into instruction in early childhood classrooms: A systematic review. *Advances in Neurodevelopmental Disorders, 7*(4), 380–391.

Pila, M., et al. (2019). Survey on technology use (computers, tablets, whiteboards) in preschool classrooms. As noted in systematic evidence about technology prevalence.

Plowman, L., et al. (2012). Interactive media and digital devices in early childhood literacy development. Cited in research syntheses.

Silva, E. F., Dembogurski, B. J., & Semaan, G. S. (2021). A systematic review of computational thinking in early ages. *International Journal of Early Years Education*, 1–20.

Uriawan, W., Zahran, M. A. H., Deswita, I. A., et al. (2025). Implementation of augmented reality as an educational tool for practice in early childhood. *arXiv preprint*.

Yi, H., Liu, T., & Lan, G. (2023). The key artificial intelligence technologies in early childhood education: A review. *arXiv preprint*.