



Management of Early Childhood Education Learning Environments Based on Digital Ecosystems to Support Adaptive and Inclusive Learning: A Literature Review

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Abstract

Digital transformation has shifted the management of Early Childhood Education (PAUD) learning environments from conventional approaches towards a digital ecosystem that supports adaptive and inclusive learning. However, the integration of digital ecosystems into the management of PAUD learning environments still faces various challenges, such as limitations in educators' digital skills, infrastructure, and implementation strategies. This study aims to analyse strategies for managing ECE learning environments based on digital ecosystems and their contribution to supporting adaptive and inclusive learning. The study employs a literature review method, examining scientific publications from 2020 to 2026 obtained from various reputable databases. The findings indicate that the management of a digital ecosystem-based learning environment: (i) enhances the accessibility and flexibility of learning; (ii) supports adaptive learning by providing learning experiences tailored to children's characteristics and needs; (iii) strengthens the implementation of inclusive education by accommodating learner diversity; (iv) enhances collaboration between teachers, parents and early childhood education institutions via digital platforms; (v) promoting the creation of an innovative, sustainable learning environment geared towards the development of 21st-century skills. These findings confirm that managing a learning environment based on a digital ecosystem is an effective strategy for improving the quality of early years education services. Therefore, it is necessary to strengthen educators' competencies, provide adequate infrastructure, and implement policies that support digital transformation to ensure optimal implementation.

INTRODUCTION

Digital transformation has become a key driver of change in the education system at various levels, including Early Childhood Education (PAUD).

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The use of digital technology is no longer limited to a learning medium, but has evolved into an ecosystem that integrates educators, students, parents, learning resources, and the educational environment into a single, interconnected system (Susilowati et al., 2025). The digital ecosystem provides opportunities to create a more flexible, collaborative, and child-centered learning environment, thus supporting the cognitive, social, emotional, and creative development of early childhood. This change requires PAUD institutions to manage the learning environment more adaptively to meet the educational needs of the digital era (Tobondo & Putra, 2025; Tamyiz et al., 2025).

Learning environment management is one of the factors that determine the success of the learning process in early childhood education (PAUD). An effectively designed learning environment encompasses not only physical aspects but also social, psychological, and digital dimensions that influence the quality of interactions and children's learning experiences (Sulistina & Wardani, 2025). In the context of digital transformation, learning environment management is directed at utilizing technology to provide meaningful, personalized learning experiences that are appropriate to children's developmental characteristics. This approach aligns with the concept of adaptive learning, which adjusts learning strategies, media, and activities based on students' needs, abilities, and learning styles, while also supporting the principle of inclusive education, which provides equal learning opportunities for all children.

As well as supporting adaptive learning, digital transformation also offers significant opportunities to strengthen the implementation of inclusive education. Inclusive education affirms that every child has an equal right to access high-quality educational services, regardless of their physical condition, abilities, social, economic or cultural background, or special needs. The digital ecosystem enables the provision of learning materials in various formats, such as text, audio, video, animation, educational games and other interactive media (Rahmawati et al., 2025; Fitriah et al., 2026). This diversity of media provides alternative learning experiences that can be tailored to the characteristics of each learner, thereby enabling the principles of equality and equity in education to be realised more effectively.

Although it offers a range of opportunities, the implementation of digital ecosystem-based learning environment management in early years education institutions still faces various challenges. A number of studies indicate that educators' digital competences have not developed evenly, meaning that the use of technology is often limited to presentation tools or communication applications without being integrated into child-centred learning strategies (Risdianto et al., 2026). Furthermore, limitations in technological infrastructure, low digital literacy, regional disparities in internet access, and insufficient funding support remain barriers to the development of a sustainable digital ecosystem. Another challenge is the sub-optimal involvement of parents in guiding the safe and educational use of technology, even though collaboration between schools and families is a vital component of early childhood education.

On the other hand, the use of digital technology in early childhood education also raises various pedagogical issues. The use of digital devices that are not designed in accordance with the principles of child development has the potential to reduce social interaction, play activities, exploration of the real environment, and hands-on learning experiences all of which are hallmarks of early childhood education. Therefore, the digitalisation of learning should not be understood as a replacement of conventional learning activities with technology, but rather as an effort to integrate technology in a balanced way to enrich children's learning experiences (Nguyen & Tuamsuk, 2022). Consequently, the success of digital transformation depends heavily on educators' ability to strike a balance between the use of technology and learning activities based on real-world experiences.

Although the use of digital technology in early childhood education (PAUD) continues to grow, its implementation still faces various challenges. Various studies report that uneven distribution of digital competencies among educators, limited technological infrastructure, low digital literacy, and suboptimal collaboration between schools and parents are factors that hinder the management of digital ecosystem-based learning environments. Furthermore, the use of technology without pedagogical planning has the potential to reduce social interaction, direct learning experiences, and stimulation of child development, which are key characteristics of early childhood education (Azzahrah et al., 2025; Al Bana et al., 2025). These conditions indicate that digital transformation requires a management strategy that is not only oriented towards technology use but also considers pedagogical aspects, child development, and inclusivity.

Several previous studies generally discuss the use of digital media, learning platforms, or teachers' digital competencies separately. Other studies have focused more on the effectiveness of technology in improving learning outcomes without linking it to the management of the learning environment as an ecosystem involving various stakeholders. Furthermore, studies specifically integrating the concepts of digital ecosystems, learning environment management, adaptive learning, and inclusive education in the context of early childhood education (ECE) are still relatively limited (Jayousi et al., 2025; Martin et al., 2020). These limitations indicate a research gap: the lack of a comprehensive literature synthesis on strategies for managing digital ecosystem-based ECE learning environments to support adaptive and inclusive learning. Based on these gaps, this study aims to analyze digital ecosystem-based early childhood education (PAUD) learning environment management strategies through a literature review and identify their contribution to the development of adaptive and inclusive learning. The results are expected to enrich conceptual studies on learning environment management in the digital era and provide recommendations for educators, PAUD institution managers, and policymakers in designing more effective, inclusive, and sustainable learning ecosystems.

METHODS

This study uses a literature review approach to analyze strategies for managing digital ecosystem-based Early Childhood Education (PAUD) learning environments to support adaptive and inclusive learning. Data sources include scientific articles, books, proceedings, and academic documents published between 2020 and 2026, obtained from reputable databases such as Scopus, Web of Science, ERIC, ScienceDirect, SpringerLink, and Google Scholar. (Jones et al., 2011; Saitadze & Lalayants, 2021; Engkizar et al., 2026). Literature is selected based on inclusion criteria, namely relevant to the research theme, available in full text, through a peer review process (*peer-reviewed*), and discussed learning environment management, digital ecosystems, adaptive learning, inclusive learning, or early childhood education. Conversely, publications that were irrelevant, duplicate, or did not meet academic standards were excluded from the analysis process. Data were analyzed using content analysis techniques (*content analysis*) through the stages of identification, reduction, categorization, synthesis, interpretation, and drawing conclusions. To enhance the validity and credibility of the research findings, source triangulation was carried out by comparing findings from various articles published in reputable journals and drawn from different research contexts. Furthermore, the synthesis of results focused on the consistency of findings, differences in perspective, and research gaps that still require further study. Through this procedure, this study has produced a comprehensive understanding of strategies for managing early childhood education (PAUD) learning environments based on digital ecosystems, the factors influencing

their implementation, and their implications for the development of adaptive and inclusive learning in the era of digital transformation. (Runcinski et al., 2018; Mukhlis & Mbello, 2019; Nisa et al., 2021; Mutathahirin et al., 2026) To increase the credibility of the results, a source triangulation process was conducted by comparing findings from various publications to obtain a comprehensive synthesis of strategies for managing early childhood education learning environments based on digital ecosystems and their implications for adaptive and inclusive learning.

RESULT AND DISCUSSION

The results of the literature review indicate that the development of digital technology has shifted the paradigm of Early Childhood Education (PAUD) learning environment management from a conventional approach to an integrated digital ecosystem. The learning environment is no longer understood solely as a physical space where the learning process takes place, but has evolved into an ecosystem that connects students, educators, parents, learning resources, digital devices, and educational policies in a single, mutually supportive system. This transformation provides an opportunity to create a more flexible, personalized, collaborative learning experience, and one that is centered on the developmental needs of children. Based on a synthesis of various studies published during the 2020–2026 period, five main themes were identified that describe strategies for managing PAUD learning environments based on digital ecosystems to support adaptive and inclusive learning. A more detailed explanation of the management of a learning environment based on students' digital ecosystems can be seen in Figure 1.

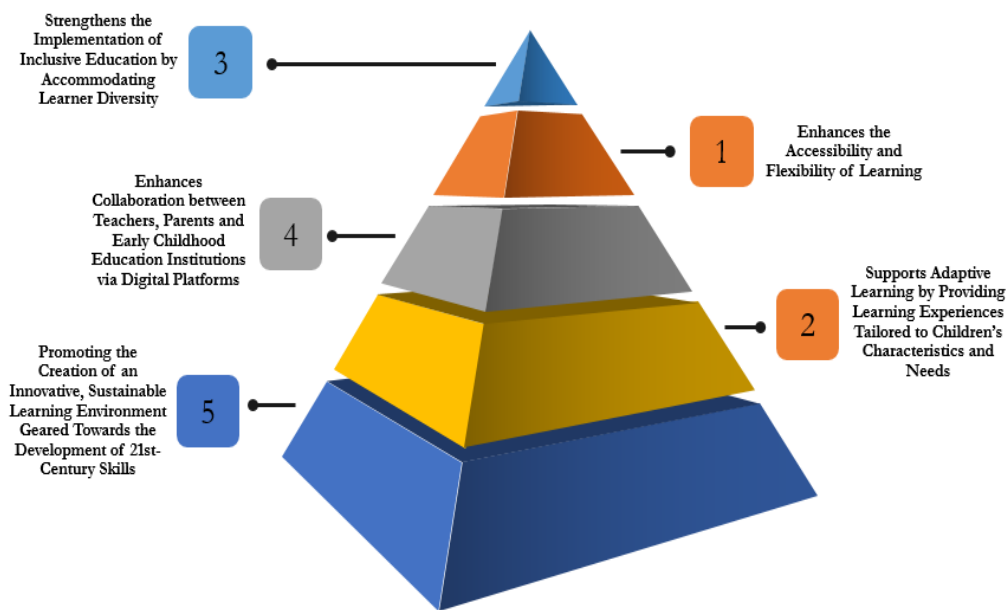


Fig 1. A Digital Ecosystem-Based Strategy for Managing the Early Years Education Learning Environment

Enhances the Accessibility and Flexibility of Learning

Most studies show that the implementation of a digital ecosystem can increase learning accessibility through the use of various learning platforms, educational applications, digital libraries, audiovisual media, and interactive educational games (Karagaianni & Drigas, 2023; Wostover, 2025). The presence of technology allows students to gain a broader learning experience without being limited by space and time. Teachers can provide various learning resources that are easily accessible, while parents can actively participate in accompanying their children's learning process at

home. This flexibility also provides opportunities for teachers to develop more varied learning according to the characteristics of students. Learning materials are no longer delivered one-way, but are developed through exploration activities, digital games, simulations, learning videos, and simple projects that can increase children's learning motivation (Ismail et al., 2024). A learning environment rich in digital experiences provides opportunities for children to build knowledge through interactions with various media that are interesting and appropriate to their developmental stage. However, various studies confirm that increased accessibility has not been fully accompanied by equitable implementation. Limited digital devices, internet network quality, and digital literacy gaps across regions remain major challenges (Leong, 2025). Therefore, managing a digital ecosystem-based learning environment must consider equitable access to ensure all students receive equal learning opportunities.

Supports Adaptive Learning by Providing Learning Experiences Tailored to Children's Characteristics and Needs

The study findings show that the digital ecosystem provides greater opportunities for the implementation of adaptive learning (*adaptive learning*). This approach allows teachers to tailor materials, methods, media, and assessment formats based on each child's initial abilities, interests, needs, and learning pace (Ghosh, 2024; Del & Indelicato, 2026;). Various digital learning applications provide content with varying levels of difficulty so that the learning process can be tailored individually without compromising established learning objectives. In the context of early childhood education (ECE), adaptive learning plays a crucial role because each child develops at a unique pace. Digital technology provides teachers with the opportunity to more systematically observe children's development through digital documentation, electronic portfolios, and development monitoring applications. This information can be used as a basis for designing more relevant and meaningful learning activities (Bartolo et al., 2021; Ortega et al., 2025). However, the effectiveness of adaptive learning is strongly influenced by the educator's pedagogical and digital competencies. Teachers are required not only to be able to operate digital devices but also to understand the principles of early childhood development so that technology is utilized as a means to enrich the learning experience, rather than replacing direct interaction, which remains the main foundation of early childhood education.

Strengthens the Implementation of Inclusive Education by Accommodating Learner Diversity

The study also showed that managing a digital ecosystem-based learning environment significantly contributes to strengthening inclusive education (Ackah, 2026). Various digital media allow for the presentation of learning materials in various formats, such as text, images, audio, video, animation, and interactive games, thus accommodating the diversity of learning styles and needs of students. This approach provides broader opportunities for children with different learning needs to participate in the learning process according to their respective abilities. Teachers can utilize technology to differentiate learning, provide additional support to students who need assistance, and provide enrichment activities for children who are developing more quickly (Maskur & Othman, 2025; Kalip et al., 2025). However, various studies confirm that digital technology is not the sole factor determining the success of inclusive education. An inclusive learning environment still requires a school culture that values diversity, educators' readiness to implement differentiated learning strategies, and family and community support (Mhlongo et al., 2023; Jain et al., 2026). Thus, the digital ecosystem functions as a supporter of the implementation of inclusive education which must be integrated with a learner-centered pedagogical

approach.

Enhances Collaboration between Teachers, Parents and Early Childhood Education Institutions via Digital Platforms

One of the most consistent findings across numerous studies is the importance of collaboration between teachers, parents, and educational institutions in building an effective digital ecosystem. Digital communication platforms enable the exchange of information on child development, the delivery of learning activities, the provision of feedback, and the coordination of various educational programs more quickly and efficiently (Andrin et al., 2024; Kyaw & Ng, 2026). Parental involvement is increasingly important because much of a child's learning takes place within the family environment. Through intensive communication, teachers can provide guidance to parents on learning support strategies, the safe use of digital media, and stimulation of children's development at home. Conversely, parents can share information about their children's development, interests, and learning difficulties, providing teachers with a more comprehensive picture in designing learning (Loi & Dillon, 2006; Liu et al., 2026). Strong collaboration between schools and families creates continuity in children's learning experiences. This not only increases the effectiveness of learning but also strengthens a sense of shared responsibility in supporting optimal child growth and development.

Promoting the Creation of an Innovative, Sustainable Learning Environment Geared Towards the Development of 21st-Century Skills

A literature review shows that the success of managing a digital ecosystem-based learning environment is not only determined by the availability of technology but also influenced by the readiness of human resources and institutional governance. The digital competence of educators is a key factor because teachers play a role as designers, implementers, and evaluators of technology-based learning (Jannah & Aslamiah, 2026). Teachers need to have the ability to select appropriate media, develop interactive learning activities, utilize child development data, and maintain the security and ethics of digital technology use. In addition to teacher competence, the availability of adequate technological infrastructure, such as digital devices, internet access, learning platforms, and technical support, is a crucial prerequisite for the successful implementation of a digital ecosystem. The leadership of educational institutions also plays a role in building a culture of innovation, providing professional development programs for teachers, and establishing partnerships with various parties to support digital transformation (Chi, 2026; Huang & Hsieh, 2026). At the policy level, the government has a strategic role in developing regulations, implementation standards, and mentoring programs that encourage sustainable digital transformation. Policies that support equal access to technology, increase digital literacy, and strengthen educator capacity will accelerate the realization of adaptive and inclusive learning environments in various PAUD units.

Overall, the study results indicate that managing a digital ecosystem-based early childhood education (PAUD) learning environment is a strategic approach to improving the quality of education services in the era of digital transformation. Integrating technology into learning environment management has been shown to increase learning accessibility, support adaptive learning, strengthen inclusive education, expand collaboration between teachers and parents, and encourage innovation in the learning process. However, successful implementation depends heavily on the synergy between educator competence, infrastructure readiness, institutional leadership, family participation, and policy support. Therefore, the development of a digital ecosystem should not be understood solely as a process of digitizing learning, but rather as a transformation of the education system that

integrates technology, pedagogy, governance, and collaboration of all stakeholders to create an adaptive, inclusive, high-quality, and sustainable PAUD learning environment.

CONCLUSION

This literature review demonstrates that managing a digital ecosystem-based early childhood education (PAUD) learning environment is a strategic approach to supporting adaptive and inclusive learning in the era of digital transformation. A synthesis of various studies identified five key findings: increasing accessibility and flexibility of learning, strengthening child-centered adaptive learning, optimizing the implementation of inclusive education, enhancing collaboration between teachers, parents, and educational institutions, and the importance of educators' digital competence, infrastructure support, and policies as determining factors for successful implementation. These findings emphasize that the digital ecosystem serves not only as a means of utilizing technology but also as a framework for managing the learning environment that integrates pedagogical aspects, collaboration, and educational governance. Therefore, the future development of PAUD learning environments needs to be directed at strengthening educator capacity, equitable access to digital infrastructure, and formulating policies that support sustainable digital transformation. This research provides a conceptual contribution to enriching studies on managing digital ecosystem-based learning environments and serves as a foundation for further research to test the model's effectiveness through empirical studies in various PAUD contexts and units.

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