E-ISSN: 2746-7767
Ainara Journal (Jurnal Penelitian dan PKM Bidang Ilmu Pendidikan)
Volume 7, Issue 3, September 2026, pp 476-489
https://doi.org/10.54371/ainj.v7i3.1444

Implementation of Unplugged Coding in Early Childhood Education Learning: A Systematic Literature Review

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Article History: Submission: 2026-05-04 || Accepted: 2026-09-01 || Published: 2026-09-20

Abstract

Unplugged coding has gained increasing attention in early childhood education as a developmentally appropriate approach to introducing computational thinking through non-digital, play-based activities. However, evidence regarding its implementation in early childhood settings remains fragmented across research designs, activity forms, learning outcomes, and teacher roles. This study systematically reviewed the characteristics and implementation of unplugged coding in early childhood education, focusing on publication trends, research approaches, activity forms, reported learning outcomes, and teacher roles. A Systematic Literature Review (SLR) was conducted following the PRISMA framework. Studies were identified through Publish or Perish using Google Scholar, resulting in 16 articles published between 2019 and 2025 for final synthesis. The findings indicate that descriptive qualitative and case-study approaches predominated, suggesting that existing research remains primarily implementation-oriented. Unplugged coding commonly involved sequencing and simple algorithms, directional or navigation games, and pattern-based or visual-manipulative activities. Computational thinking emerged as the primary learning focus, particularly sequencing, pattern recognition, logical reasoning, and problem solving, while several studies also reported outcomes related to language, numeracy, motor skills, and executive functions. Teachers played important roles in designing activities, providing instruction and scaffolding, facilitating exploration, and evaluating learning processes. Overall, unplugged coding represents a promising pedagogical approach for introducing computational thinking in developmentally appropriate early childhood contexts. Nevertheless, the predominance of descriptive studies and limited evidence base preclude strong conclusions regarding comparative effectiveness. Further experimental and longitudinal research is needed to determine which forms of unplugged coding are most effective, for whom, and under what instructional conditions.

Keywords: *Computational Thinking, Early Childhood Education, PRISMA, Systematic Literature Review, Unplugged Coding.*

I. INTRODUCTION

Early childhood education plays a strategic role in establishing the foundations of children's thinking, learning dispositions, and readiness for subsequent levels of education (Putri et al., 2025). Learning at this developmental stage emphasizes direct experiences through structured and meaningful play-based activities. The quality of early childhood education is therefore strongly influenced by how learning activities are designed and managed in the classroom. Poorly structured learning may result in routine activities that provide limited opportunities for children to develop sequential and reflective thinking. This highlights the importance of effective learning management in supporting developmental and learning outcomes in early childhood education (Khoirotin et al., 2025). Accordingly, pedagogical approaches that stimulate systematic thinking while remaining appropriate to young children's developmental characteristics are increasingly needed.

One ability that has received growing attention in both elementary and early childhood education is computational thinking (Zahara et al., 2025). Computational thinking involves the ability to organize sequences of steps, recognize patterns, apply logical reasoning, and solve problems systematically. In early childhood education, introducing computational thinking does not necessarily require children to interact directly with digital technologies. Instead, its fundamental processes can be introduced through concrete and developmentally appropriate activities. Technology-dependent approaches may not always be suitable for early childhood settings, particularly where access to digital resources is limited or where play-based and hands-on experiences are pedagogically prioritized. This has encouraged the development of non-digital approaches capable of fostering computational ways of thinking. Unplugged coding is particularly

relevant in this context because it integrates computational thinking concepts into play-based activities that are compatible with young children's developmental characteristics (Fitriyah et al., 2023).

Empirical findings indicate that early childhood education settings continue to face challenges in developing learning experiences that optimally stimulate children's thinking abilities. Learning outcomes, particularly in the cognitive domain, suggest that reasoning and sequential thinking skills are not always developed consistently. Conceptual understanding as an aspect of cognitive development involves more than remembering information; it also requires children to explain, interpret, and apply ideas in particular situations (Putra, 2024). These conditions underscore the need for more purposeful learning approaches that facilitate meaningful understanding in early childhood. Within this context, approaches that introduce and stimulate computational thinking from an early age warrant further investigation.

Research on unplugged coding and computational thinking has expanded considerably in recent years. Chen et al. (2023), for example, conducted a systematic literature review and meta-analysis of 49 studies examining unplugged activities for developing computational thinking across K–12 education between 2006 and 2022. Their review mapped research characteristics, activity designs, instructional tools, and the effectiveness of unplugged activities, while also conducting a meta-analysis of studies that met the required statistical criteria. Other studies have similarly demonstrated increasing scholarly attention to computational thinking in early childhood education, including both robotics-based and unplugged approaches. Consequently, the research gap addressed in the present study does not arise from an absolute absence of previous reviews. Rather, it concerns the need for a synthesis that specifically examines the implementation of unplugged coding in early childhood education and its pedagogical characteristics.

Existing studies in the corpus examined in this review demonstrate substantial diversity in research approaches and implementation practices. Research designs range from qualitative and case studies to quantitative studies, developmental research, literature reviews, and conceptual articles. The reported activities are similarly diverse, including sequencing tasks, directional games, manipulation of patterns and symbols, everyday-life activities, puzzles, and other physical learning materials. Several studies also emphasize the role of teachers in designing activities, providing instructions and scaffolding, facilitating children's problem-solving processes, and evaluating learning. Such diversity indicates that understanding unplugged coding in early childhood education requires more than determining whether it produces particular learning outcomes. It is equally important to examine how unplugged coding is implemented, which computational thinking processes are represented, what learning outcomes are reported, and how teachers support these activities.

Accordingly, this study extends previous reviews by focusing specifically on the implementation of unplugged coding in early childhood education. Unlike broader reviews encompassing multiple educational levels and primarily emphasizing the effectiveness of computational thinking interventions, the present study maps publication trends, research approaches and designs, forms of unplugged coding implementation, reported learning outcomes, and teacher roles within early childhood education contexts. This specific focus is intended to provide a clearer understanding of how unplugged coding has been conceptualized and implemented for young learners while also characterizing the nature of the existing evidence base.

Based on this focus, the study aims to systematically review the implementation of unplugged coding in early childhood education in terms of publication trends, research characteristics, forms of implementation, reported learning outcomes, and teacher roles. The synthesis is expected to provide an integrated account of current research and implementation patterns while identifying areas in which stronger empirical evidence is still needed.

II. METHOD

This study employed a Systematic Literature Review (SLR) to systematically identify, examine, evaluate, and synthesize relevant studies on the implementation of *unplugged coding* in early childhood education based on predefined research questions (Akmal et al., 2025). The PRISMA framework was used to guide the study-selection process and ensure transparency from initial

identification to final inclusion. The review procedure comprised the formulation of research questions, development of the literature search strategy, establishment of eligibility criteria, article selection following the PRISMA flow, quality assessment, data extraction, and synthesis of findings (Widiana et al., 2025).

The review was guided by five research questions. The first examined the distribution of publications on *unplugged coding* in early childhood education between 2019 and 2025. The second investigated the research approaches employed in the identified studies. The third examined the forms of *unplugged coding* implemented in early childhood learning. The fourth identified the learning outcomes reported across the studies. The fifth examined the roles of teachers in facilitating the implementation of *unplugged coding*. These questions served as the analytical framework for organizing and synthesizing the evidence included in the review.

Search Strategy and Eligibility Criteria

The literature search was conducted using Publish or Perish, with Google Scholar as the primary data source. Google Scholar was selected because of its broad coverage of national and international publications, including accredited national journals and international journals relevant to early childhood education (Khosibah et al., 2025). The search was restricted to studies published between 2019 and 2025 to capture recent developments in the field. Search terms included combinations of "computational thinking," "early childhood education," "unplugged coding," and "early childhood." These terms were used in several combinations to identify articles relevant to the objectives of the review.

Studies were included if they: (1) were scientific journal articles addressing the implementation of *unplugged coding* in early childhood education; (2) were published between 2019 and 2025; (3) were written in Indonesian or English; and (4) were available in full text. Eligible studies were also required to provide sufficient information regarding the research method, form of *unplugged coding* activity, and reported learning outcomes. Studies were excluded if they did not address *unplugged coding*, involved participants outside early childhood education, were published outside the specified period, or were not scientific journal articles.

Study Selection

The article-selection process followed the PRISMA stages of identification, screening, eligibility assessment, and inclusion, as illustrated in Figure 1.

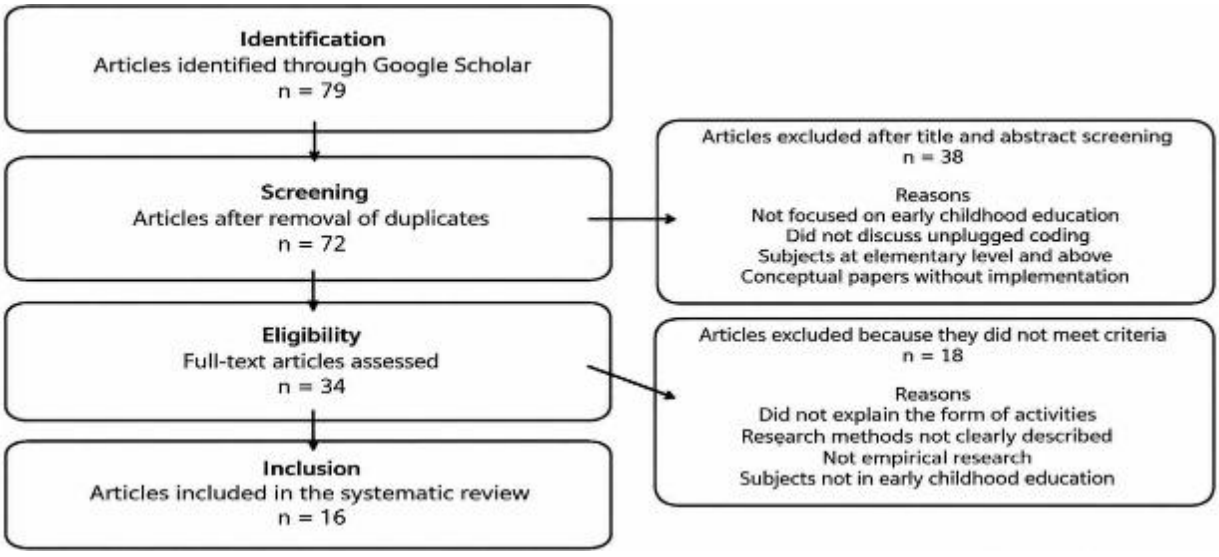

Figure 1. PRISMA Flow Diagram of the Study Selection Process

The initial search identified 79 articles from Google Scholar through Publish or Perish. After duplicate records were removed, 72 articles remained for screening. Title and abstract screening excluded 38 articles because they did not focus on early childhood education, did not examine

unplugged coding, involved participants at elementary or higher educational levels, or were conceptual papers without implementation. The full texts of the remaining 34 articles were subsequently assessed for eligibility. At this stage, 18 articles were excluded because they did not clearly describe the implemented activities, lacked sufficient methodological information, were not empirical studies, or did not involve early childhood participants. Consequently, 16 articles published between 2019 and 2025 were included in the final systematic synthesis.

Quality Assessment

The quality of the included studies was assessed using four criteria: (1) clarity of the research objectives, (2) appropriateness and clarity of the research methods, (3) clarity in describing the implementation of *unplugged coding*, and (4) relevance of the findings to early childhood learning. Each article was examined against these criteria to assess the adequacy and relevance of the evidence used in the synthesis. The quality assessment was not used as an additional exclusion criterion for studies that had passed the eligibility stage; rather, it served as a basis for considering the strength and clarity of the evidence during the analysis and interpretation of findings.

Data Extraction and Synthesis

Data were extracted using a structured summary table containing the author(s), publication year, publication source, research approach, form of *unplugged coding* implementation, learning outcomes, and teacher roles. The extracted data were first analyzed using simple descriptive statistics to summarize frequencies and percentages across the included studies. This was followed by thematic analysis to identify and synthesize recurring patterns according to the five research questions. This analytical procedure enabled the review to describe both the distribution of the available evidence and the pedagogical patterns emerging from the included studies.

This review is subject to potential publication and coverage bias because the literature search was limited to articles indexed in Google Scholar and available in full text. Unpublished studies and publications not indexed in Google Scholar were therefore not included, meaning that potentially relevant evidence may not have been captured in the final synthesis.

III. RESULTS AND DISCUSSION

A. Results

Based on the literature selection process, 16 articles were identified as meeting the eligibility criteria and were included in the systematic review of *unplugged coding* implementation in early childhood education. The included studies were published between 2019 and 2025, consisted of scientific journal articles, and specifically addressed the implementation of *unplugged coding* in early childhood education contexts. The articles were drawn from relevant national and international publications. Table 1 presents an overview of the included studies and provides the basis for the subsequent analysis of publication trends, research approaches, forms of implementation, reported learning outcomes, and teacher roles.

Table 1. Summary of the Included Studies

Authors and Year	Article Title	Research Method	Key Findings
Lee & Junho (2019)	*Implementing Unplugged Coding Activities in Early Childhood Classrooms*	Conceptual article based on a review of practices and examples of classroom implementation	*Unplugged coding* was implemented through children's everyday activities, such as handwashing and delivering objects using illustrated coding sheets. Activities incorporated direction cards, arrow symbols, sequencing, and debugging through discussions of incorrect steps. These activities introduced children to algorithms, sequencing, direction, and repetition in concrete ways.
Widiastutik et al. (2025)	*Coding Unplugged sebagai Inovasi Pembelajaran untuk Membangun Literasi Digital Anak Usia Dini di PAUD*	Descriptive qualitative study using observation, interviews, and documentation	*Unplugged coding* was implemented through two main activities, "Jalan ke Rumah Teman" and "Mewarnai Sesuai Kode." Children demonstrated greater enthusiasm and independence and developed an understanding of sequencing, symbolic patterns, and simple problem solving.

			Activities involved movement games, route tracing, and code-based color matching.
Fajriyah et al. (2022)	*Analisis Perbandingan Pendekatan Plugged-In dan Unplugged dalam Pengembangan Computational Thinking pada Anak Usia Dini*	Systematic Literature Review of 28 articles (2019–2024)	The review indicated that unplugged approaches were appropriate in contexts with limited access to technology and suitable for young children. Common activities included role-playing, physical puzzles, sequencing, and pattern recognition. The approach supported algorithmic thinking, decomposition, and simple decision making.
Salamah et al. (2025)	*Pendampingan Unplugged Coding Berbasis Aktivitas Visual Motorik untuk Menstimulasi Computational Thinking Anak Usia 3–5 Tahun*	Participatory Action Research (PAR)	Teacher assistance was associated with improved teacher understanding and children's computational thinking following visual-motor activities. Activities included robot-step games, color-pattern arrangement, movement mazes, and picture sequencing, which supported pattern recognition, logical sequencing, and simple problem solving without digital devices.
Maulidya et al. (2025)	*Media Pembelajaran Inovatif Unplugged Coding untuk Penguatan Keterampilan Pemecahan Masalah di Pendidikan Anak Usia Dini*	Research and Development (R&D) using the ADDIE model	The *unplugged coding*-based children's worksheet was rated highly feasible by content and media experts. Its implementation supported logical thinking and problem-solving skills among children aged 4–5 years. Activities involved pattern arrangement, route sequencing, directional symbols, and animal-themed challenges.
Alubuaman Kempirmase & Firman (2025)	*Implementasi Puzzle Coding Blok sebagai Media Edukatif Unplugged untuk Anak Usia Dini di TK ABA 2 Aimas*	Qualitative case study	Coding-block puzzles were used to introduce patterns, sequencing, and problem solving through physical play. Children were able to follow logical instructions and arrange steps sequentially. Activities included block arrangement, route exploration, and solution discussions with teachers.
Akiba (2022)	*Computational Thinking and Coding for Young Children: A Hybrid Approach to Link Unplugged and Plugged Activities*	Conceptual perspective article	Unplugged activities were emphasized as an initial foundation for computational thinking before children transitioned to digital activities. Activities included directional words, temporal sequencing, treasure maps, and visual symbols. The study highlighted the importance of establishing a conceptual bridge between unplugged and plugged activities.
Rahmawati & Kurniati (2024)	*Implementation of Unplugged Coding in Playdate*	Qualitative case study using structured interviews and non-participant observation	*Unplugged coding* was implemented through physical play without digital devices at Playdate Zona Kreativa. Children were introduced to computational thinking concepts, particularly sequencing and logic, through structured games. Teachers demonstrated a good understanding of unplugged coding, although consistency of implementation remained challenging. Activities included movement games, instruction simulations, and role-playing.
Metin (2020)	*Activity-Based Unplugged Coding During the Preschool Period*	Quantitative, one-group pretest–posttest design	Activity-based unplugged coding improved basic coding and robotic coding skills among five-year-old children. Activities involved sequencing games, directional concepts, and algorithm simulations without computers. Children demonstrated improved ability to follow instructions and logical sequences.
Küçükkara & Aksüt (2021)	*An Example of Unplugged Coding Education in Preschool Period*	Descriptive qualitative study using classroom observation	Children actively participated in 24 game-based algorithmic activities over eight weeks. They developed an understanding of units, commands, and repetition through problem solving and generated multiple solutions to activities. Materials included wooden blocks, directional arrows, and problem-based storylines.

Kılıç et al. (2025)	*Unplugged Coding in Preschool: Tiny Hands Coding Project*	Quantitative, single-group pretest–posttest design	*Unplugged coding* activities improved computational thinking, numeracy, language, and motor skills among children aged 4–5 years. Improvements were reported in sequencing, pattern recognition, and basic logic. Activities included instruction games, sequential counting, and simulations of directional concepts.
Kempirmase & Firman (2025)	*Implementasi Puzzle Coding Blok sebagai Media Edukatif Unplugged*	Qualitative case study	Coding-block puzzles were used to introduce patterns and logical sequencing to children aged 5–6 years. Children developed computational thinking through manipulative play, while teachers facilitated exploratory activities. Implementation included block puzzles, pattern arrangement, and simple algorithm simulations.
Zhang et al. (2025)	*Developing Preschool Children's Computational Thinking and Executive Functions*	Experimental, randomized controlled trial	Unplugged programming improved children's computational thinking compared with conventional activities. The intervention involved paper-based algorithmic tasks and group discussions. Improvements were reported in sequencing, simple debugging, and problem solving. Activities included route mapping, algorithm drawing, and paper-based logic tasks.
Kamil et al. (2025)	*Unplugged Activity-Based Computational Thinking Using Algorithm Tasks*	Descriptive qualitative case study	*Fun cooking* activities supported children's gradual understanding of algorithmic concepts. Children followed sequential instructions, recognized repeated processes, and completed step-based tasks without digital devices. Activities consisted of cooking procedures, sequencing, and repetition.
Fitriyah et al. (2023)	*Praktik Unplugged Coding Berbasis Daily Lives*	Qualitative phenomenological study	Daily-life-based *unplugged coding* activities supported computational thinking among children aged 5–6 years. Children followed instructions, solved problems, and independently divided tasks. Activities were integrated into children's everyday routines through daily-life simulations, activity sequencing, and small-group discussions.
Karimah & Sholeha (2024)	*Pengaruh Permainan Unplugged Coding terhadap Kemampuan Berpikir Komputasional Anak Usia 5–6 Tahun*	Quantitative, pre-experimental one-group pretest–posttest design	Children's computational thinking scores increased significantly following *unplugged coding* games, from a pretest mean of 14.96 to a posttest mean of 21.46 ($p < .001$). Coding-station and tic-tac-toe games addressed algorithms, debugging, design processes, decomposition, control structures, and symbolic understanding through physical and board-game activities.

1. Characteristics of the Included Studies

A total of 16 articles were analyzed, all focusing on the implementation of *unplugged coding* in early childhood education. The articles were selected based on their relevance to the review topic, the implementation of non-digital coding activities, and their direct connection to early childhood education. The distribution of publication years indicates that research on *unplugged coding* in early childhood settings has gained increasing attention in recent years. This emerging body of research suggests that *unplugged coding* is increasingly being considered a relevant pedagogical approach for fostering computational thinking among young children (Lee & Junho, 2019b).

Figure 2. Distribution of Articles by Publication Source

As illustrated in Figure 2, 9 articles (56.25%) were published in national journals, while 7 articles (43.75%) appeared in international publications. This distribution indicates that *unplugged coding* in early childhood education has attracted scholarly attention at both national and international levels. Across the included studies, the participants were young children aged approximately 3–6 years, situated in early childhood education, kindergarten, or structured play settings. Several studies also involved teachers as supporting participants, particularly those examining the planning, implementation, and evaluation of learning activities (Kempirmase & Firman, 2025).

2. Distribution of Studies by Publication Year

The distribution of publication years illustrates the development of research on unplugged coding in early childhood education between 2019 and 2025. In 2019 and 2020, one article (6.25%) was published in each year. The number increased to two articles (12.5%) in 2021, three articles (18.75%) in 2022, and reached its highest level in 2023 with four articles (25%). This was followed by three articles (18.75%) in 2024 and two articles (12.5%) in 2025.

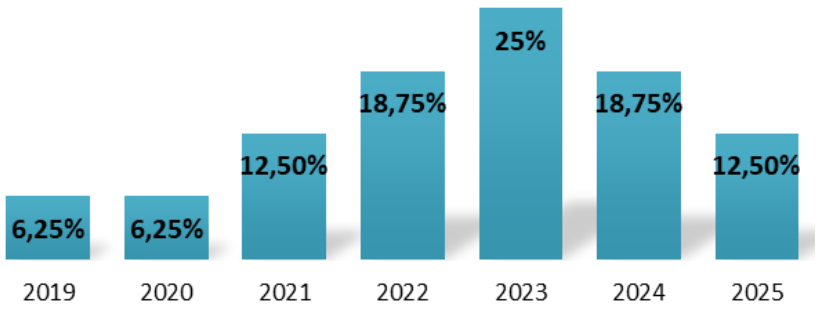

Figure 3. Distribution of Articles by Publication Year

The publication pattern shows a gradual increase from the initial period, reaching a peak in 2023. Although the number of publications subsequently declined, studies continued to appear in 2024 and 2025. This pattern indicates sustained scholarly attention to unplugged coding as a research topic within early childhood education (Rahmawati & Kurniati, 2024).

3. Research Approaches in Studies of *Unplugged Coding* in Early Childhood Education

The 16 included articles employed a range of research approaches. Descriptive qualitative and case-study approaches were the most frequently used, accounting for 7 articles (43.75%). Quantitative approaches were employed in 4 articles (25%), while Research and Development (R&D) approaches focusing on the development of learning media were identified in 2 articles (12.5%). The remaining 3 articles (18.75%) consisted of literature reviews and conceptual studies (Fajriyah et al., 2022).

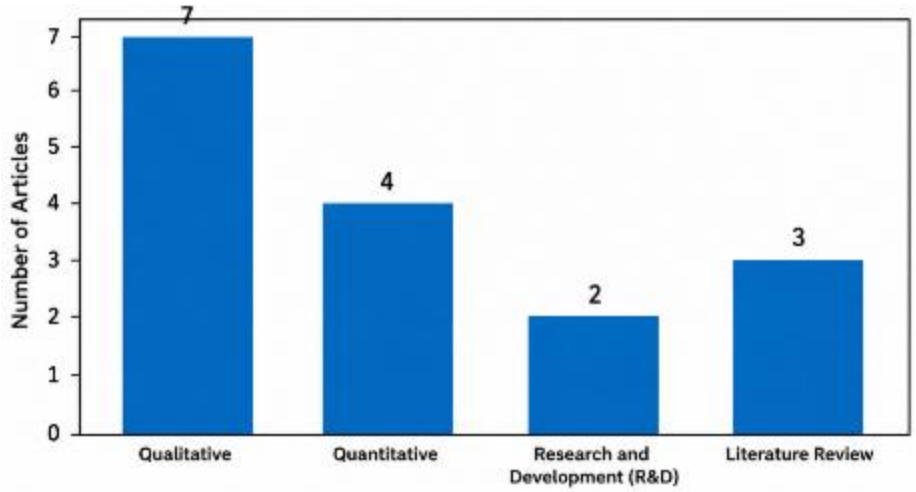

Figure 4. Distribution of Research Approaches in *Unplugged Coding* Studies in Early Childhood Education

The predominance of descriptive qualitative and case-study approaches indicates that existing research on *unplugged coding* in early childhood education has focused more extensively on describing and understanding implementation processes than on rigorous experimental testing. These approaches have primarily been used to capture classroom dynamics, children's responses to unplugged activities, and teachers' roles during the learning process (Amelya et al., 2025).

4. Forms of *Unplugged Coding* Implementation in Early Childhood Education

The analysis revealed considerable variation in how *unplugged coding* was implemented in early childhood education. Sequencing activities and simple algorithms were the most frequently reported forms of implementation, appearing in 13 articles (81.25%). Directional and navigation games were identified in 10 articles (62.5%), while pattern-based and visual-manipulative activities were reported in 9 articles (56.25%). In addition, activities based on children's everyday experiences were identified in 6 articles (37.5%) (Lee & Junho, 2019a).

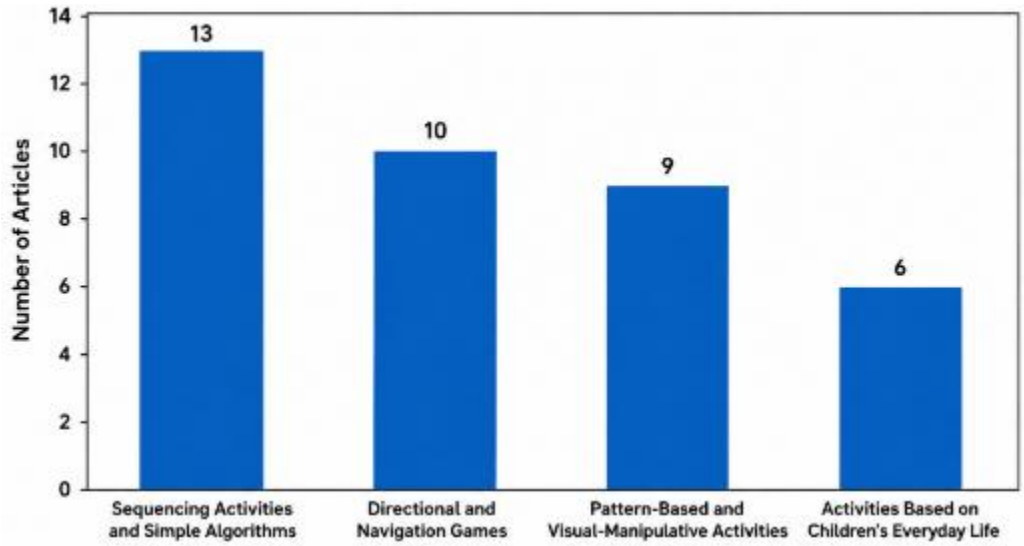

Figure 5. Distribution of *Unplugged Coding* Implementation Forms in Early Childhood Education

These findings indicate that *unplugged coding* in early childhood education is predominantly implemented through concrete, sequential, and experience-based activities

that are closely connected to children's everyday learning contexts. Play and direct experience serve as the primary means of introducing fundamental computational concepts, including algorithms, patterns, direction, and simple problem solving, without requiring the use of digital devices (Küçükkara & Aksüt, 2021).

5. Learning Outcomes Addressed in *Unplugged Coding*

   All 16 articles (100%) identified computational thinking as the primary learning outcome addressed through *unplugged coding*. The most frequently reported supporting outcomes were problem-solving skills and basic logical reasoning, which appeared in 12 articles (75%). Additional outcomes related to motor skills, language, and numeracy were reported in 5 articles (31.25%) (Dayurni & Rahmadani, 2025). These findings indicate that the implementation of *unplugged coding* in early childhood education primarily focuses on developing sequential thinking, pattern recognition, simple decision making, and problem solving through concrete activities. At the same time, several studies reported additional developmental outcomes, particularly when unplugged activities incorporated physical play, manipulative materials, and social interaction.

6. Teachers' Roles in the Implementation of *Unplugged Coding*

   The findings indicate that teachers play an important role in implementing *unplugged coding* in early childhood education. Their roles include designing learning activities, facilitating children's participation during activities, and evaluating the learning process. Teachers organize the sequence of games, adapt learning materials to children's developmental stages, provide simple and understandable instructions, observe children's responses, and reflect on the activities to inform subsequent improvements (Küçükkara & Aksüt, 2021).

   Several studies also identified challenges faced by teachers, particularly regarding their understanding of unplugged coding concepts, pedagogical readiness, and classroom management, especially when activities involve physical movement and group work (Salamah et al., 2025). These findings position teachers as a key factor in the effective implementation of *unplugged coding* in early childhood education, as the quality of activity design, facilitation, and instructional support depends substantially on teachers' pedagogical understanding and ability to adapt activities to young children's developmental needs.

B. Discussion

The findings indicate that research on unplugged coding in early childhood education is still dominated by descriptive qualitative and case-study approaches. This pattern suggests that researchers have focused more extensively on how unplugged activities are implemented in classroom settings than on experimentally testing their effects. The existing body of research therefore appears to remain largely oriented toward establishing and understanding implementation practices in early childhood learning contexts (Metin, 2020). The smaller proportion of quantitative studies further indicates that evidence regarding the effectiveness of unplugged coding needs to be strengthened through more systematic, measurable, and comparative research designs (Kılıç et al., 2025).

Differences are also evident in the orientation of national and international publications. National studies tend to position unplugged coding as an accessible learning approach that can be implemented in early childhood settings with limited technological resources, with considerable emphasis on concrete activities and simple learning materials (Karimah & Sholeha, 2024). In contrast, international studies more frequently position unplugged coding as an initial foundation for preparing children to engage with subsequent digital or robotics-based activities (Zhang et al., 2025). These differences suggest that the pedagogical orientation of unplugged coding varies according to educational needs and contexts. Within national studies, greater emphasis is placed on the practicality and accessibility of classroom implementation, whereas international studies tend to discuss unplugged coding within a broader progression of computational thinking development (Akiba, 2022).

The most frequently identified form of implementation involved sequencing activities and the construction of simple algorithms. This pattern appeared across most of the reviewed studies and suggests that sequencing represents one of the most accessible computational concepts to introduce to young children (Dayurni & Rahmadani, 2025). Activities such as arranging steps, following instructions, and determining routes are compatible with young children's cognitive development because they translate abstract computational processes into concrete actions. At the same time, the predominance of these activities indicates that much of the current implementation of unplugged coding remains concentrated on foundational computational thinking skills. More complex processes, including debugging, decomposition, and solution evaluation, have begun to appear in the literature but have not yet received comparable attention across studies.

The frequent use of directional and navigation games, pattern-based tasks, and visual-manipulative materials further demonstrates the close connection between unplugged coding and concrete learning experiences. Activities involving physical movement, visual representations, and direct interaction can support children in constructing conceptual understanding through meaningful experiences (Marethi et al., 2024). However, some studies remain largely descriptive, identifying the types of activities implemented without examining in sufficient depth the relationships among the activities, the learning processes they generate, and the outcomes subsequently reported. This limitation suggests that future analyses should move beyond identifying commonly used activities toward explaining how particular unplugged activities facilitate specific learning processes and outcomes.

Regarding learning outcomes, all reviewed articles positioned computational thinking as the primary focus. This consistency reflects a shared view that unplugged coding is relevant to developing sequential and logical ways of thinking among young children (Fajriyah et al., 2022). Nevertheless, computational thinking was operationalized differently across studies. Some emphasized children's ability to follow sequences, whereas others focused on pattern recognition, logical reasoning, or simple problem solving. Such variation indicates that computational thinking in early childhood research is addressed through a broad range of indicators. Consequently, findings across studies should be interpreted with careful consideration of how computational thinking was defined and measured in each study rather than treating all reported outcomes as conceptually identical.

The additional outcomes reported across the studies, including problem solving, language, numeracy, and motor development, suggest that unplugged coding may be associated with multiple dimensions of early childhood development. Activities involving play, social interaction, physical movement, and object manipulation provide opportunities for children to engage several developmental domains simultaneously. These findings reinforce the view that unplugged coding can be considered not only as a means of introducing computational thinking but also as a learning approach that can be integrated with broader developmental experiences in early childhood education. However, because the reviewed studies employed diverse methodological designs, these additional outcomes should be interpreted as reported or associated outcomes rather than uniform evidence of causal effects.

Another important finding concerns the role of teachers in implementing unplugged coding. Teachers are responsible for designing activities, guiding learning processes, and assessing children's engagement and development (Putra & dkk., 2020). Several studies suggest that the quality of teacher facilitation may be particularly important, as even relatively simple activities can support meaningful learning when accompanied by clear instructions, sufficient repetition, and opportunities for children to explore. Conversely, limited teacher understanding of unplugged coding concepts and insufficient pedagogical readiness may constrain implementation. These findings indicate that successful implementation depends not only on the learning materials or activities selected but also on teachers' ability to adapt, facilitate, and evaluate those activities according to children's developmental needs.

The review also reveals several areas in which research on unplugged coding in early childhood education remains underdeveloped. Studies directly comparing the effectiveness of different forms of unplugged activities are still limited, making it difficult to determine which

implementation strategies are most appropriate for particular learning outcomes. Similarly, the relationships among activity type, teacher facilitation, and learning outcomes have not been examined extensively. Further research is therefore needed to investigate the implementation of unplugged coding using more focused and rigorous designs, particularly experimental, comparative, and longitudinal approaches that can provide stronger evidence regarding its outcomes and the instructional conditions under which they emerge.

Conceptually, unplugged coding can be regarded as a pedagogical approach that is compatible with the developmental characteristics of young children because it emphasizes direct experience, play-based activities, and social interaction. Through these experiences, fundamental computational thinking concepts can be introduced concretely without requiring dependence on digital technologies. Its educational potential is likely to be better realized when activities are systematically designed and teachers are adequately prepared to facilitate the learning process. Taken together, the reviewed evidence suggests that unplugged coding represents a promising and developmentally relevant approach for early childhood education. Nevertheless, given the predominance of descriptive studies and the methodological diversity of the current evidence base, stronger empirical research is still required before firm conclusions can be drawn regarding its comparative effectiveness.

IV. CONCLUSION

The systematic review of 16 articles indicates that research on *unplugged coding* in early childhood education is predominantly characterized by descriptive qualitative and case-study approaches, with most studies focusing on classroom implementation practices. The most frequently reported forms of implementation include sequencing activities, directional games, and pattern-based or visual-manipulative activities. Across the reviewed studies, computational thinking emerged as the primary learning outcome, particularly in relation to problem-solving skills and basic logical reasoning. Teachers also play a key role in the implementation process, particularly in designing, facilitating, and evaluating learning activities. Overall, *unplugged coding* demonstrates potential as a pedagogical approach that is relevant and developmentally appropriate for early childhood education, particularly when supported by structured instructional planning and adequate teacher pedagogical readiness.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this article.

AUTHOR CONTRIBUTIONS

Elia Azizah: *Conceptualization, Methodology, Literature Search, Data Curation, Formal Analysis, Writing – Original Draft, and Visualization.* ***Lisa Virdinarti Putra:*** *Conceptualization, Methodology, Validation, Supervision, Writing – Review & Editing, and Final Approval of the Manuscript. Both authors contributed to the interpretation of the findings, critically reviewed the manuscript, and approved the final version for publication.*

FUNDING

This research received no external funding.

ACKNOWLEDGMENT

The authors would like to express their sincere gratitude to Universitas Ngudi Waluyo for the academic support provided throughout the preparation of this study. The authors also extend their appreciation to all parties who contributed valuable support and insights during the systematic review and manuscript preparation process.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES

During the preparation of this manuscript, the authors used generative AI and AI-assisted technologies to support language editing, proofreading, and improvements in the clarity and readability of the manuscript. These technologies were not used to generate research data, conduct the literature selection process,

perform data analysis, or determine the findings and conclusions of the study. All AI-assisted outputs were critically reviewed, revised, and verified by the authors. The authors take full responsibility for the accuracy, integrity, and content of the final manuscript.

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