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Research Article

Integration of Artificial Intelligence and Deep Learning Pedagogy in the Transformation of Early Childhood Education in the Era of Society 5.0

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Abstract:

Background: The development of Artificial Intelligence (AI) in the Society 5.0 era drives transformation in Early Childhood Education (PAUD). However, AI implementation remains largely limited to digital learning media and lacks systematic integration with child-centered pedagogy.

Objective: This study aims to develop a conceptual model integrating AI and Deep Learning Pedagogy as a framework for transforming early childhood learning to be adaptive, ethical, and aligned with child development.

Methods: A qualitative Systematic Literature Review (SLR) was conducted using reputable international journals, academic books, and education policy documents published between 2018 and 2025. Data were analyzed using content analysis through data reduction, categorization, thematic synthesis, and interpretation.

Results: Integrating AI and Deep Learning Pedagogy creates adaptive, personalized, interactive, and human-centered learning. The model positions AI as a pedagogical facilitator supporting exploration, collaboration, creativity, communication, reflection, and problem-solving through intelligent educational applications, digital storytelling, adaptive learning systems, and AI-based assessments. This study formulates a novel Human-Centered AI framework tailored for early childhood education.

Conclusion: The integration of AI and Deep Learning Pedagogy offers a transformative framework for Early Childhood Education in Society 5.0. It strengthens 21st-century competencies and holistic child development while providing theoretical contributions to digital pedagogy and practical insights for teachers and curriculum developers.

Keywords: Artificial Intelligence, Deep Learning Pedagogy, Early Childhood Education, Human-Centered Learning, Society 5.0

1. INTRODUCTION

Digital technology has changed nearly every part of how people live, including how education works. In the time of Society 5.0, technology isn't just about advanced tools anymore.It's about using technology to make life better for people by connecting the real world with the digital world (Aşiroğlu, 2026; Supaat & Ihsan, 2023).

The Society 5.0 concept, first introduced by the Japanese Government, positions Artificial Intelligence (AI), the Internet of Things (IoT), Big Data, cloud computing, and other digital technologies as the main drivers of innovation that remains oriented towards human well-being (Budiarto et al., 2024; Wulansari et al., 2025). In the field of education, this change demands a transformation of the learning paradigm that is able to integrate technological advances with a humanistic pedagogical approach so that students not only master digital literacy but also develop creativity, critical thinking, communication, collaboration, and character as 21st-century competencies (Fitri et al., 2026; Susanto et al., 2022).

Early Childhood Education (PAUD) is the main foundation of human resource development because in the age range of 0–8 years, brain development occurs very rapidly, so that learning experiences during this period will influence the cognitive, social, emotional, language, and character development of children in the next stage of life (Sangadah & Fitri, 2026). Findings from the Center on the Developing Child Harvard University show that active, responsive, and meaningful learning experiences can strengthen the brain's synaptic

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connections, thereby improving executive function, self-regulation skills, and children's readiness to learn (Dulyapit et al., 2026; Syamsiah & Darmawan, 2025). Therefore, the implementation of technology in PAUD must be designed as a tool that enriches learning interactions, not replace the role of teachers or children's social relationships (Yusuf & Darmasnyah, 2025).

The growth of Artificial Intelligence in education creates new chances to change how young children learn (Renz & Vladova, 2021). AI allows learning to be tailored, interactive, and based on data, so that the content, tools, and activities can be adjusted to match each child's way of growing and developing (Klímová et al., 2023). Various innovations such as intelligent tutoring systems, adaptive educational applications, digital storytelling, educational chatbots, automated assessments, and child development analysis have begun to be implemented in various countries as part of the digital education transformation (Tuanpusa et al., 2026). However, many international groups stress that when using AI in education, it's important to focus on human-centered AI.This means using technology that helps people grow, follows ethical rules, protects data, ensures everyone has access, and promotes the health and happiness of students (Anastasiades et al., 2024).

In the Indonesian context, digital education transformation is further strengthened through the Independent Curriculum policy, which emphasizes differentiated learning, meaningful learning, strengthening the Pancasila Student Profile, and developing 21st-century competencies (Allehyani & Algamdi, 2023; Masturoh et al., 2024). The implementation of digital technology, including Artificial Intelligence, is expected to support teachers in designing creative, contextual, and student-centered learning. However, various studies show that the use of AI in early childhood education (PAUD) units in Indonesia is still predominantly used as a digital learning medium and has not been optimally utilized as part of a pedagogical strategy that supports holistic child development (Puspitaningsih et al., 2022; Winata et al., 2026; Yang, 2022).

In addition to Artificial Intelligence, the Deep Learning Pedagogy approach has developed as a learning paradigm that emphasizes meaningful learning through exploration, reflection, collaboration, creativity, communication, and problem-solving (Alkouri, 2026; Ndlovu et al., 2023). Unlike the term "deep learning" in computer science, Deep Learning Pedagogy denotes a learning approach that encourages students to construct knowledge through authentic, active engagement, and hands-on learning (Metin et al., 2023; Pölzl-Stefanec et al., 2023). This approach is firmly grounded in (Yin et al., 2026) constructivism theory and (Murray, 2021) sociocultural theory, which positions children as active subjects in constructing knowledge through interactions with their social and physical environments (Blanch & Martín, 2024). In early childhood education, this approach is highly relevant because it aligns with children's learning characteristics through play, exploration, interaction, and direct discovery of new experiences (Alghamdi, 2026; Monteira, 2025).

Many earlier studies show that using Artificial Intelligence (AI) in education has grown a lot over time (Ilić et al., 2023). Research by (Lin et al., 2023) showed that AI can help with flexible learning, tailored learning, and assessments based on data. Furthermore, (Medina & Abdelmaula-Mesaud, 2024) stated that AI can enhance the learning process by utilizing learning analytics, intelligent tutoring systems, and data-driven decision-making. However, both studies looked at education in general and did not create a specific conceptual framework for Early Childhood Education. (Sajja et al., 2025).

On the other hand, (Zhao et al., 2023) argued that Deep Learning Pedagogy can develop creativity, communication, collaboration, critical thinking, character, and meaningful learning through active student engagement (Zhai et al., 2024). Research by (Oktaviani et al., 2026) also showed that STEM learning from an early age can improve scientific thinking and problem-solving skills. Meanwhile, (Wang et al., 2026) and the (Δαρδανού et al., 2026) emphasized that AI implementation must be based on the principles of human-centered Artificial Intelligence, ethics, inclusivity, and the development of 21st-century competencies. However, these studies still discuss Artificial Intelligence and Deep Learning Pedagogy separately and therefore have not yet produced a learning model that specifically integrates these two concepts in the context of Early Childhood Education (Carvalho et al., 2022).

Based on the synthesis of previous research, there is still a research gap in the lack of a conceptual model that integrates Artificial Intelligence, Deep Learning Pedagogy, human-centered Artificial Intelligence, and the characteristics of early childhood development into a single learning transformation framework in the Society 5.0 era (Chan, 2023; Walter, 2024). Most studies still position Artificial Intelligence as a learning technology tool, while Deep Learning Pedagogy is more often positioned as a pedagogical strategy without systematic Artificial Intelligence support (Fitri et al., 2026). As a result, there is not yet a framework that can explain how Artificial Intelligence can be utilized as a facilitator of meaningful learning that still maintains social interaction, humanistic values, and the characteristics of early childhood development (Ng et al., 2023).

This study offers a fresh perspective by creating a conceptual model for integrating Artificial Intelligence and Deep Learning Pedagogy to revolutionize Early Childhood Education in the Society 5.0 era (Qian, 2026; Yi et al., 2024). Different from previous studies that only discussed Artificial Intelligence or Deep Learning

Pedagogy partially, the proposed model integrates four main dimensions, namely human-centered Artificial Intelligence, Deep Learning Pedagogy, characteristics of early childhood development, and 21st-century competencies in one complete conceptual framework (Sihag & Vibha, 2024; Techakosit et al., 2026). This model positions Artificial Intelligence as a facilitator of pedagogical innovation that supports adaptive, meaningful, ethical, inclusive learning, and is oriented towards holistic child development, thus providing theoretical contributions to the development of digital pedagogy while also serving as a practical reference for teachers, curriculum developers, and policymakers (Tao & Nasri, 2025).

This study seeks to examine how Artificial Intelligence and Deep Learning Pedagogy can be integrated into Early Childhood Education during the Society 5.0 era. It also aims to create a conceptual model that supports meaningful learning and the development of 21st-century skills for young children. This study aims to examine how Artificial Intelligence and Deep Learning Pedagogy can transform Early Childhood Education in the Society 5.0 era.It also seeks to develop a conceptual model that supports meaningful learning and the development of 21st-century skills in early childhood.

2. MATERIAL AND METHOD

This study employs a qualitative approach that combines library research with a Systematic Literature Review (SLR) method. This approach was chosen because the study aims to analyze, synthesize, and develop a conceptual model about how Artificial Intelligence (AI) and Deep Learning Pedagogy can be integrated into Early Childhood Education in the Society 5.0 era. It is based on published research. Unlike studies that involve direct observation of respondents, this research relies on scientific publications as its main source of data, leading to a thorough conceptual analysis with a solid theoretical base.

The research objects are various scientific publications discussing Artificial Intelligence, Deep Learning Pedagogy, Early Childhood Education, digital pedagogy, and Society 5.0. The sources used include articles from well-known international journals, nationally recognized academic journals, books published by academic institutions, papers presented at international conferences, documents related to education policy, and official reports from international organizations like UNESCO and the OECD. The selection of literature was done through a purposive sampling method, which involves choosing publications that are highly relevant to the research topic. Inclusion criteria include publications in English and Indonesian published in the period 2018–2025, have gone through a peer review process, and specifically discuss the implementation of Artificial Intelligence, Deep Learning Pedagogy, or the transformation of Early Childhood Education. Conversely, irrelevant articles, duplicate publications, opinion articles, or sources that lack academic validity were excluded from the analysis process.

The study took place from January to May 2026 at the Early Childhood Islamic Education Study Program, Faculty of Islamic Education and Teacher Training, Muhammad Azim Islamic Institute, Jambi. A thorough search of the literature was carried out using several international scientific databases, including Scopus, Web of Science, ERIC, ScienceDirect, SpringerLink, Taylor & Francis Online, IEEE Xplore, and Google Scholar. The keywords used included Artificial Intelligence, Artificial Intelligence in Education, Deep Learning Pedagogy, Meaningful Learning, Early Childhood Education, Society 5.0, Digital Pedagogy, and Human-Centered Artificial Intelligence. Keyword combinations were used with Boolean operators (AND and OR) to improve the search's sensitivity and specificity.

The research procedure was carried out through six stages, namely: (1) identification of the research problem; (2) systematic literature search; (3) screening process based on inclusion and exclusion criteria; (4) quality assessment (critical appraisal) of publications that meet the criteria; (5) data extraction and categorization; and (6) conceptual synthesis to build an integration model of Artificial Intelligence and Deep Learning Pedagogy in the transformation of Early Childhood Education in the Society 5.0 era. These stages refer to the principles of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) which emphasizes transparency in the process of literature identification, selection, and synthesis.

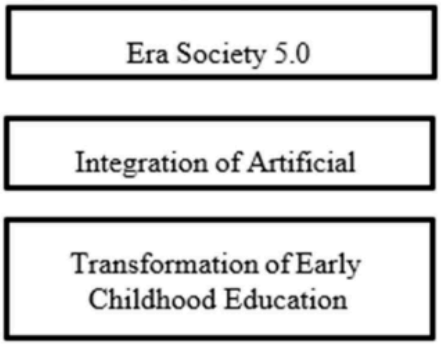
The data collection technique used in the documentation studies involves identification, critical reading, and recording of various literature relevant to the research focus. The research tool used was a literature review protocol sheet that included a data extraction matrix. The matrix was used to document key information from each publication, including the author's name, year of publication, country of origin of the study, research objectives, research methods, main results, implementation of Artificial Intelligence, characteristics of Deep Learning Pedagogy, educational implications, and research limitations. The use of a data extraction matrix is intended to enhance the consistency of the synthesis process across different studies.

Data analysis was done through content analysis along with thematic synthesis. The analysis process model includes three stages: data condensation, data presentation, and drawing and verifying conclusions. Each research outcome was analyzed, grouped according to key themes, and then carefully examined to find connections between ideas, identify areas that need more study, and explore possibilities for building new theories. The findings from this synthesis were used to create a conceptual model that integrates Artificial Intelligence and Deep Learning Pedagogy, serving as a framework for transforming Early Childhood Education in the Society 5.0 era. To enhance the reliability of the

research findings, a method called source triangulation was used.This involved comparing information from multiple credible scientific articles, academic books, and international policy documents to ensure the results were valid and thorough.

The scope of this research is limited to a conceptual study of the integration of Artificial Intelligence and Deep Learning Pedagogy in Early Childhood Education in the Society 5.0 era based on available scientific publications. This research does not involve field observations or experiments, so the resulting conceptual model still requires empirical validation through qualitative, quantitative, and mixed-method research in various Early Childhood Education contexts. Nevertheless, the results of this study are expected to contribute to the development of digital pedagogy theory and serve as a reference for teachers, curriculum developers, and policymakers in implementing Artificial Intelligence-based learning that is ethical, humanistic, and oriented towards holistic child development.

Figure 1. Conceptual Framework for Research



3. RESULTS AND DISCUSSION

3.1 Result

This section outlines the findings from a systematic review of multiple studies focusing on Artificial Intelligence, Deep Learning Pedagogy, Early Childhood Education, and Society 5.0. The combination of these results shows that Artificial Intelligence is quickly advancing as an educational tool that can help provide adaptive, personalized, and data-informed learning experiences. Artificial Intelligence can improve learning by using smart tutoring, digital stories, chatbots, adaptive tests, and tracking student progress.

On the other hand, Deep Learning Pedagogy has developed as a learning approach that emphasizes meaningful learning through exploration, collaboration, reflection, creativity, communication, and authentic problem-solving. This approach positions students as active participants in constructing knowledge, making it highly suited to the learning characteristics of early childhood.

However, the study results show that most research still discusses Artificial Intelligence as an educational technology innovation and Deep Learning Pedagogy as a learning approach separately. Research integrating these two concepts into a single pedagogical model specifically for Early Childhood Education is still very limited. These findings indicate the need to develop a conceptual framework that connects Artificial Intelligence technology with the principles of child-centered pedagogy.

Table 1. Synthesis of Previous Research

Researchers	Research Focus	Key Findings	Research Gaps
(Zhao et al., 2023)	Artificial Intelligence in education	AI supports personalized learning	Not yet discussed PAUD pedagogy
(Sajja et al., 2025)	STEM in Early Childhood Education	STEM integration enhances creativity	AI has not been discussed
(Medina & Abdelmaula-Mesaud, 2024)	Deep Learning Pedagogy	Meaningful learning improves competence	AI is not yet integrated
(Ilić et al., 2023)	AI in education	AI enhances adaptive learning	Focus on general education

(Alkouri, 2026)	AI Ethics	AI must be human-oriented	Have not developed a pedagogical model

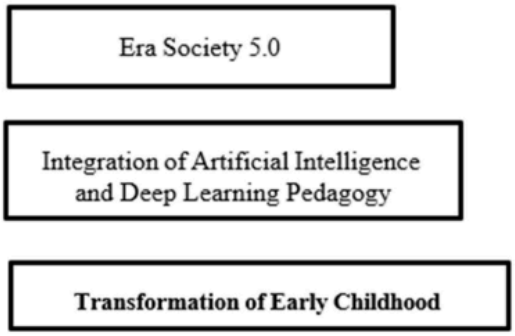
The results of the literature analysis show that the implementation of Artificial Intelligence in Early Childhood Education can be synthesized into four main themes, namely: (1) personalized learning, (2) strengthening deep learning pedagogy, (3) the role of teachers as facilitators of AI-based learning, and (4) developing 21st-century competencies oriented towards holistic child development. These four themes appear consistently in various studies and thus form the basis for developing the conceptual model of this research.

3.2 Discussion

The synthesis results show that Artificial Intelligence has significant potential to transform Early Childhood Education when integrated with the right pedagogical approach. Unlike most previous studies that position Artificial Intelligence solely as a digital learning medium, this study views AI as a supporting technology that enhances the quality of the learning process through a Deep Learning Pedagogy approach. Children construct knowledge through direct experience, social interaction, and environmental exploration. Therefore, Artificial Intelligence should not replace the role of teachers, but rather serve as a technology that enriches the learning experience through adaptive presentation of materials, rapid feedback, and more personalized learning activities.

The results of this study also support the idea of Human-Centered Artificial Intelligence, which emphasizes that the use of Artificial Intelligence should focus on humanitarian values, ethical considerations, child safety, and the well-being of students. The use of Artificial Intelligence and Deep Learning in education can create a learning experience that is both technologically advanced and meaningful, ensuring it is inclusive and focused on the overall development of children.

Figure 1. Conceptual Model of Integration of Artificial Intelligence and Deep Learning Pedagogy



3.2.1 Implication

This research has both theoretical and practical implications. Theoretically, the results expand the study of digital pedagogy through the integration of Artificial Intelligence and Deep Learning Pedagogy in the context of Early Childhood Education. The developed conceptual model enriches the literature on technology-based learning that maintains a focus on holistic child development.

Table 2. Theme Synthesis Results

Theme	Synthesis of Findings
Personalized Learning	AI enables adaptive learning according to the characteristics and learning needs of each child.
Deep Learning Pedagogy	AI supports active learning through exploration, reflection, collaboration, and problem solving.
Teacher Facilitation	Teachers act as facilitators who integrate AI ethically and meaningfully.
Holistic Development	The integration of AI and pedagogy supports children's cognitive, social, emotional, creative, and character development.

All articles that met the inclusion criteria were analyzed using an open coding process. Each article was coded based on the main concepts that emerged, then grouped into categories and themes to obtain patterns of relationships between concepts.

Table 3. Results of Open Coding and Concept Synthesis

Code	Theme	Meaning of Synthesis Results
C1	Adaptive Learning	AI facilitates adaptive learning according to the needs and characteristics of each child.
C2	Personalized Learning	AI supports the personalizationof learning materials, activities, and assessments.
C3	Human-Centered AI	AI implementation is oriented towards children's needs, welfare, ethics and development.
C4	Deep Learning Pedagogy	Learning emphasizes exploration, reflection, collaboration, creativity, and problem solving.
C5	Teacher Facilitation	Teachers act as facilitators who integrate AI pedagogically and humanistically.
C6	Meaningful Learning	AI supports the creation of active, contextual, and meaningful learning experiences.
C7	21st Century Skills	The integration of AI and pedagogy develops creativity, critical thinking, communication, and collaboration.
C8	Holistic Child Development	Al-based learning supports children's cognitive, social, emotional, language, moral and creative development holistically

A conceptual framework was created through coding and thematic synthesis that explains the connection between technological advancements in the Society 5.0 era, the use of Human-Centered Artificial Intelligence, the application of Deep Learning Pedagogy, and the changes taking place in Early Childhood Education. This framework shows that AI serves as a teaching aid, while teachers continue to play the main role in guiding students toward meaningful learning that supports the overall development of children. Based on the analysis of all available literature, this study develops a conceptual model that combines Human-Centered Artificial Intelligence and Deep Learning Pedagogy as a method to transform Early Childhood Education during the Society 5.0 era. AI is not a replacement for teachers but a tool that supports learning.It strengthens learning processes, personalizes learning, and helps develop 21st-century skills and overall child development.

Practically, this model can be a reference for PAUD teachers in designing Artificial Intelligence-based learning that supports meaningful learning, increases children's creativity, strengthens critical thinking, communication, collaboration, and digital literacy skills without reducing the importance of social interaction between teachers and students.

3.2.2 Research Contribution

The main contribution of this research lies in the development of a conceptual model that integrates Artificial Intelligence, Human-Centered Artificial Intelligence, and Deep Learning Pedagogy in a single framework for the transformation of Early Childhood Education in the Society 5.0 era. In contrast to previous research that discussed the two concepts separately, this research offers a conceptual synthesis that connects adaptive technology with the principles of meaningful learning, resulting in a learning framework that is more comprehensive, ethical, and appropriate to the characteristics of early childhood development.

3.2.3 Limitation

This research is a desk study, so all findings are based on a synthesis of scientific literature and have not been validated through empirical implementation in Early Childhood Education units. Furthermore, the publications analyzed were limited to the period 2018–2025, so developments in Artificial Intelligence after that period have not been fully addressed.

3.2.4 Suggestion

Further research is recommended to test the conceptual model developed through empirical research using qualitative, quantitative, and mixed methods approaches in various early childhood education institutions. Furthermore, the development of an artificial intelligence-based learning model that takes into account ethical aspects, child data security, teacher preparedness, and educational policy is needed so that technology implementation truly supports the creation of humanistic, inclusive, and sustainable learning. The synthesis results show that the relationship between Human-Centered Artificial Intelligence and Deep Learning Pedagogy forms a conceptual framework that positions meaningful learning as the main mechanism in transforming Early Childhood Education in the Society 5.0 era.

4. CONCLUSION

This study concludes that combining Artificial Intelligence (AI) with Deep Learning Pedagogy is a strategic method for transforming Early Childhood Education during the Society 5.0 era. Artificial Intelligence functions as an innovation in educational technology and can also support adaptive, personalized, and interactive learning when applied through a child-centered approach. Deep Learning Pedagogy offers a teaching approach that supports children in learning through exploration, working together, thinking about their experiences, sharing ideas, being creative, and solving problems, all in line with the natural ways young children develop.

The main findings of this study show that most earlier research continues to address Artificial Intelligence and Deep Learning Pedagogy as separate topics. This study presents a conceptual model that integrates Artificial Intelligence and Deep Learning Pedagogy, linking it to the principles of Human-Centered AI, meaningful learning, the role of teachers as facilitators, and the development of 21st-century competencies. It offers a single framework for the transformation of Early Childhood Education. This model contributes to scientific research by broadening the study of digital pedagogy through the combination of adaptive technology with a humanistic learning approach, which is specifically tailored to the needs and characteristics of Early Childhood Education.

Theoretically, this research enriches the development of digital pedagogy concepts based on Human-Centered Artificial Intelligence and Deep Learning Pedagogy in the context of Early Childhood Education. Practically, the resulting model can serve as a reference for teachers, curriculum developers, educational institutions, and policymakers in designing ethical, inclusive, child-centered AI-based learning that maintains social interaction and holistic child development.

However, this research is still limited to a conceptual study based on a literature synthesis, so the developed model has not been validated through empirical implementation in Early Childhood Education units. Therefore, further research is recommended to test the effectiveness of this conceptual model through qualitative, quantitative, and mixed methods research in various educational contexts to obtain empirical evidence regarding its impact on the quality of learning and child development.

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The author also thanks the reviewers and editors for their helpful comments, feedback, and suggestions that contributed to improving this manuscript. This support has greatly helped in enhancing the scientific quality of this article. The author hopes that the results of this study can contribute to the development of science, especially in the field of Early Childhood Education, and can serve as a reference for educators, researchers, curriculum developers, and policymakers. The study emphasizes the importance of developing Artificial Intelligence-based learning that is humanistic, ethical, and focused on holistic child development.

6. AUTHOR CONTRIBUTION STATEMENT

Author Contributions: KP played a role in the conceptualization of the study, the development of the research design, supervision, validation of the conceptual framework, as well as critical review and refinement of the manuscript. SK was responsible for the literature search and review, data collection and analysis, development of the conceptual model, and preparation of the initial draft of the article. MW contributed to the development of the research design, interpretation of the results, revision of the manuscript substance, and management of references. MN played a role in the validation of the research results, language editing, final review of the manuscript, and approval of the final version of the article. All authors have read, approved, and are responsible for the content of the published manuscript.

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