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Exploring the Impact of Digital Literacy on Cognitive Development in Early Childhood Education: A Systematic Literature Review

Anggun Karnita[1]✉, Siti Aisyah[1], Noviana Mustapa[1], Erie Siti Syarah[1], Della Raymena Jovanka[1], Samihah bt Mahamud[2]
[1]Universitas Terbuka, Indonesia
[2]Albukhary International University, Malaysia

Abstract

Purpose – This systematic literature review explores the development of digital literacy among children in the post-typographic era, where digital technology increasingly dominates daily life. The purpose of this study is to identify the impact of digital literacy on various dimensions of cognitive development in young children, including early numeracy, executive functioning, critical thinking, and creativity. By broadening the conceptualization of cognitive development, this study aims to provide a comprehensive understanding of how digital literacy contributes to children's intellectual growth in early childhood education.
Design/methods/approach – Analysis of 33 studies obtained from the period between 2019 and 2024 indicates that children engage in multimodal practices, using technology for both play and learning. This highlights the importance of educators' understanding of digital literacy practices at home. Factors such as children's age, family structure, household income, and Human Development Index (HDI) significantly contribute to predicting preschool children's early digital literacy.
Findings – The findings show that while children's literacy skills may benefit from access to digital resources, their mathematical skills do not demonstrate significant improvement. However, this study recommends that teachers collaborate with parents to enhance digital literacy and awareness of digital data security. Additionally, the use of interactive digital media can increase children's engagement and motivation in learning, allowing for more differentiated and inclusive learning approaches.
Research implications/limitations – Future research should prioritize the development of age-appropriate, culturally relevant, and innovative digital content that can support effective teaching and learning in the digital age. Additional longitudinal studies are needed to explore the long-term cognitive and socio-emotional effects of digital media exposure in early childhood.
Practical implications – Digital literacy can help children develop critical thinking, problem-solving, and creativity skills. However, exposure to age-inappropriate content can hinder their social-emotional development. The conclusion of this study emphasizes the need for training and support for educators in using digital media, as well as close collaboration with parents to ensure the successful implementation of digital literacy in early childhood education.
Originality/value – This review offers a novel contribution by integrating multiple dimensions of cognitive development with the concept of digital literacy. It provides valuable insights into the future of educational practices, emphasizing the importance of digital competencies as foundational elements in early childhood education in the digital era.

Keywords Digital literacy, Cognitive development, Early childhood

Paper type Literature review

✉ Corresponding author:
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1. Introduction

Children today are in the post-typographic era, where electronic devices increasingly dominate everyday life (Laidlaw et al., 2021). Children actively engage in multimodal practices, using digital technology for play and learning at home (Ozturk & Ohi, 2022). This finding emphasizes the importance for educators to understand the existing digital literacy practices at home as a foundation for further literacy learning. Parents may also need support in understanding how the use of technology can contribute to children's literacy learning (Ozturk & Ohi, 2022). Reading and writing involve a variety of skills, but both can be divided into two relatively distinct groups: one related to encoding and decoding (the conversion between the written and spoken forms of language) and the other related to linguistic comprehension. In the early stages of the literacy learning process, encoding and decoding skills are crucial. Merely memorizing the spelling of individual words is a highly inefficient strategy for learning literacy, and mastery of sub-word patterns that connect pronunciation with spelling is necessary. This requires an understanding of the sound structure of words, known as phonological awareness (Sysoev et al., 2022).

The results of PISA 2009 and 2012 are based on data collected from students, while the data from the International Computer and Information Literacy Study (ICILS) 2013 and 2018 comes from teachers. PISA 2009 and PISA 2012 include basic indicators of technology use by students, such as the proportion of students who regularly use computers at school, at least once a week. The average across all participating countries showed that in 2009, 71% of students used computers regularly at school, while in 2012, this figure increased to 72%. ICILS 2013 highlighted teachers' perspectives on technology use during lessons, finding that across participating countries, 62% of teachers often used computers. However, the frequency of technology use in teaching varied greatly between countries. For instance, in Germany, only 34.4% of teachers frequently used computers in their teaching. The results from ICILS 2018 indicated that nearly half of the teachers utilized digital technology in their daily teaching activities. These findings suggest that digital technology is increasingly being used in schools and becoming an integral part of teaching and learning practices. However, the results do not explain how digital technology is applied in the classroom context (Sailer et al., 2021).

Developing digital literacy begins at an early age and contributes to the widening digital divide (Cao et al., 2024). The need to involve experts in curriculum development to improve digital literacy among students has been emphasized in recent research (Polizzi, 2020). Storytelling has been shown to significantly enhance children's literary and digital literacy skills, serving as an effective and valuable pedagogical method in early education (Maureen et al., 2020). These findings emphasize the importance of storytelling as a tool that is not only enjoyable but also effective in enhancing reading ability and understanding information in the digital era (Maureen et al., 2020). The use of augmented reality technology has been found to increase children's motivation, engagement, and comprehension of complex concepts, while simultaneously developing important skills for digital literacy (Wang et al., 2024). Early literacy education is crucial for helping children adapt and succeed in today's information-rich world (Sysoev et al., 2022). With the increasing use of digital devices, children need to develop the necessary skills to interact with technology effectively (Akiba, 2022). Various social and economic factors influence the development of digital literacy in early childhood, including age, gender, income, and access to technology at home (Cao et al., 2025). The family environment plays a significant role in shaping children's ability to use technology and comprehend digital information (Cao et al., 2024).

Collaboration among parents, educators, and policymakers is essential to enhance digital literacy among preschool children and support the creation of evidence-based policies that address the digital divide (Cao et al., 2024). Family background, such as parental marital status and household income levels, also affects children's screen usage behavior. To improve cognitive development in children from low- and middle-income countries, investment in education that considers socioeconomic context is necessary. Cognitive development in early childhood is not limited to numeracy or mathematical reasoning but also includes executive functions, critical thinking, and creative engagement. The need for a more targeted and effective use of digital

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technology to support children's foundational skills has also been highlighted (Parks & Tortorelli, 2021). Teachers' professional development should combine practical skills and positive attitudes to better equip them for teaching digital literacy (Pires Pereira et al., 2023). Teachers, students, and parents—key stakeholders in education—need to understand digital parenting, digital literacy, and digital information security, especially in this era where digital life has become the norm (Akman et al., 2023). To meet modern educational challenges and improve reading instruction quality, it is important to consider historical contexts and developmental models (Semingson & Kerns, 2021).

Collaboration and innovation have a significant positive effect on children's digital learning and sustainable education, with digital learning acting as a mediator in strengthening these relationships (Ika Sari et al., 2024). Enhancing digital learning can improve children's understanding of sustainability. Overall, there is a need to integrate collaboration and innovation into education to promote digital literacy and sustainability awareness among children in Indonesia, supported by evidence-based policies (Ika Sari et al., 2024). Modern preschool education must support children's digital literacy development (Otterborn et al., 2020). The increasing proliferation of inaccurate or harmful content on the internet necessitates collaboration among researchers, educators, school leaders, parents, policymakers, and students (Alexander, 2020). Although there are recommendations to limit digital media use for young children, digital devices have become an integral part of their daily lives (Maureen et al., 2020).

The rapid development of digital technologies and shifts in early childhood education have created challenges for teachers, particularly in integrating digital play to support children's language development (Van Der Westhuizen & Hannaway, 2021). Teacher training has proven effective in enhancing digital competencies and improving teaching quality (Mattar et al., 2022). Moreover, educational frameworks must be adapted to ensure inclusivity and relevance for all stakeholders (Mattar et al., 2022). Therefore, this study conducts a systematic literature review to identify the impact of digital literacy on cognitive development in early childhood. Based on the existing literature, this systematic review is guided by three research questions: Can digital literacy enhance cognitive development in early childhood?, What is the impact of digital literacy use on young children?, What are the challenges of digital literacy for young children?.

2. Methods

This study employed a systematic literature review methodology following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. This approach ensures transparency and comprehensive reporting in literature reviews and provides a structured framework for analyzing studies on digital literacy and cognitive development in early childhood.

2.1. Eligibility Criteria

Articles included in this review had to meet the following criteria (1) SCOPUS: Published between 2019 and 2024; Written in English; Belonging to the fields of Social Sciences, Psychology, Computer Science, or Medicine; Classified as journal articles (excluding book series); Containing keywords such as *digital literacy*, *child*, and *early digital literacy*; Cross-sectional studies were excluded. (2) Science Direct: Published between 2019 and 2024; Written in English; Classified as review articles or research articles; Published in relevant journals such as *International Journal of Child Computer Interaction*, *Computers and Education*, and others; Belonging to the fields of Psychology and Computer Science; Articles from irrelevant journals and document types such as encyclopedias, case reports, and editorials were excluded.

2.2. Data Sources

The databases used for article searches included SCOPUS and Science Direct. In addition, manual searches were conducted in several other databases to broaden the scope of relevant references. The final search was conducted in 2024.

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2.3. Search

Searches were conducted using specific search strings tailored to each database. The search strings included: (1) SCOPUS: "digital literacy" AND "early childhood", "Digital Literacy" AND "Early Childhood Education" AND "Cognitive Development", "Digital Literacy" AND "Cognitive Development". (2) Science Direct: “Digital Literacy” and “Digital Literacy for Early Childhood Education Cognitive Development”. Searches were performed on article abstracts, and filters were applied to align with the screening criteria. A more detailed explanation can be found in the table 1. The inclusion and exclusion criteria for SCOPUS are presented in Table 2, while those for ScienceDirect are shown in Table 3.

2.4. Study Selection

The study selection process was conducted in several stages, beginning with the initial identification of articles through database searches, followed by screening based on titles and abstracts, and then eligibility assessment based on inclusion and exclusion criteria. Articles that met all criteria were selected for further analysis. A flow diagram of the selection process is presented in Figure 1.

2.5. Evaluation

The quality of each article was assessed using a rubric that included seven criteria: Objectives and Purpose, Literature Review, Theoretical Framework, Participants, Methods, Results and Conclusions, and Significance. Each criterion was rated on a 4-point scale (1 = Does Not Meet Standard, 2 = Nearly Meets Standard, 3 = Meets Standard, 4 = Exceeds Standard). Articles scoring 14 or lower were excluded from the analysis. Only articles that met the quality standards were retained for further review.

2.6. Data Analysis

Data were analyzed using thematic analysis (Braun & Clarke, 2006), which involves six phases: (1) Familiarization with the data, (2) Generating initial codes, (3) Searching for themes, (4) Reviewing themes, (5) Defining and naming themes, and (6) Producing the report. A coding protocol was developed based on four main categories: (a) Digital literacy, (b) Cognitive development in early childhood, (c) Early childhood education, and (d) Digital context. Two researchers independently analyzed the selected articles, and inter-rater reliability was calculated using a percentage agreement metric.

Table 1. Database-Based Search

Search Directory	Search String
Scopus	"digital literacy" AND "early childhood"
	"Digital Literacy" AND "Early Childhood Education" AND "Cognitive Development"
	"Digital Literacy" AND "Cognitive Development"
Science Direct	Digital Literacy
	Digital Literacy for Early Childhood Education Cognitive Development

Table 2. Inclusion and Exclusion Criteria for SCOPUS

No	Criteria	Inclusion	Exclusion
1	Year of Publication	Articles published from 2019 to 2024	Articles published before 2019
2	Language	Articles written in English	Articles written in languages other than English
3	Subject Area	Social Sciences, Psychology, Computer Science, Medicine	
4	Document Type	Article	Book Series
5	Source Type	Journal	
6	Keywords	Digital literacy, child, early digital literacy	Cross sectional study

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Table 3. Inclusion and Exclusion Criteria for Science Direct

No	Criteria	Inclusion	Exclusion
1	Year of Publication	Articles published from 2019 to 2024	Articles published before 2019
2	Language	English	Spanish, French
3	Article Type	Review article, research article	encyclopedia, book chapters, conference abstracts, case reports, discussion, editorials, errata, mini review, practice guidelines, short communications, other.
4	Publication Title	International Journal of Child Computer Interaction, Computers and Education, Early Childhood Research Quarterly, Teaching and Teacher Education, Children and Youth Services Review, Thinking Skills and Creativity, Computers and Education: Artificial Intelligence, Cognitive Development, Journal of Experimental Child Psychology	Computers in Human Behavior, Procedia - Social and Behavioral Sciences, International Encyclopedia of Education 2023, The Lancet, Heliyon, Contemporary Clinical Trials, Journal of Second Language Writing, Journal of the Academy of Nutrition and Dietetics, JACC: Advances, Learning and Individual Differences, Annals of Emergency Medicine, Journal of the American Pharmacists Association, Procedia Computer Science
5	Subject Areas	Psychology, Computer Science	Social Science, Medicine and Dentistry, Nursing and Health Professions, Arts and Humanities, Neuroscience, Economics, Econometrics and Finance, Agricultural and Biological Sciences, Business, Management and Accounting.

Table 3 outlines the inclusion and exclusion criteria applied to articles sourced from the ScienceDirect database for this systematic review. The criteria were designed to ensure the selection of relevant, high-quality literature aligned with the research objectives. *First*, regarding the year of publication, only articles published between 2019 and 2024 were included to ensure the data reflects the most recent developments in the field. Articles published before 2019 were excluded due to potential obsolescence. *Second*, the language criterion limited the review to articles written in English, as it is the primary language of academic communication in the selected journals. Articles published in Spanish or French were excluded to maintain consistency and accessibility. *Third*, in terms of article type, only review articles and original research articles were included, as these provide comprehensive data and empirical findings. Other types of publications—such as encyclopedias, book chapters, conference abstracts, case reports, editorials, mini reviews, and practice guidelines—were excluded due to their limited methodological rigor or scope. *Fourth*, specific publication titles were prioritized to ensure relevance and quality. Journals such as the International Journal of Child Computer Interaction, Computers and Education, Early Childhood Research Quarterly, and Teaching and Teacher Education were included, among others. In contrast, journals such as Computers in Human Behavior, The Lancet, and Heliyon were excluded as their primary focus does not align closely with early childhood education and digital literacy.

Finally, the subject area criterion restricted inclusion to articles categorized under Psychology and Computer Science, reflecting the interdisciplinary focus of the study. Articles from broader or unrelated subject areas such as Medicine, Nursing, Social Sciences, Arts and Humanities, and Business were excluded to maintain the specificity and relevance of the review.

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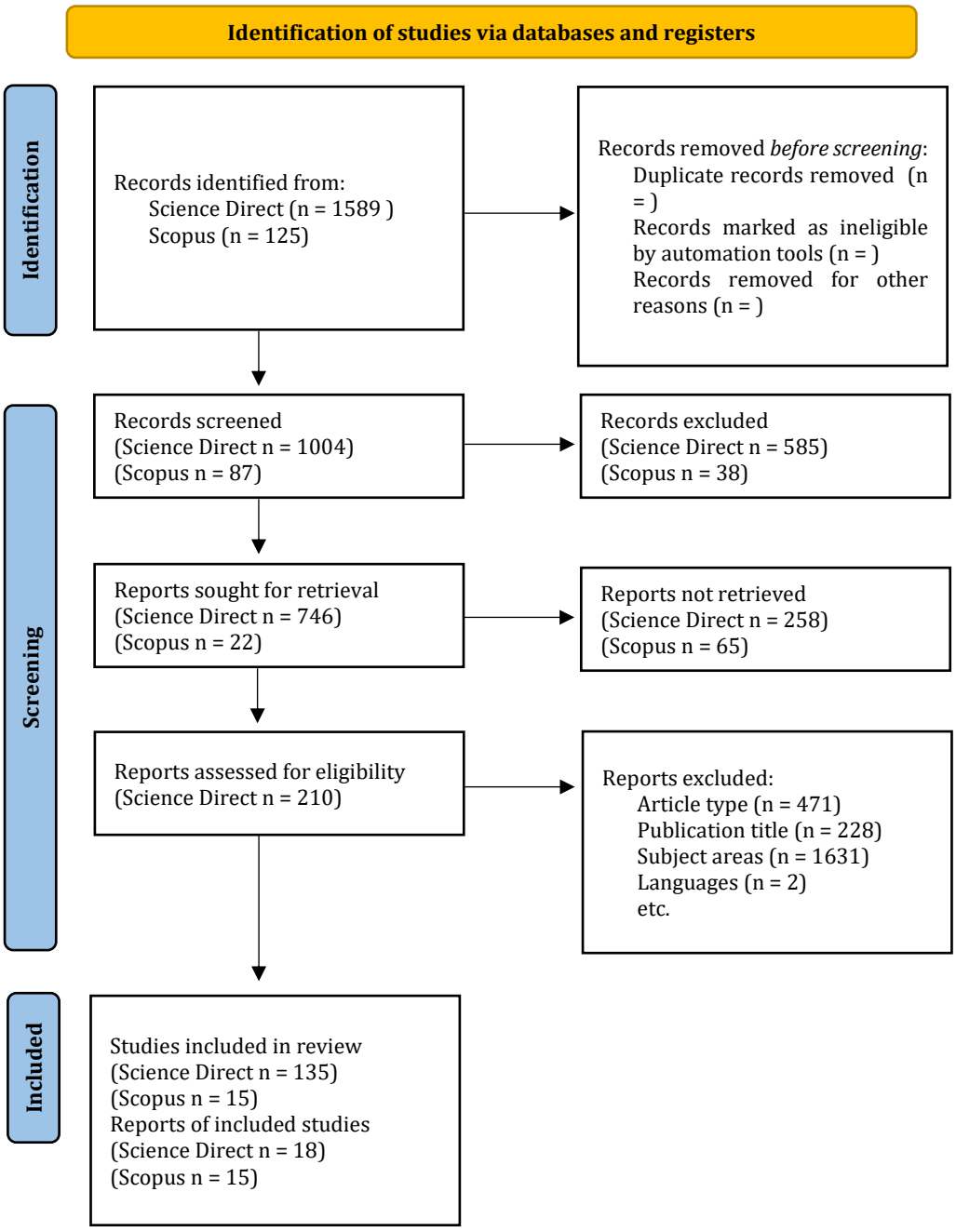

Figure 1. Gambar 1. PRISMA study flow diagram

3. Result

3.1. The Impact of Digital Literacy on Cognitive Development in Early Childhood

This study first addresses the extent to which digital literacy influences cognitive development in early childhood, particularly in basic mathematical skills. The reviewed findings indicate that the use of digital technology does not significantly improve young children's mathematical abilities. The digital resources provided to children are insufficient to stimulate meaningful cognitive growth (Parks & Tortorelli, 2021). One of the main reasons is that much of the digital content used is not yet fully aligned with children's developmental needs, both in terms of instructional design and pedagogical approach. This suggests that access to technology alone does not guarantee cognitive improvement unless accompanied by high-quality, developmentally appropriate content.

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Further evidence demonstrates that digital media can potentially enhance children's cognitive skills and creativity through access to interactive educational content (Laidlaw et al., 2021). However, the benefits are highly dependent on the quality, relevance, and context in which digital media is used. There is also limited effectiveness found in "unplugged" learning activities—those that do not directly involve digital devices—highlighting the need for careful evaluation of such approaches (Akiba, 2022). Without proper instructional planning, children may not be adequately prepared to engage meaningfully with digital technologies. Therefore, pedagogical readiness and adequate teacher training are essential to ensure digital literacy contributes positively to children's cognitive development (Akiba, 2022).

One plausible explanation for the limited impact of digital literacy on mathematical abilities is the misalignment between most digital learning applications and young children's developmental needs in numeracy. Many digital tools prioritize symbolic drills and gamified repetition without fostering deeper conceptual understanding, such as number sense or spatial reasoning. Furthermore, early math learning requires hands-on experiences and concrete manipulatives that may not be adequately replicated through screen-based activities. This suggests that digital literacy, while beneficial in broader cognitive domains, requires more intentional instructional design to support foundational numeracy development.

3.2. The Effects of Digital Literacy on Young Children's Learning and Socio-Emotional Development

The second research question explores the broader effects of digital literacy on children's learning processes and socio-emotional development. Digital literacy has the potential to enhance critical thinking, problem-solving, and creativity through engagement with interactive media (Sailer et al., 2021). Children who are exposed to digital tools gain broader access to learning resources and information, which can expand their understanding of the world. The collaborative use of digital technology also strengthens social interaction and empathy, which are essential components of socio-emotional development (Sailer et al., 2021). These dimensions underline the capacity of digital literacy to support both academic and interpersonal growth in early childhood.

To ensure effective integration, the TPACK (Technological Pedagogical Content Knowledge) framework emphasizes the importance of teachers' mastery of content, pedagogy, and technology as a unified domain (Sailer et al., 2021; Salsabila et al., 2023). This framework advocates for the purposeful and integrated use of technology in teaching and underscores the necessity for teachers to skillfully plan, deliver, and evaluate technology-based learning experiences. Additionally, the ICAP (Interactive, Constructive, Active, Passive) framework is employed to classify levels of cognitive engagement, with empirical findings suggesting that higher interactivity leads to better educational outcomes (Sailer et al., 2021). This model supports the notion that instructional design should be oriented toward maximizing active and constructive engagement to fully realize the benefits of digital literacy. Educators must therefore create learning experiences that foster deeper levels of interaction and reflection among children.

Evidence also shows how kindergarten teachers in Sweden use digital programming and applications to construct interdisciplinary and engaging learning experiences (Otterborn et al., 2020). These practices contribute not only to the development of children's technical abilities but also enhance critical thinking and 21st-century competencies across domains such as mathematics, science, and language. Furthermore, the early introduction of computational thinking positions digital literacy as a foundational competence in contemporary education (Otterborn et al., 2020). A well-integrated digital learning environment thus offers promising support for both cognitive and socio-emotional development in early childhood. When thoughtfully designed and collaboratively implemented, digital tools can significantly contribute to the holistic growth of young learners.

3.3. Challenges in Implementing Digital Literacy in Early Childhood Education

The third research question focuses on the challenges of implementing digital literacy in early childhood education. One key finding reveals that limited parental understanding of technology is a major barrier to supporting children's digital engagement (Akman et al., 2023). Other challenges

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include concerns over data security and privacy, unequal access to high-quality digital resources, and infrastructural limitations in underserved areas. Parents often require structured support to comprehend how technology can enhance literacy development, making parental involvement a critical factor in fostering safe and purposeful digital practices among young children (Ozturk & Ohi, 2022).

Socioeconomic variables such as geographic location, household income, and parental education level significantly influence children's digital literacy development (Cao et al., 2024). In this regard, parental mediation and the availability of digital resources at home serve as mediating factors between socioeconomic background and the development of early digital skills. A growing challenge is the prevalence of online misinformation, which highlights the need for coordinated collaboration among educators, parents, researchers, and policymakers to ensure digital literacy efforts are grounded in both social and educational contexts (Alexander, 2020). Consequently, digital literacy should not be reduced to a technical matter but must be addressed as a social and pedagogical concern through a systemic and integrative approach.

Professional development is necessary to enhance teachers' confidence and competence in utilizing digital tools effectively in classroom settings (Pires Pereira et al., 2023). A shift in focus from merely providing hardware to strengthening teacher capacity is needed, with collaborative and innovative approaches forming the basis of inclusive and adaptive digital learning environments (Ika Sari et al., 2024). Teachers' digital competence is often more influential than device availability in determining the success of digital learning (Sailer et al., 2021). Therefore, sustainable implementation of digital literacy requires long-term investments in teacher training and pedagogical design, along with strategic alignment across sectors.

Although digital applications have the potential to promote creativity and social interaction, they may be misused by children with underdeveloped executive functioning or weak phonological awareness (Sysoev et al., 2022). To address this issue, adaptive scaffolding mechanisms should be employed to support learners who may otherwise be at risk. Moreover, digital literacy must be approached as a cross-curricular competency that integrates critical and functional skills across multiple disciplines (Polizzi, 2020). While interest in digital game-based instruction among teachers is increasing, a significant number still lack the required digital pedagogical skills to implement it effectively (Van Der Westhuizen & Hannaway, 2021). Addressing these multifaceted challenges will require comprehensive and collaborative efforts across curriculum development, teacher preparation, parental engagement, and policy frameworks to advance equitable and meaningful digital literacy in early childhood education.

4. Discussion

Digital literacy has undergone significant development since it was first conceptualized as the integration of technical, cognitive, and intellectual skills required for navigating digital environments. Over the decades, this definition has expanded through frameworks developed by institutions such as the European Union and UNESCO, which emphasize individuals' capacities to access, evaluate, analyze, and apply information using digital tools. This evolution marks a transition from perceiving digital literacy as mere technical proficiency to recognizing it as a complex, multidimensional competence shaped by broader cultural, educational, and societal factors. The redefinition of digital literacy also underscores its pivotal role in fostering critical citizenship in the digital age. Consequently, digital literacy is no longer confined to operational knowledge but is closely linked to social practices, meaning-making, and equitable participation in digital environments.

Digital literacy in early childhood must be understood as a multidimensional construct that encompasses not only technical proficiency but also the development of cognitive, creative, and socio-emotional competencies. Drawing on frameworks such as Bloom's revised taxonomy and the executive function model, this review positions cognitive development as an umbrella term that includes skills such as critical thinking, attention regulation, creativity, and early problem-solving—skills increasingly nurtured through digital media. Therefore, even if digital tools do not

significantly enhance mathematical skills, their role in fostering higher-order thinking and creative engagement still represents a meaningful contribution to early childhood development. This reframing allows for a more coherent interpretation of the findings, aligning them with the broader definition of cognitive growth (Manassero-Mas et al., 2022).

In early childhood education, the role of digital literacy has become increasingly prominent due to the pervasive integration of technology in children's daily lives. Digital tools serve not only as aids for learning but also as instruments to foster 21st-century skills such as computational thinking and basic coding (Murcia et al., 2018). Children today grow up immersed in a digital culture where smartphones, tablets, and computers are commonplace in both home and school environments (Murcia et al., 2024). This context necessitates the development of early digital competencies that go beyond simple screen interaction to include creative and critical engagement with digital content. Hence, early exposure to digital environments must be scaffolded with age-appropriate pedagogical strategies to maximize developmental outcomes.

Digital literacy should be viewed as a foundation for achieving equitable and high-quality education, especially within inclusive learning environments (Feng et al., 2025). This perspective is supported by findings showing that teachers' appreciation for traditional cultural values correlates positively with their digital literacy levels, particularly when moderated by openness to technology and a sense of job security. These findings suggest that cultural awareness and professional well-being are key factors in enhancing educators' digital competencies. As such, professional development programs should not only provide technical training but also nurture cultural sensitivity and emotional readiness. Strengthening these aspects can bridge gaps between traditional educational practices and emerging digital demands.

Technological innovations such as augmented reality (AR) have further expanded the scope of digital literacy by transforming learning experiences into interactive and immersive activities (Wang et al., 2024). AR applications enhance children's ability to access and apply information visually and contextually, promoting deeper cognitive engagement. Tools like educational robots and learning apps support this process by encouraging playful exploration and concept reinforcement (Çetin & Demircan, 2020; Lee & Junoh, 2019; Strawhacker & Bers, 2019). These tools demonstrate how digital literacy can be cultivated through experiential learning models that are developmentally appropriate. Consequently, technology in early education should be viewed not as a distraction but as a medium for meaningful and creative learning experiences

A particularly innovative approach in this domain is Novel Roboting, which blends storytelling, engineering principles, and robotics to support children's holistic digital developmen(Palinko et al., 2025)t. This model fosters key digital literacy skills such as creativity, communication, and problem-solving. By embedding technical learning within narrative and hands-on contexts, this method aligns with constructivist pedagogical ideals and proves effective in real-world classrooms. Moreover, Novel Roboting helps children relate digital concepts to their lived experiences, thereby enhancing both engagement and understanding. This approach exemplifies the potential of integrated learning designs in promoting inclusive and empowering digital literacy education (Uğur Erdoğmuş, 2021).

Despite these innovations, the integration of technology in early education remains uneven and heavily dependent on educators' preparedness (Mathebula et al., 2025). A lack of confidence and technical expertise among many early childhood educators hampers effective use of digital tools in classroom settings. Educational robotics, while promising, are underutilized due to inadequate training, limited institutional support, and resistant attitudes (Feng et al., 2025). These findings reflect a systemic need for ongoing professional development and institutional capacity-building. Without these supports, the gap between educational potential and actual implementation of digital technology in early education will persist.

Beyond educators, parents also play a critical role in shaping children's digital experiences. Parental mediation in digital use at home significantly influences children's engagement with technology (Macrides et al., 2022; Uğur Erdoğmuş, 2021). The family—especially parents—serves as the most immediate and influential microsystem in a child's development. Children utilize digital media for diverse purposes such as play, learning, entertainment, and communication, highlighting the importance of guided exposure (Milford et al., 2022). Therefore, parental

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understanding of digital opportunities and risks is essential for fostering responsible and enriching digital engagement in young children.

The nature and quality of parental mediation vary widely and often involve tensions between encouraging digital competence and limiting screen exposure. Conflicts at home more frequently concern screen time duration rather than content. Parents are thus caught in a dilemma: fostering digital literacy while protecting children from potential negative effects on executive functioning, such as attention, emotional regulation, and behavioral control. These concerns are particularly salient during early childhood, a sensitive period for neurological development (Milford et al., 2022). As a result, balanced and informed digital parenting is necessary to support children's holistic growth in digital contexts.

The concept of digital parenting continues to evolve, emphasizing the active involvement of parents in regulating and facilitating children's interactions with digital media. Parents with higher digital literacy are more confident in safeguarding their children from online threats (Durak & Kaygin, 2020). Younger children rely on structured rules and consistent adult guidance when navigating digital environments (Stoilova et al., 2021). Continuous improvement in parents' digital competencies is crucial for maintaining their role as effective guides (Murcia et al., 2024). This underlines the importance of school-family collaboration in developing comprehensive and sustainable digital literacy foundations.

While interest in emerging technologies such as generative artificial intelligence (AI) is growing among educators, their classroom applications remain limited (Chiu et al., 2024; Long et al., 2023; Rizvi et al., 2023). Major barriers include the absence of professional development programs and insufficient access to enabling infrastructure. In addition, educators advocate for a balance between digital engagement and sensory-rich, hands-on learning experiences essential for early childhood development (Almatrafi et al., 2024; Laidlaw et al., 2021; Marzano, 2025). These perspectives reflect the need for a nuanced integration of technology that respects developmental needs. Therefore, technology should serve as a complement, not a replacement, for holistic pedagogical practices.

Digital literacy in early childhood is not merely about access to devices or digital platforms. It demands the convergence of pedagogical design, teacher and parent readiness, cultural contextualization, and institutional support (Chiu et al., 2024). These interconnected factors collectively shape children's digital competencies and determine their capacity to thrive in digitally mediated societies. As the digital landscape continues to evolve, early and intentional cultivation of digital literacy will be critical for educational equity and lifelong learning. Only through collaborative, culturally responsive, and developmentally appropriate strategies can digital literacy become a transformative force in early childhood education.

4.1. Research Contribution

The discussion of the research findings reveals significant insights into the role of digital literacy in early childhood education, particularly concerning its impact on cognitive development, social interaction, and the challenges faced by educators and children alike. The results suggest a complex interplay between digital literacy and various educational outcomes, which can be interpreted through the lens of existing theories and previous studies.

The first research question explored the impact of digital literacy on young children's cognitive abilities in mathematics. The findings indicate that digital literacy does not significantly enhance early mathematical skills, aligning with Parks and Tortorelli, who argue that the digital resources available may not be sufficient for cognitive development (Parks & Tortorelli, 2021). This raises important questions about the quality and appropriateness of digital content provided to children, suggesting that merely having access to technology is not enough; rather, the content must be engaging and pedagogically sound.

Conversely, Sailer et al. highlight that digital literacy can foster critical thinking, problem-solving, and creativity through interactive media (Sailer et al., 2021). This dichotomy underscores the necessity for educators to carefully select digital tools that promote meaningful engagement rather than passive consumption. The application of TPACK and ICAP theories further emphasizes

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that effective integration of technology requires a nuanced understanding of content knowledge, pedagogical strategies, and technology use. Teachers must be equipped with the skills to create interactive learning experiences that encourage active participation, as these are shown to yield better educational outcomes.

The literature review provides a theoretical contribution by expanding previous findings related to the limitations of digital literacy in enhancing early mathematical abilities in young children, as well as emphasizing the importance of content quality and active child engagement. The methodological contribution lies in integrating the TPACK and ICAP theories in the analysis and identifying external factors such as parental involvement and socioeconomic background that influence the development of digital literacy in early childhood. Furthermore, the practical contribution is reflected in recommendations for educators to be more selective in choosing digital tools and to emphasize the importance of teacher training to optimally utilize technology in early childhood education.

However, this literature review has limitations in the research design used. The design does not capture long-term information regarding the effects of digital literacy interventions. Additionally, limitations in teacher training have resulted in suboptimal improvements in children's learning outcomes. External factors, such as parental involvement and socioeconomic background, have not been fully controlled. This research needs to be tested with a broader and more diverse population, especially among children with special needs.

Based on these findings and limitations, several recommendations can be made, including conducting longitudinal studies to examine the long-term effects of digital literacy interventions on children's cognitive and social development. Exploring the impact of various types of digital content (e.g., educational games, interactive storytelling) on different aspects of learning is also suggested. Developing inclusive educational technologies, particularly for children with special learning needs such as low executive function or phonological awareness difficulties, is essential. Further research on teachers' beliefs about technology integration and their professional development needs is necessary to foster a culture of innovation in early childhood education. Lastly, prioritizing parental involvement and family support in digital literacy programs is crucial, given the significant influence of socioeconomic factors and the home environment.

4.2. Limitations

The implications of these findings extend beyond individual classrooms. They suggest a need for systemic changes in how digital literacy is approached within early childhood education. For instance, the Threshold Model indicates that simply increasing technological resources may not lead to improved educational outcomes unless educators are adequately trained to utilize these tools effectively. This aligns with Akiba's (2022) skepticism regarding "unplugged" learning activities; without proper guidance and training, children may struggle to engage meaningfully with technology.

Moreover, the research highlights the importance of parental involvement and socioeconomic factors in shaping children's digital literacy development. As Cao et al. demonstrate, family background plays a crucial role in accessing digital resources and mediating technology use at home (Cao et al., 2024). This suggests that initiatives aimed at enhancing digital literacy must also consider family dynamics and provide support for parents to foster their children's learning effectively.

4.3. Suggestions

Future research should focus on several key areas to build upon these findings. First, longitudinal studies examining the long-term effects of digital literacy interventions on children's cognitive and social development would provide deeper insights into optimal practices. Additionally, exploring how different types of digital content—ranging from educational games to interactive storytelling—affect various aspects of learning could inform curriculum design.

Another critical area for future inquiry is the development of inclusive educational technologies that cater to children with diverse learning needs, particularly those with low executive function or phonological awareness challenges. Understanding how scaffolding

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mechanisms can be tailored to support these children will be essential in creating more effective learning environments.

Finally, investigating teachers' beliefs about technology integration and their professional development needs will be vital for fostering a culture of innovation in early childhood education. As Van Der Westhuizen and Hannaway suggest, teachers desire to experiment with digital games but require further training to do so effectively (Van Der Westhuizen & Hannaway, 2021).. Addressing this gap will empower educators to leverage technology as a tool for enhancing language acquisition and other critical skills among young learners.

5. Conclusion

This study concluded that while digital literacy does not significantly enhance young children's early mathematical skills—likely due to the lack of high-quality, developmentally appropriate content—it contributes positively to other essential aspects of cognitive development such as critical thinking, creativity, problem-solving, and executive functioning. Digital tools, when designed and implemented thoughtfully, can foster active engagement, exploration, and collaboration among children, thereby supporting their holistic development. However, challenges remain, including unequal access to quality digital resources, limited parental digital competencies, data privacy concerns, and insufficient teacher training. Addressing these issues requires a comprehensive and collaborative approach involving educators, families, and policymakers. Overall, the findings emphasize that digital literacy should be viewed not merely as a technical skill but as a multidimensional competence that plays a transformative role in fostering inclusive, equitable, and developmentally appropriate early childhood education.

Declarations

Author contribution statement

Anggun Karnita conceived the idea. Siti Aisyah and Noviana Mustapa conducted data collection. Erie Siti Syarah and Della Raymena Jovanka developed the theory digital literacy, cogntive development, and early childhood education. Samihah bt Mahamud performed the analysis. All authors in discussions regarding the findings and made contributions to the final manuscript.

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Data availability statement

The dataset generated and analyzed during the research is available from the corresponding author upon reasonable request.

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All authors declare that they have no financial or personal interests that could influence the work presented in this manuscript.

Additional information

Correspondence and material requests should be addressed to anggunkarnita33@gmail.com.

ORCID

Anggun Karnita https://orcid.org/0009-0006-9816-5023
Noviana Mustapa https://orcid.org/0009-0003-0471-8810
Erie Siti Syarah https://orcid.org/0000-0001-7629-7806
Della Raymena Jovanka https://orcid.org/0000-0001-6279-7578

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Table 4 Digital Literacy - Scopus

No	Author	Research Design	Population and Sample	Purpose of the Study	Variables	Research Results
1	(Laidlaw et al., 2019)	Research Design: Qualitative research through content analysis. Type of Research: Descriptive research that explores the representation of children in popular media related to digital technology.	Population: Children affected by the use of mobile devices and digital technology in the context of education and literacy. Sample: Articles from popular media collected during the period from 2013 to 2018 that discuss children and digital technology.	Analyzing the Representation of Children and Digital Technology: This study aims to investigate how popular media depicts children and digital technology over a five-year period (2013–2018), focusing on mobile devices and their impact on children's literacy practices.	Independent Variable: Use of mobile devices and digital technology. Dependent Variables: Literacy practices of children, parents' beliefs, and curriculum responses.	This study found that: 1. Popular media has a significant influence on parents' and teachers' perceptions of children's use of digital technology. 2. Key themes emerged from the articles, including the positive and negative impacts of mobile device usage on children's literacy development. 3. The implications of these media reports are important in shaping parents' beliefs and curriculum approaches in education.
2	(Ozturk & Ohi, 2022)	This study employs a descriptive research design with a qualitative approach. It aims to describe the digital literacy practices at home	Population: Turkish children aged 5-7 years who have access to digital technology at home. Sample: 105 children selected from	To understand the multimodal digital literacy practices that children engage in within the context of play and learning at home.	Independent Variable: Type of digital technology used (e.g., tablet, computer, smartphone). Dependent Variable: Children's digital literacy practices, including	This study found that: 1. Children actively engage in multimodal practices through the use of digital technology in play and learning activities at home.

✉ Corresponding author:
Email Address: anggunkarnita33@gmail.com.
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		carried out by children through data collection from questionnaires and interviews.	questionnaires completed by parents, along with interviews conducted with five families to gain deeper insights into technology usage and digital literacy practices.		how they use technology in play and learning.	2. It is important for educators to be aware of the existing digital literacy practices at home as a foundation for further literacy learning. 3. Parents may need support to understand how technology usage can contribute to their children's literacy learning.
3	(Cao, Dong, et al., 2024)	This study employs a quantitative research design with a survey approach, in which data is collected through questionnaires completed by parents.	Population: Parents with at least one child under the age of six living in Central China. Sample: 2,272 parents who participated in this study.	1. To explore the development of digital literacy in early childhood. 2. To identify age and gender differences in early digital literacy. 3. To analyze factors related to children's digital literacy, including home location, household income, digital resources at home, and parents' age.	Independent Variables: Child's age, gender, home location, household income, digital resources at home (DRH), family structure, parents' education, and parents' occupation. Dependent Variable: Early digital literacy of children.	This study found that: 1. There are significant differences in early digital literacy based on age, with television literacy emerging first, followed by touchscreen literacy, artificial intelligence, and personal computers. 2. Factors such as home location, household income, digital resources at home (DRH), and parents' age have a significant correlation with children's digital literacy. Family structure and parents' education are also related to specific aspects of digital literacy. 3. Digital resources at home serve as a mediator in the relationship between home context factors and

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						preschool children's digital literacy. 4. Child's age, family structure, household income, and digital resources at home significantly contribute to predicting preschool children's early digital literacy.
4	(Otterborn et al., 2020)	This study uses a quantitative research design employing an online national survey method. Data was collected via an online questionnaire involving 199 kindergarten teachers in Sweden..	Population: Kindergarten teachers in Sweden. Sample: 199 kindergarten teachers participating in the nationwide online survey.	This study aims to explore how kindergarten teachers in Sweden implement programming activities in their pedagogical practices. Specific objectives include: 1. Discussing the variety of applications and digital resources used alongside tablets in the integration of learning activities. 2. Identifying the implications of computer programming in the context of early childhood learning. 3. Understanding how the established learning objectives relate to computational thinking skills and "21st-century skills."	Independent Variable: Implementation of programming activities by kindergarten teachers. Dependent Variables: Computational thinking skills, 21st-century skills, and integration with other subject areas such as science, mathematics, technology, and language.	This study found that: 1. Kindergarten teachers use various applications and digital resources alongside tablets to enhance the integration of learning activities. 2. Programming activities are often combined with non-programming activities or a combination of both. 3. Kindergarten teachers widely embrace learning objectives related to computational thinking skills and "21st-century skills." 4. Programming is often actively related to learning in other domains such as science, mathematics, technology, and language, indicating that the traditional practices of Swedish kindergarten

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						education are being recontextualized in terms of programming.
5	(Alexander, 2020)	This study employs a critical research design with an analytical approach. Its aim is to revise the concepts of reading, reading development, and reading research beyond the confines of the "science of reading" controversy. The context of this revision is reading in the digital age and the challenges faced by readers today.	Population: Modern readers facing the challenge of reading in the digital era. Sample: A theoretical and critical analysis of the phenomenon of reading in the digital era, not involving statistical samples.	The specific objectives of this research are: 1. Reconceptualizing Digital Reading: To revise the fundamental concepts of reading and reading development beyond the controversy of traditional reading science. 2. Identifying Reader Challenges: To identify the challenges faced by modern readers, including awareness of abundant information, fake online content, and difficulties in using valid evidence to support claims. 3. Recommendations for Strategies: To design actionable strategic recommendations for reading researchers, reading teachers, school principals, parents, governments, and the students themselves	This study does not utilize conventional independent and dependent variables but focuses on contemporary phenomena in digital reading, such as: • Information Abundance: Awareness of the overwhelming amount of information. • Fake/Malicious Content: Incorrect or harmful online content. • Valid Evidence: Difficulties in using valid evidence to support claims. • Oversimplification: The tendency to address complex issues in an overly simplistic manner.	The findings of this research include: 1. Analysis of Fundamental Concepts of Digital Reading: A revision of the basic concepts of reading to move beyond the controversy of traditional reading science. 2. Description of Modern Reader Challenges: Identification of the specific challenges faced by today's readers, including information abundance, fake online content, and difficulties in using valid evidence. 3. Strategies for Digital Literacy Reconstruction: Four strategic recommendations to address the challenges of digital reading, involving multidisciplinary collaboration among researchers, teachers, school principals, parents, governments, and the students themselves.

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				to address the challenges of digital reading.		
6	(Akiba, 2022)	This study employs a qualitative research design with a critical analysis approach. The focus of the research is to explore effective methods for building digital literacy among young children, particularly in educational contexts that do not always involve digital tools directly.	Population: Young children exposed to the use of digital devices in educational settings. Sample: This study does not specify a particular sample but focuses on the practices of early childhood educators who lack digital expertise.	1. To evaluate the effectiveness of existing teaching methods in developing digital skills in early childhood classrooms. 2. To understand the challenges faced by educators who are not digital experts in teaching digital literacy. 3. To formulate new methods that can effectively integrate "unplugged" and "plugged" activities in digital literacy instruction.	Independent Variable: Teaching methods (unplugged activities vs. plugged activities). Dependent Variable: Children's digital literacy skills (such as computational thinking, coding, and programming).	This study found that: 1. Many current teaching efforts focus on "unplugged" activities that do not involve digital tools directly; however, their effectiveness in developing digital skills remains questionable. 2. There is a need to develop more effective methods for teaching digital literacy in early childhood classrooms, especially in environments where teachers lack specific expertise in technology. 3. Recommendations for further research include creating approaches that can bridge the gap between "unplugged" and "plugged" activities, thereby fostering a more comprehensive and integrated development of digital literacy.
7	(Mattar et al., 2022)	This study employs a comparative research design with a document analysis approach. The aim of	Population: International digital competency frameworks used in education.	1. To analyze and compare international digital competency	Independent Variable: Characteristics of digital competency frameworks (objectives, structure, competencies, levels).	This study found that: 1. The characteristics of the frameworks are determined by their objectives, theoretical

		the research is to analyze and compare various international digital competency frameworks in the context of education.	Sample: The frameworks analyzed include various characteristics such as objectives, structure, competencies, and levels from several existing digital competency frameworks.	frameworks in education. 2. To identify common characteristics of these frameworks, including objectives, structure, competencies, and indicators for instrument development. 3. To provide recommendations on how digital competency frameworks can be segmented based on educational actors (students, teachers, and administrators) as well as educational levels (early childhood, primary, secondary, and corporate).	Dependent Variable: The quality and relevance of the frameworks in the context of education.	background, and target groups. 2. Most of the analyzed frameworks focus on teacher training. 3. The compared frameworks identify common competencies such as communication, collaboration, sharing information and data, digital content, technical skills, teaching, learning, and ethics. 4. All frameworks include profiles, objectives, descriptors, activities, examples, and cases of knowledge, skills, and attitudes. 5. The authors conclude that digital competency frameworks should be segmented based on educational actors and educational levels, with appropriate assessment instruments.
8	(Van Der Westhuizen & Hannaway, 2021)	This study employs a qualitative research design with a descriptive analysis approach. The method aims to analyze teachers' understanding of digital games and how they use them	Population: Teachers instructing in early childhood classrooms (Grade R) at primary schools. Sample: Eight Grade R teachers from a primary school in an urban area that has digital technology	1. To analyze teachers' understanding of digital games and their use in language instruction in early childhood classrooms. 2. To explore the interactions between teachers and	Independent Variable: The use of digital games in language instruction. Dependent Variables: Teachers' understanding of language instruction, interactions with students, and students' language acquisition.	This study found that: 1. Teachers are willing to experiment with digital games, but they feel the need to enhance their understanding of digital technology and how to use digital games in language instruction.

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		for language instruction in early childhood classrooms.	available in the classroom.	students when using digital technology in teaching. 3. To assess teachers' views on the role of Information and Communication Technology (ICT) in education and how digital games can enhance language acquisition.		2. Teachers believe that digital games should be used to enhance language teaching, similar to traditional game-based pedagogy, as the current generation grows up in a digital environment. 3. Emphasis should be placed on developing games that utilize relevant digital technology for language instruction. 4. The findings indicate a need for further investigation into teachers' beliefs and digital literacy, as well as their practices in more diverse contexts, to understand the value of digital games in language instruction.
9	(Parks & Tortorelli, 2021)	This study employs a quantitative research design with an experimental approach. The aim of the research is to evaluate the impact of one-to-one technology on the mathematical development and literacy of	Population: Kindergarten students in a small urban public school district. Sample: Kindergarten students who received tablets from the district's outreach program, randomly grouped into two categories: (1) the	1. To analyze the impact of using tablets and digital resources on the development of math skills and literacy in kindergarten students. 2. To evaluate teachers' perceptions of using tablets in instruction and how digital	Independent Variable: The use of tablets and digital resources in instruction. Dependent Variable: The development of students' math skills and literacy.	This study found that: 1. Teachers value the presence of tablets and believe that digital resources can enhance instruction. 2. Although students' literacy skills may benefit from access to digital resources, their math skills did not show significant improvement.

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		kindergarten students over the course of one academic year.	group that received only tablets, and (2) the group that received tablets equipped with digital resources to support basic math skills.	resources influence teaching practices. 3. To determine whether access to digital resources is sufficient to enhance students' math skills.		3. The use of digital resources in the classroom is gradually low, which may contribute to the failure to improve targeted math skills. 4. Access to digital resources shows potential to influence some foundational skills in children, but access alone is not sufficient to enhance the targeted skills.
10	(Pires Pereira et al., 2023)	This study employs a qualitative research design with a case study approach. Data were collected through in-depth interviews focusing on teachers' perceptions of digital literacy practices and the underlying professional development.	Population: Early childhood education teachers in Portugal. Sample: An early childhood education teacher known for their innovative pedagogical methods.	1. To analyze teachers' understanding of digital literacy practices in the context of early childhood education. 2. To explore how digital literacy practices influence teachers' pedagogy. 3. To assess the professional development underlying these digital literacy practices.	Independent Variable: Digital literacy practices implemented by teachers. Dependent Variable: The impact of these practices on teachers' pedagogy and professional development.	This study found that: 1. From the teachers' perspective, the implementation of digital literacy practices has both enhanced and challenged their pedagogy. 2. Teachers' innovative practices combine functional professional learning with attitudinal dispositions such as professionalism, professional identity, resilience, and commitment. 3. It is important to integrate both functional and attitudinal dimensions in professional development initiatives

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							to enhance the integration of digital literacy practices in early childhood education.
11	(Akman et al., 2023)	This study employs a quantitative research design with a correlational approach. The aim of the research is to explore the relationship between preschool parents' digital parenting attitudes, digital literacy, and awareness of digital data security.	Population: Preschool parents and preschool teachers. Sample: 410 participants consisting of parents and preschool teachers.	1. To analyze the level of digital parenting attitudes among preschool parents. 2. To evaluate the level of digital literacy and awareness of digital data security among preschool teachers and parents. 3. To investigate whether there is a general relationship between these variables.	Independent Variable: Parents' digital parenting attitudes. Dependent Variables: Levels of digital literacy and awareness of digital data security.	This study found that: 1. The levels of digital literacy and awareness of digital data security among preschool teachers are higher than those of preschool parents. 2. There are statistically significant differences in the levels of digital literacy and awareness of digital data security between the two groups. 3. The study recommends that teachers collaborate with parents to enhance digital literacy and awareness of digital data security. 4. School administrators are advised to strive for the sustainability of this collaboration by implementing various activities to improve digital literacy for both parents and students, thereby increasing their awareness of digital data security.

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12	(Semingson & Kerns, 2021)	This study employs a historical research design with a contextual analysis approach. The aim of the research is to reconstruct the context of historical debates on phonetics in literacy and modern discussions about reading science, focusing on the works and impact of Jeanne Chall.	This study does not involve a specific statistical sample; instead, the analysis is based on a historical and critical examination of the development of reading theories, including the works of Jeanne Chall.	1. Examining the Origins of Phonetic Debate: To analyze the origins of the ongoing debates since the 19th and 20th centuries, focusing on the beginnings of reading, decoding, and phonetics. 2. Comparing Whole Language Approaches: To explore Kenneth Goodman and Yetta Goodman's views on the whole language movement, as well as synthesizing key ideas from Chall's critiques of the whole language approach. 3. Analysis of Editions of Learning to Read: To analyze the shifts in editions of *Learning to Read: The Great Debate* by Chall and summarize the main ideas from her work, including the stages model of reading development. 4. Implications for Educational Stakeholders: To	This study does not utilize conventional independent and dependent variables but focuses on current phenomena in the field of reading science, such as: • Phonetic Debate vs. Whole Language Approach • Stages Model of Reading Development • Implications for Teachers and Policymakers	This research findings include: 1. Summary of Key Ideas from Chall's Work: The analysis shows that Chall was highly influential in changing the direction of the reading debate in the latter half of the 20th century with her strong work and invaluable integrity. 2. Significant Differences Between Instructional Methods: The findings indicate significant differences between phonetic instructional methods and the whole language approach in the context of children's reading development. 3. Strategic Recommendations: Strategic recommendations are made for reading instruction to be informed by a broad historical lens and to utilize stages of reading development models as proposed by Chall. 4. Chall's Perspective on the Digital Age: Chall's perspective on learning to read in the digital age is reflected upon, considering the

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				present implications for teachers, textbook publishers, researchers, and policymakers in addressing current reading debates, while considering what Chall might say about learning to read in the digital age.		pressures on educators to align their practices with what is deemed as reading science.
13	(Maureen et al., 2020)	This study employs an experimental research design. The aim of the research is to evaluate the effects of a structured storytelling approach on the development of literacy and digital literacy skills in early childhood.	Population: Children aged 5–6 years in kindergarten. Sample: 62 children from three classes in two participating public kindergartens.	1. To investigate the influence of a structured storytelling approach on the development of children's literacy skills. 2. To compare the effectiveness of storytelling activities supported by play-based activities, digital storytelling, and regular literacy activities. 3. To assess early literacy skills and digital literacy skills before and after a six-week intervention.	Independent Variable: Type of activity (regular literacy activities, structured storytelling with play, and digital storytelling activities). Dependent Variables: Development of early literacy skills and children's digital literacy skills.	The research findings indicate that: 1. Both storytelling conditions (structured storytelling with play and digital storytelling) significantly enhance children's literacy skills and digital literacy skills. 2. Structured storytelling activities prove to be an effective way to improve literacy and digital literacy skills in early childhood education. 3. The use of storytelling methods integrated with play-based activities provides effective stimulation for the development of early literacy.
14	(Cao, Zhang, et al., 2024)	This study employs a quantitative research design with a	Population: Parents of preschool children in China.	1. To analyze the relationship between family socioeconomic	Independent Variable: Family socioeconomic status (SES).	The research findings indicate that:

		correlational survey approach. The aim is to explore the complex interactions between family socioeconomic status, digital resources at home, parental mediation, and the early digital literacy development of children.	Sample: 1,876 parents who completed the Home Digital Practice Survey (HDPS), with an average child age of 4.28 years (SD = 0.98), of which 48.8% are girls.	status (SES) and early digital literacy development in children. 2. To investigate the roles of digital resources at home (HDR) and parental mediation (PM) as mediators in the relationship between SES and early digital literacy. 3. To provide insights on how to reduce the digital divide through the enhancement of children's digital literacy.	Mediator Variables: Digital resources at home (HDR) and parental mediation (PM). Dependent Variable: Early digital literacy development in children.	1. There is a significant correlation between family socioeconomic status and early digital literacy development in children (β = 0.102, p < 0.01). 2. Digital resources at home (β = 0.285, p < 0.001) and parental mediation (β = 0.290, p < 0.001) serve as simultaneous mediators linking SES to early digital literacy development. 3. These findings have important implications for minimizing the digital divide and enhancing children's digital literacy.
15	(Ika Sari et al., 2024)	This study employs a quantitative research design with a regression analysis approach. The aim of the research is to investigate the relationship between collaboration, digital learning in early childhood education (DLEC), and sustainability education (SE) within the context of education in Indonesia.	Population: Teachers and education practitioners in Indonesia involved in early childhood education. Sample: Not specifically mentioned in the abstract, but includes data from various respondents relevant to the research topic.	1. To analyze the relationship between collaboration and innovation with digital learning in early childhood education (DLEC) and sustainability education (SE). 2. To explore the role of DLEC as a mediator in the relationship between collaboration, innovation, and sustainability education.	Independent Variables: Collaboration and Innovation. Dependent Variables: Digital learning in early childhood education (DLEC) and sustainability education (SE). Mediator Variable: DLEC as a mediator influencing the relationship between collaboration, innovation, and SE.	The research findings indicate that: 1. There is a significant relationship between collaboration and innovation with digital learning in early childhood education and sustainability education. 2. DLEC plays an important role as a mediator in enhancing understanding of sustainability education through collaboration and innovation. 3. This study recommends the development of

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				3. To provide recommendations for educational practices that support collaboration, innovation, and DLEC within the context of sustainability education.		educational practices that promote collaboration, innovation, and DLEC to improve understanding of sustainability among educators.

Table 5 Digital Literacy – Science Direct

No	Author	Research Design	Population and Sample	Purpose of the Study	Variables	Research Results
1	(Polizzi, 2020)	This study employs a qualitative research design with a semi-structured interview approach and diary methodology. The aim is to explore how experts in the UK interact with and evaluate online content, as well as to understand what is meant by digital literacy and how to promote it within the UK national curriculum.	Population: Experts in the fields of information, IT, and media in the UK. Sample: Interviews were conducted with a number of experts who have experience and knowledge in digital literacy.	1. To investigate experts' understanding of digital literacy and how they evaluate online content. 2. To identify the key elements of digital literacy that need to be promoted within the UK national curriculum. 3. To provide recommendations for revising the Citizenship and Computing curriculum to include digital literacy as a cross-curricular subject.	Independent Variable: Experts' understanding and practices in evaluating online content. Dependent Variable: The level of digital literacy promoted within the national curriculum.	The research findings indicate that: 1. Evaluating online content involves reflecting on the nature and origin of information, contextual knowledge, the use of various sources, as well as functional and critical digital skills and knowledge. 2. It was found that digital literacy should be viewed as a cross-curricular subject involving multiple disciplines. 3. Recommendations are made to revise the Citizenship and Computing curriculum to better support the development of digital literacy among students.

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2	(Sailer et al., 2021)	This study employs a quantitative research design with a regression analysis approach. The research aims to investigate how frequently teachers apply digital technology in their teaching and the student learning activities they initiate, as well as to analyze the factors related to the use of technology.	Population: Teachers in the state of Bavaria, Germany. Sample: 410 teachers representing the population of teachers in Bavaria.	1. To analyze the frequency of digital technology use by teachers in their teaching. 2. To identify the types of learning activities initiated by teachers using technology. 3. To explore the factors influencing the use of technology in teaching.	Independent Variables: Teachers basic digital skills and technology-related teaching skills. Dependent Variables: The frequency of digital technology use in teaching and the types of student learning activities.	The research findings indicate that: 1. Teachers spend a substantial amount of time using digital technology in each lesson. 2. Basic digital skills and technology-related teaching skills have a greater influence than the digital technology resources themselves. 3. Although there is a minimum requirement for digital technology in schools, the findings suggest that the focus should be more on teachers' skills in using technology effectively, rather than simply providing hardware or software.
3	(Sysoev et al., 2022)	This study employs a qualitative research design with a case study approach. The aim of the research is to explore the effectiveness of literacy applications inspired by constructivism in providing scaffolding for children aged 4 to 6 years.	Population: Preschool children aged 4 to 6 years. Sample: Evaluation was conducted in kindergarten classrooms during a design study that lasted for 11 weeks, although the specific number of children involved is not directly mentioned in the abstract.	1. To investigate how the scaffolding mechanisms in literacy applications can support creative expression and social interactions related to literacy among children. 2. To evaluate the impact of scaffolding on children with low executive function and phonological	Independent Variable: Scaffolding mechanisms implemented in literacy applications. Dependent Variables: Creative expression, social interactions related to literacy, and the ways in which children interact with the applications (including impulsivity and systematic behavior).	The research findings indicate that: 1. Scaffolding mechanisms help enhance creative expression and social interactions among children, allowing for highly autonomous play for some of them. 2. Children with low executive function and phonological awareness tend to use the applications in an impulsive and

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		awareness when using the applications. 3. To identify strategies that can mitigate the negative effects of low phonological awareness and executive function on children's learning.	unsystematic manner, which hinders their learning. 3. Despite the challenges, child-guided machine-based approaches appear promising in supporting early literacy development.