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Pedagogical Positioning of Digital Technology in Childhood Literacy and Numeracy Instruction: A Qualitative Multi-Site Study in Indonesia

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Abstract. Although digital technology has become increasingly prevalent in early childhood education, particularly in literacy and numeracy instruction, existing research has focused primarily on adoption, attitudes, and effectiveness, leaving a limited empirical understanding of how digital technology is pedagogically positioned within everyday classroom practice. To address this gap, this qualitative multi-site study examines how early childhood teachers enact and regulate digital pedagogical strategies for literacy and numeracy instruction across diverse formal and non-formal early childhood education institutions in West Java, Indonesia. Drawing on classroom observations, instructional documents, and semi-structured interviews with 43 early childhood teachers, the study employed inductive thematic analysis to identify dominant pedagogical patterns shaping digital practice. The findings identify five interrelated patterns: the positioning of digital technology as an engagement-oriented instructional entry point; substitution-based digital use without pedagogical redesign; reliance on informal assessment and digital documentation; limited formal professional guidance alongside peer-based support; and emerging strategic needs for more pedagogically grounded digital instruction. Collectively, the findings demonstrate that teachers' digital practices are shaped less by technological availability than by pedagogical judgment, developmental considerations, and institutional conditions. This results in digital tools being positioned as supportive, time-limited resources rather than as central drivers of literacy and numeracy learning. The study contributes theoretically by conceptualizing digital technology use as a form of pedagogical positioning within a bounded instructional ecology, and practically by identifying strategic gaps with implications for teacher

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education, institutional guidance, and policy development in early childhood digital literacy and numeracy instruction.

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1. Introduction

The integration of digital technology in early childhood education (ECE) has expanded substantially over the past decade, particularly in early literacy and numeracy. Digital resources such as educational videos, interactive storybooks, tablet-based applications, and gamified learning platforms are increasingly embedded within early childhood classrooms across diverse educational contexts. Recent studies suggest that these technologies hold potential to support children's engagement with language, symbols, and foundational mathematical concepts when aligned with developmentally appropriate pedagogies and contextual learning needs (Çelik et al., 2023; González-González, 2021). As a result, digital technology is now widely recognized as a prominent feature of contemporary early childhood learning environments rather than a supplementary instructional option.

Despite this growing presence, the literature indicates that digital technology in ECE is most often positioned as a tool for engagement and motivation, rather than as part of a deliberately planned pedagogical strategy for literacy and numeracy learning. Research consistently reports that teachers tend to use digital media to capture children's attention, introduce learning topics, or maintain classroom interest, particularly through audiovisual content and interactive applications (Hatzigianni et al., 2025; Wong et al., 2025). Although these practices can boost children's short-term engagement, they are often not integrated into coherent instructional planning, assessment processes, or long-term learning goals. This pattern suggests that the pedagogical potential of digital technology is often underutilized, with technology functioning as a supporting medium rather than as an integrated component of literacy and numeracy instruction.

Existing studies further reveal that teachers' digital pedagogical practices are shaped by multiple constraints, including limited professional preparation, insufficient pedagogical guidance, concerns about developmental appropriateness, and uneven access to resources (Çelik et al., 2023; Nurhayati & Judijanto, 2025). Early childhood teachers frequently express uncertainty about how to align digital tools with curriculum goals, balance digital and non-digital learning experiences, and assess children's learning during technology-mediated activities. As a result, digital practices tend to remain fragmented and situational, driven more by practical convenience or engagement considerations than by clearly articulated pedagogical strategies. These challenges are particularly evident in early literacy and numeracy instruction, where abstract concepts, play-based learning principles, and developmental sensitivities demand careful pedagogical design.

Although a substantial body of research has examined digital technology use in ECE, much of this literature privileges questions of adoption, competence, tool effectiveness, and perceived benefits, while giving limited analytical attention to how digital technology is pedagogically positioned within teachers' everyday instructional practices. As a result, there remains an insufficient empirical understanding of how literacy and numeracy instruction is planned, enacted, and evaluated when digital tools are embedded within routine classroom activity, as well as how pedagogical judgments, rather than technological affordances alone, shape instructional decision-making.

This gap is especially significant given the global expansion of digital technologies in early childhood education, where similar challenges related to pedagogical integration, professional capacity, and institutional guidance have been reported across diverse national contexts. Without a clearer understanding of how teachers interpret, regulate, and embed digital tools within their instructional routines, efforts to promote digital pedagogy risk remaining disconnected from classroom realities. Current research underscores the urgent need to foreground teachers enacted pedagogical strategies beyond a narrow focus on adoption or effectiveness.

In response to this need, the present study adopts an exploratory qualitative approach to examine how early childhood teachers integrate digital technology into literacy and numeracy teaching across multiple early childhood education settings in West Java, Indonesia. Rather than evaluating effectiveness or outcomes, the study focuses on identifying existing pedagogical patterns, practical challenges, and strategic limitations in teachers' digital practices. By analyzing teachers' classroom practices, reflections, and instructional decisions, the study aims to generate contextually grounded insights that can inform more pedagogically coherent approaches to digital literacy and numeracy instruction in early childhood education. This study examines digital technology use as a pedagogical positioning to inform global debates on early childhood digital pedagogy, especially in settings with limited institutional and professional support.

Accordingly, this study is guided by the following research questions:

1. What digital strategies are currently employed by early childhood teachers in teaching literacy and numeracy?
2. What challenges and limitations do teachers encounter in implementing digital-based literacy and numeracy instruction?
3. What pedagogical strategy gaps can be identified from current digital practices, and what strategic directions can be suggested to support more pedagogically grounded digital literacy and numeracy instruction?

2. Literature Review

Recent studies indicate an increasing integration of digital technology in early childhood education, especially in literacy and numeracy instruction. However, this body of work has primarily emphasized patterns of adoption, types of tools, and general pedagogical considerations, rather than examining how digital

technology is positioned within teachers' enacted instructional decision-making. Across diverse contexts, digital tools such as interactive applications, educational games, digital storytelling platforms, and tablet-based resources have been increasingly incorporated into early learning environments to support children's engagement with language and mathematical concepts (González & Miranda, 2024; Rodríguez & Area-Moreira, 2022). These studies commonly emphasize that digital learning in early childhood is not limited to technology use itself, but is closely connected to pedagogical intentions, developmental appropriateness, and the broader learning environment in which technology is embedded (Hatzigianni et al., 2025).

However, existing research indicates that the nature and quality of digital technology use vary considerably across educational contexts. Comparative studies highlight differences in infrastructure, institutional support, and professional development shape not only access to digital tools but also the pedagogical logics governing their classroom use. In well-resourced settings, digital tools are often integrated within structured pedagogical frameworks and supported by institutional infrastructure and professional development, enabling more consistent implementation (Bortolotti et al., 2025; Hong et al., 2025). In contrast, studies conducted in less-resourced or socio-economically constrained contexts frequently report fragmented and uneven digital practices, shaped by limited access to devices, unstable connectivity, and insufficient pedagogical guidance (Magaya & Petro, 2025; Okoye et al., 2025). These differences highlight that digital technology in early childhood education cannot be examined in isolation, as institutional and socio-cultural conditions fundamentally shape its use.

A substantial body of literature has focused on teachers' attitudes, digital competence, and readiness to adopt technology in early childhood classrooms. Research consistently highlights professional digital competence as a key factor influencing whether digital tools are adopted and how they are used (Miočić et al., 2025; Papavasopoulou et al., 2024). However, scholars increasingly note that competence alone does not determine pedagogical integration; teachers' instructional beliefs, curriculum priorities, and perceptions of developmental appropriateness also play a critical role. While many educators express positive attitudes toward digital technology, studies also report persistent uncertainty regarding pedagogical integration, particularly in balancing digital activities with play-based learning principles and curriculum demands (Çelik et al., 2023; Finch & Arrow, 2017). This tension has contributed to patterns of engagement-oriented digital use rather than systematic instructional integration.

In relation to early literacy and numeracy, prior research has largely examined learning outcomes, tool effectiveness, or specific digital interventions. This effectiveness-oriented focus has generated important evidence regarding potential benefits while leaving teachers' day-to-day pedagogical decision-making relatively underexamined. Digital games and interactive applications have been shown to support emergent literacy skills and numeracy understanding when designed appropriately (Cruz et al., 2025; Disney et al.,

2019). At the same time, scholars caution that technology alone does not guarantee meaningful learning and that excessive or uncritical use may reduce opportunities for social interaction, physical play, and hands-on exploration (Finch & Arrow, 2017; González & Miranda, 2024). As a result, questions of how digital tools are pedagogically sequenced, regulated, and evaluated in routine classroom practice remain insufficiently addressed.

Importantly, several studies point to a lack of systematic attention to the pedagogical functions of digital technology in early childhood classrooms. Rather than being analyzed as part of instructional design, digital tools are frequently discussed as neutral support or engagement enhancers. Digital tools are frequently described as instructional supports or engagement enhancers, yet their roles in instructional sequencing, assessment practices, and long-term pedagogical planning remain underexplored (Novik & Tvardovskaya, 2025). Furthermore, teacher-related challenges—such as limited professional development, uncertainty about developmental appropriateness, and insufficient institutional support—continue to constrain deeper pedagogical integration (Mathebula et al., 2025). Taken together, these studies indicate a gap in empirically grounded accounts of how teachers position digital technology within their everyday literacy and numeracy teaching practices.

In light of these gaps, there is a need for empirical studies that move beyond examining technology adoption or perceived benefits to analyze how digital technology is pedagogically positioned within everyday classroom practice and why its use often remains engagement oriented. The present study addresses this need by exploring patterns, challenges, and strategic limitations in early childhood teachers' digital pedagogical practices for literacy and numeracy instruction across multiple institutional contexts. By focusing on teachers' instructional strategies rather than effectiveness or outcomes, the study seeks to provide a contextually grounded understanding of current practices and to identify pedagogical gaps that may inform future research and professional development.

Synthesizing prior research on digital integration, teacher decision-making, and early childhood pedagogy, this study is conceptually oriented toward understanding digital technology as a form of pedagogical positioning shaped by instructional intentions, developmental considerations, and institutional conditions. This orientation informs the examination of how digital literacy and numeracy practices are enacted, constrained, and sustained in everyday early childhood classrooms.

3. Methodology

3.1 Research Design

This study adopted an exploratory qualitative research approach to examine how early childhood teachers in West Java, Indonesia, integrate digital technology into literacy and numeracy instruction. An interpretive qualitative design was selected to examine how teachers make pedagogical judgments and position digital technology within everyday instructional practice, consistent with qualitative

inquiry aimed at understanding meaning, context, and enacted practice (Creswell & Poth, 2018). A qualitative approach was considered appropriate because the study aimed to gain an in-depth understanding of teachers' instructional practices and experiences as they occur in natural classroom settings, rather than to measure learning outcomes or test predetermined variables. The multi-site design allowed the study to capture patterned variation across institutional contexts, a common strategy in classroom-based pedagogical research (Miles et al., 2020). The study was conducted across multiple early childhood education institutions to capture variation in instructional practices within a shared regional context. By focusing on teachers' classroom activities, reflections, and instructional decisions, the study sought to identify common patterns of digital technology use in early literacy and numeracy teaching.

3.2 Data Collection

Data collection was designed to obtain a comprehensive understanding of how digital technology was used by teachers during literacy and numeracy instruction. To achieve this, the study employed multiple qualitative data collection techniques, namely classroom observation, document collection, and interviews. The use of multiple-case design allowed the researcher to examine instructional practices from different perspectives and to cross-check information obtained from various data sources. This triangulated design strengthened the credibility of the findings by enabling convergence across enacted practice (observation), planned/recorded practice (documents), and teachers' rationales (interviews). Data collection was carried out over a period of six months from March to September 2025, during which the researcher engaged directly with participating teachers in their respective institutional contexts.

3.2.1 Classroom Observation

Classroom observation served as the primary method for documenting teachers' instructional practices. Observation was considered suitable because it allowed the researcher to examine actual classroom activities and teacher-child interactions, rather than relying solely on teachers' retrospective accounts. Each participating teacher was observed during one to two literacy or numeracy instructional sessions in which digital media were used. Observation sessions were conducted during regular teaching hours and lasted approximately 30 to 60 minutes, depending on lesson structure and classroom routines. Conducting observations during normal instructional time ensured that instructional activities occurred naturally and were not staged for research purposes.

During classroom observations, attention was given to how teachers introduced digital tools, how digital media were positioned within the lesson sequence, and how digital activities were combined with non-digital instructional practices. Particular focus was placed on teacher-child interaction and children's responses to digital learning activities. Observation data were recorded in written form as detailed observation notes. These notes captured descriptions of classroom activities, instructional flow, and interactions between teachers and children. To support procedural transparency, a consistent observation focus was applied across sites (lesson phase of digital use, teacher prompts, children's responses, and transitions to non-digital activities), enabling cross-case comparison of how

digital tools were positioned within routine instruction. The use of written notes enabled systematic documentation of instructional practices while minimizing disruption to classroom activities.

3.2.2 Document Collection

In addition to classroom observation, the study collected professional instructional documents to gain further insight into teachers' pedagogical planning and reflections. The documents included teachers' instructional journals, written reflections on literacy and numeracy activities, and classroom-related documentation produced by the teachers. Document collection was important because it provided stabilized representations of instructional practice that complemented observation data. While classroom observations captured enacted practices, instructional documents offered insight into how teachers planned, reflected on, and evaluated their use of digital technology in literacy and numeracy instruction.

Documents were treated as a complementary data source and were coded alongside observation and interview materials to examine alignment (or mismatch) between intended plans, enacted routines, and reflective rationales. The collected documents were used to support cross-contextual comparison and to clarify instructional decisions that were not always directly observable during classroom activities.

3.2.3 Interviews

Interviews were conducted to clarify and expand upon observed instructional practices. The interviews were semi-structured, allowing teachers to describe their experiences and instructional decisions in their own words while enabling the researcher to probe for additional detail when necessary. Interviews were conducted after classroom observations so that teachers could reflect on specific instructional episodes that had been observed. Each interview lasted approximately 20 to 40 minutes and was conducted in Bahasa Indonesia, allowing participants to communicate comfortably and accurately. Interview data were documented as analytic notes, which were written immediately following each interview to ensure that key explanations, examples, and reflections were accurately captured.

To enhance credibility, interview prompts were anchored to observed episodes (e.g., why a digital tool was selected, how long it was used, and what learning purpose it served), reducing reliance on general or decontextualized accounts. The interview data were used to contextualize and deepen understanding of teachers' classroom practices rather than to function as standalone data sources. A summary of the data collection methods and sources is presented in Table 1.

Table 1: Data Collection Methods and Sources

Data collection method	Data source	Purpose
Classroom observation	Literacy and numeracy instructional sessions	To document enacted instructional practices and teacher-child interaction involving digital technology
Document collection	Instructional journals and written reflections	To examine teachers' planning and reflections on digital literacy and numeracy instruction
Interviews	Teachers' reflective accounts	To clarify observed practices and explore instructional decisions

3.3 Population of the Study and Sampling Procedure

The population of the study consisted of early childhood education teachers who were actively involved in teaching literacy and numeracy in early childhood education institutions in West Java, Indonesia. At the time of the study, these teachers were responsible for planning and implementing daily instructional activities and had experience using digital technology in classroom teaching. A total of 43 early childhood teachers participated in the study. The participants were drawn from early childhood education institutions located in Bandung City, Cimahi, Bandung Regency, West Bandung Regency, and Purwakarta.

The institutions included Early Childhood Institution (PAUD), Kindergarten (TK), Islamic Early Childhood Education Institution (RA), and Community Learning Center (PKBM), representing both formal and non-formal early childhood education settings. Including different institutional types allowed the study to capture instructional variation within a single regional context. Participants were selected using purposive sampling, as the study specifically targeted teachers who were directly involved in literacy and numeracy instruction and who had experience integrating digital technology into classroom activities.

This sampling approach was considered appropriate because not all early childhood teachers routinely use digital media in their teaching, and the study required participants who could meaningfully describe and demonstrate such practices. Access to participants was facilitated through coordination with school administrators, after which teachers were invited to participate voluntarily. This recruitment process helped establish trust and familiarity, which was important given that the study involved classroom observation and discussion of teachers' instructional practices.

Eligibility for participation was based on the following criteria: (a) being an active early childhood teacher at the time of data collection; (b) having direct responsibility for literacy and numeracy instruction; and (c) Having experience using digital technology in classroom teaching activities.

Purposive sampling across institution types (PAUD, TK, RA, PKBM) was used to enable analytic comparison of digital pedagogical positioning under differing governance, resources, and routine structures within the same regional context. All participants in the study were female. This reflects the predominantly female

composition of the early childhood education teaching workforce in Indonesia, particularly in PAUD, TK, RA, and PKBM institutions, and is treated as a contextual characteristic of the field. In terms of educational background, participants demonstrated varied professional trajectories. Some teachers had completed an undergraduate degree in early childhood education, while others were senior high school graduates who were concurrently enrolled in an undergraduate (S1) Early Childhood Education (PGPAUD) program while teaching. Teaching experience among participants ranged from one to fifteen years. An overview of participant characteristics is presented in Tables 2 and 3.

Table 2: Profile of Research Participants

Aspect	Description
Professional role	Early childhood education teachers
Teaching responsibility	Literacy and numeracy instruction
Teaching level	PAUD, TK, RA, PKBM
Geographic location	West Java (Bandung City, Cimahi, Bandung Regency, West Bandung Regency, Purwakarta)
Digital teaching experience	Experience integrating digital technology in classroom instruction
Number of participants	43 teachers

Table 3: Demographic Characteristics of Participants

Demographic characteristic	Description
Gender	Female (100%)
Educational background	23 teachers: senior high school graduates enrolled in S1 PGPAUD; 20 teachers: completed S1 degree
Teaching experience	1-15 years
Institutional context	PAUD, TK, RA, PKBM

3.4 Ethical Considerations

Before data collection, institutional permission was obtained from the management of the participating early childhood education institutions. The study was conducted in accordance with ethical principles governing educational research. All participants were provided with clear information regarding the purpose of the study, the nature of their participation, and the procedures involved in data collection. Participation in the study was entirely voluntary, and teachers were informed of their right to decline participation or withdraw from the study at any stage without any negative consequences. Informed consent was obtained from all participants before classroom observations, document collection, and interviews were conducted.

To ensure confidentiality, all identifying information related to participants and institutions was removed from the research records, and pseudonyms were used in reporting the findings. Throughout the data collection process, care was taken to minimize disruption to classroom activities and to respect the professional roles of the teachers. The researcher maintained a non-intrusive role during classroom

observations to ensure that teaching and learning activities were not affected. Digital records and written notes were stored securely with restricted access, and any classroom documentation shared for research purposes was anonymized before analysis.

3.5 Data Analysis

Data analysis followed an inductive thematic analysis approach. In line with the exploratory qualitative nature of the study, the analysis focused on identifying patterns in teachers' instructional practices related to the integration of digital technology in literacy and numeracy teaching. The study relied on Braun and Clarke's (2022) six-step thematic analysis to guide the analysis process. The first step involved familiarization with the data. All observation notes, instructional documents, and interview records were read and re-read carefully to gain an overall understanding of the data.

During this stage, attention was given to descriptions of classroom activities, teacher-child interactions, and teachers' explanations of instructional decisions. The second step involved the generation of initial codes. Coding focused on meaningful segments of data that described instructional actions, uses of digital tools, and teachers' responses to children's engagement in literacy and numeracy activities. These codes were recorded and organized systematically. Coding was conducted across the full dataset and iteratively refined through analytic memoing to track emerging interpretations and to support transparency in how codes developed into themes.

In the third step, related codes were grouped into broader categories to identify emerging patterns across the data set. Codes reflecting similar instructional practices or pedagogical purposes were clustered together. The fourth step involved reviewing the categories by comparing them across different data sources to ensure that they accurately represented the data. Categories were refined through repeated reference to the original data. At this stage, triangulation across observations, documents, and interviews was used to confirm that each theme reflected convergent evidence rather than a single-source account. In the fifth step, the categories were further refined and developed into themes representing common instructional practices related to digital literacy and numeracy teaching.

The final step involved writing up the analysis, in which the themes were presented and illustrated using data excerpts. The analysis emphasized identifying shared instructional patterns rather than quantifying frequencies, consistent with the qualitative design of the study. To support dependability, an audit trail was maintained through organized code lists, category definitions, and successive theme revisions, enabling readers to trace the logic from raw data to reported findings.

3.6 Trustworthiness of The Study

Multiple strategies were applied across the research process to enhance trustworthiness. Credibility was supported through methodological triangulation (observations, documents, and interviews) and by anchoring interview prompts

in observed instructional episodes. Dependability was enhanced by applying consistent observation foci across sites and maintaining an audit trail of coding decisions and theme refinements. Confirmability was supported through analytic memoing and repeated checking of themes against the original dataset. Transferability was addressed by providing contextual detail about institutional types and regional settings, allowing readers to evaluate the relevance of the findings to comparable early childhood contexts.

4. Results and Findings

4.1 Digital Technology as an Engagement-Oriented Tool (RQ1)

Analysis across institutional contexts indicates that digital technology was predominantly positioned as an engagement-oriented pedagogical tool, functioning primarily as an instructional entry point rather than as a central medium for sustained literacy and numeracy learning. Rather than functioning as a central instructional medium, digital resources were incorporated selectively within classroom routines, reflecting a shared pedagogical orientation that emphasized moderation, intentionality, and developmental sensitivity.

Across sites, patterns suggest that digital media were most commonly integrated at the opening phase of instruction. Teachers frequently used short audiovisual materials—such as animated videos, digital slides with illustrated words, interactive stories, and recorded sounds—to introduce learning themes and stimulate initial interest. In literacy contexts, these resources supported early exposure to letters, sounds, and vocabulary, while in numeracy activities they were used to present numbers, shapes, quantities, and basic counting concepts. This pattern of early-stage digital use was consistently followed by a transition to teacher-led discussion, questioning, singing, and hands-on activities, indicating that digital tools functioned primarily as a preparatory frame rather than as a sustained mode of instruction.

This engagement-oriented positioning was further characterized by explicit regulation of duration and intensity. In several settings, participants described deliberate efforts to limit children's exposure to screens in order to maintain focus and prevent overreliance on digital media. One teacher noted that digital tools were selected because they "increase children's enthusiasm through visual and audio approaches," yet emphasized that their use was intentionally brief. Similarly, another participant explained that learning activities "usually begin with a short video related to the theme, followed by light discussion, questions, and singing together." These accounts illustrate a shared pedagogical judgment in which digital engagement was intentionally time-bound and tightly managed.

While this overarching pattern remained stable, bounded variation emerged in how digital tools were extended beyond lesson openings. In some contexts, teachers reported using design platforms such as Canva to enhance the visual appeal of learning materials or interactive applications such as Quizizz during evaluative moments to sustain children's interest. As one participant described, "Canva is used to make learning materials more visually attractive, while Quizizz is used as an interactive evaluation tool." Nevertheless, observational data

revealed that specialized literacy and numeracy applications, digital writing tools, and advanced interactive features were rarely employed, and assessment practices largely relied on teacher observation, anecdotal records, portfolios, and printed outputs generated from digital platforms, rather than on continuous digital assessment systems.

Collectively, patterns across sites suggest a bounded and carefully managed model of digital engagement, constituting a dominant pedagogical positioning rather than isolated instructional choices. Although specific tools and extensions varied across institutional contexts, the underlying pedagogical logic remained consistent: digital technology was used selectively to initiate engagement, while instructional continuity and learning progression were maintained through predominantly teacher-guided, non-digital interactions.

4.2 Substitution-Based Digital Practices without Pedagogical Integration (RQ1)

Analysis across institutional contexts indicates that digital technology was frequently employed in substitution-based ways, where digital tools replaced conventional instructional materials without substantially reshaping pedagogical design or learning trajectories. Rather than functioning as an embedded component of learning processes, digital practices were commonly positioned as surface-level enhancements layered onto existing routines.

Patterns across sites suggest that lesson planning for digital activities largely mirrored traditional instructional formats. Teachers described preparing digital lesson plans using standard word-processing documents or adapting existing plans by inserting videos, songs, or visual slides aligned with weekly themes. In several settings, digital activities followed a predictable sequence: children watched a thematic video or animation, participated in brief discussion or question-and-answer sessions, and then transitioned to non-digital activities. This sequencing reflects a substitution logic in which digital media functioned as digital analogues of printed flashcards, posters, or worksheets rather than as tools for pedagogical transformation.

This substitution-oriented approach was also evident in assessment and evaluation practices. Across settings, teachers reported evaluating digital learning primarily through observable engagement indicators, such as children's interest, attentiveness, and immediate responses, rather than through structured digital assessment strategies. One participant explained that success was assessed by "observing children's interest and responses directly," while another noted that children were guided "one by one when they experience difficulty." These practices indicate reactive, teacher-mediated support rather than systematically embedded digital differentiation or formative assessment strategies.

Empirical data further illustrate that while teachers were able to design visually appealing digital content, pedagogical integration remained limited. For example, one teacher described preparing numeracy activities using Canva by presenting numbers accompanied by images and sounds, followed by verbal praise animations when children answered correctly. As the teacher explained, "Children are asked to name the numbers shown on the screen while counting the

objects.” Although multimodal features were present, these activities largely replicated worksheet-based counting tasks in digital form, emphasizing reinforcement rather than conceptually sequenced learning.

Observational data reinforced these patterns. In literacy instruction, digital tools such as animated videos, digital flashcards, and recorded sounds were used consistently across classrooms to support letter recognition and pronunciation. However, applications designed specifically for early literacy or digital writing were not utilized. In numeracy contexts, teachers introduced numbers, shapes, and quantities through animations and videos, more complex digital practices – such as interactive problem-solving, data classification, or simulated real-life numeracy tasks – were largely absent. Teachers indirectly acknowledged these limitations by emphasizing the need for additional training and digital equipment support.

Taken together, these findings suggest a stable reliance on substitution-based digital practices, where technology served to digitize existing instructional routines without pedagogical reconfiguration. While classroom conditions and tools varied, the underlying logic of digital use remained consistent across sites: digital media were adopted to support presentation and engagement rather than to enable integrated, strategically designed literacy and numeracy instruction.

4.3 Informal Assessment and Digital Documentation Practices (RQ2)

Analysis across institutional contexts indicates that assessment and documentation of digital-based literacy and numeracy learning were predominantly conducted through informal, observational, and experience-based practices, rather than through systematically planned digital assessment frameworks. Assessment emerged as a moment-to-moment pedagogical activity embedded within instruction, shaped by immediacy and teacher.

Patterns across settings suggest that evaluation of digital learning was closely intertwined with teachers’ real-time interactions with children during lessons. Teachers commonly described monitoring children’s interest levels while digital media were in use and adjusting instruction responsively when difficulties emerged. Assessment decisions were therefore enacted through direct observation and ad hoc instructional support, including providing additional explanations to children who appeared confused or grouping children based on perceived ability levels. Differentiation occurred reactively rather than through pre-planned digital assessment designs, and assessment outcomes were rarely documented in ways that informed subsequent instructional planning.

This reliance on informal assessment was further reinforced by the absence of institutional guidance. Participants across sites consistently reported that no formal written guidelines or standardized procedures were provided by their institutions regarding digital assessment practices. One teacher explained that evaluation was conducted by “observing children’s interest and responses directly during the lesson,” while another noted that there was “no official guideline, only general suggestions”. These accounts highlight how assessment

practices were shaped by contextual constraints rather than shared pedagogical frameworks.

Teachers also reported that digital media themselves were infrequently evaluated for pedagogical suitability. Several participants indicated that digital tools were “not evaluated often” or only “occasionally” due to limited time and available resources. In some cases, teachers stated that they had “never evaluated digital learning formally,” suggesting that digital materials were reused without systematic reflection on instructional alignment.

Despite these limitations, observational data indicate that digital documentation practices were more consistently implemented than assessment practices. Across literacy and numeracy contexts, teachers documented children’s learning outcomes digitally by recording reading performance, capturing activity results through applications, and sharing feedback with parents via online platforms. These documentation practices primarily functioned as records of participation and communication rather than as analytic tools for instructional redesign.

In several settings, teachers articulated a clear awareness of the limitations of their assessment practices and expressed the need for additional support. One participant noted the necessity of “teacher training and clearer planning,” while another emphasized the importance of “equal access to facilities and professional development” to strengthen digital assessment strategies. These reflections suggest that informal assessment practices were not the result of pedagogical preference alone, but also of structural and institutional constraints.

Collectively, these findings indicate that assessment and documentation practices were characterized by informality, immediacy, and contextual responsiveness, with limited integration into strategically planned digital pedagogy. While practices varied across classrooms, the dominant orientation remained consistent: assessment functioned as an observational and supportive activity embedded within instruction rather than as a systematically designed component of digital literacy and numeracy teaching.

4.4 Limited Professional Guidance and Reliance on Peer Support (RQ2)

Teachers’ engagement with digital pedagogical strategies was consistently shaped by the absence of structured professional guidance and a corresponding reliance on peer-based support mechanisms. Rather than operating within clearly articulated institutional frameworks, teachers navigated digital integration through individual judgment and informal coordination across all institutional contexts.

Participants reported that decisions regarding digital tool selection, classroom rules, and instructional sequencing were largely self-directed. Although some teachers had participated in external webinars or online training, these experiences were not systematically integrated into institutional professional development routines. As a result, digital pedagogical practices remained uneven and dependent on individual confidence rather than shared standards.

In this context, peer collaboration emerged as a central mechanism for sustaining digital practices. Teachers described informal discussions, shared experimentation, and reciprocal assistance as primary strategies for addressing disparities in digital competence. One participant explained that differences in digital ability were managed through “informal discussions to help each other,” while another noted that colleagues regularly “share experiences about newly learned digital skills.” Professional learning thus occurred through collegial adaptation rather than formal mentoring or institutional programs.

At the same time, teachers articulated clear perceptions of unmet conditions necessary for improving digital pedagogy. Participants emphasized the need for targeted training and more equitable access to digital facilities. Others expressed interest in developing their own instructional media, such as learning videos or interactive content, yet framed these aspirations as contingent upon institutional support and clearer pedagogical guidance. Overall, these findings suggest that limited professional guidance positioned peer support as the primary mechanism through which teachers navigated digital pedagogy. While this reliance enabled continuity of practice, it also constrained pedagogical coherence and produced bounded variation shaped by local capacity and informal norms.

4.5 Emerging Strategic Needs for Pedagogically Grounded Digital Literacy Instruction (RQ3)

Analysis across institutional contexts revealed identifiable pedagogical strategy gaps underlying teachers’ digital literacy and numeracy practices. These gaps were not expressed as abstract deficiencies but emerged empirically from observed practices, documented absences, and teachers’ reflective accounts. Digital instruction was largely sustained through pragmatic, situational decision-making rather than coherent instructional planning. Teachers prioritized activities that could be readily integrated into existing routines, positioning digital media as introductory stimuli, reinforcement tools, or documentation supports rather than as components of a sequenced instructional design. This pattern revealed gaps in planning coherence, instructional continuity, and alignment between digital activities and learning objectives.

Teachers also identified gaps related to evaluative consistency. While informal observation and documentation were routinely employed, systematic review of digital media use and learning impact was rare. One participant noted that “evaluation of digital media is not done often because there are limited options available,” while others emphasized the need for clearer planning structures and classroom rules to guide digital use. These reflections indicate a gap between teachers’ awareness of pedagogical needs and the institutional support required to address them. Empirical accounts further reveal that perceived strategic gaps were closely associated with limited institutional support and fragmented professional preparation.

One participant noted that digital practices were largely self-developed, explaining that “there has never been specific training on technology use, so we usually help each other and learn together.” While peer collaboration enabled continuity, it also constrained the development of shared pedagogical standards.

Similarly, another teacher highlighted the absence of formal guidance, stating that “there are no written guidelines from the institution, only general suggestions,” resulting in digital practices being interpreted and enacted differently across classrooms.

Teachers also articulated emerging needs related to planning coherence and evaluative consistency. Although informal observation and digital documentation were routinely employed, systematic review of digital media use was described as infrequent. As one participant reflected, “evaluation of digital media is not done often because there are limited options available.” Others emphasized the need for clearer planning structures, indicating that “training and clearer rules for children are needed so digital strategies can be applied more consistently.” These reflections suggest an awareness of pedagogical grounding alongside limited access to coordinated support mechanisms.

Taken together, these findings demonstrate that current digital literacy and numeracy practices are sustained through adaptive strategies that compensate for the absence of structured institutional scaffolding. The pedagogical strategy gaps identified—particularly in planning, assessment alignment, and professional guidance—constitute empirical findings grounded in teachers’ everyday instructional realities rather than post-hoc interpretations.

5. Discussion

Taken together, the findings indicate that early childhood teachers’ digital pedagogical practices were shaped by four interrelated conditions: the positioning of digital technology as an engagement-oriented entry point, the predominance of substitution-based instructional use, the reliance on informal assessment and documentation practices, and the persistence of structural constraints related to professional guidance and institutional support. Conceptually, these conditions can be understood as constituting a bounded pedagogical ecology in which digital practices are not individually determined but systematically shaped by institutional norms, developmental priorities, and professional capacity.

Across contexts, the engagement-oriented use of digital technology can be understood as a pedagogical positioning that closely aligns with dominant principles of early childhood education. Teachers’ selective and time-limited use of audiovisual media as introductory stimuli reflects an intentional effort to balance digital engagement with play-based, relational, and hands-on learning experiences. Rather than signaling pedagogical underdevelopment, this pattern reflects teachers’ active mediation of digital affordances in accordance with developmental norms and instructional priorities.

Prior research similarly interprets digital technology in early childhood classrooms as functioning primarily to attract attention, stimulate curiosity, and support participation rather than to serve as a continuous instructional medium (Brinck et al., 2023; Marín-Suelves et al., 2022). Studies on digital play further emphasize that technology is pedagogically appropriate when embedded within playful, inquiry-oriented activities that preserve children’s agency and social

interaction (Cohrssen, 2022). At the same time, educators' cautious regulation of screen exposure echoes widely documented tensions between the motivational affordances of digital media and concerns regarding developmental appropriateness and excessive screen time (Bortolotti et al., 2025; Xie et al., 2025). This finding contributes to international debates by reframing engagement-oriented digital use as a normative pedagogical strategy rather than a deficit. Closely related to this engagement-oriented positioning is the prevalence of substitution-based digital practices, which illustrates how digital technology is incorporated into existing instructional logics rather than used to reconfigure pedagogical structures. This pattern resonates with international findings that characterize early stages of digital integration as functionally substitutive rather than transformative.

Consistent with prior studies, digital tools in this study primarily replaced conventional materials – such as printed flashcards, visual aids, or worksheets – without fundamentally altering instructional sequencing or learning trajectories (Al-Abdullatif, 2022; Rina et al., 2025). Research on early literacy and numeracy instruction has repeatedly shown that such substitution-level uses are common, particularly when teachers possess basic digital skills but limited pedagogical confidence to experiment with more complex forms of integration (Hasibuan et al., 2024; Miočić et al., 2025). The present findings extend this literature by demonstrating how substitution-based practices are maintained not by resistance to innovation but by institutional constraints and pedagogical caution.

Assessment and documentation practices further illuminate how digital pedagogy is enacted under conditions of limited formal guidance. In this study, assessment was largely grounded in observational judgments of engagement, participation, and immediate responsiveness, while digital documentation functioned primarily as a mechanism for record-keeping and communication. This finding highlights a tension between responsiveness and systematic planning, where assessment supports immediate pedagogical adjustment but offers limited guidance for longer-term instructional redesign. This orientation aligns with research describing early childhood assessment as inherently informal, process-oriented, and embedded within everyday interaction, particularly within play-based pedagogical traditions (Becker et al., 2023; Hojnoski et al., 2020). The findings thus contribute to ongoing debates about the role of digital assessment in early childhood by underscoring the need for pedagogically aligned assessment literacy rather than solely technological solutions.

Underlying these instructional and assessment practices are structural and professional constraints that shape the boundaries of digital pedagogy. Consistent with international literature, teachers in this study navigated digital integration in the absence of comprehensive institutional guidelines, relying instead on individual judgment and peer-based learning (Hatzigianni et al., 2025). This reliance on informal professional networks highlights a critical policy implication: without institutional scaffolding, digital pedagogy remains contingent rather than systematic. Research on professional digital competence emphasizes that

sustained, practice-oriented professional development is critical for moving beyond surface-level technology use toward more pedagogically grounded integration (Gabarda Méndez et al., 2025; Verdú-Pina et al., 2023). The findings thus underscore the need for policy and institutional interventions that align professional development with pedagogical – not merely technical – competence.

Viewed collectively, this study extends existing research by offering a fine-grained, contextually grounded account of how digital pedagogy in early literacy and numeracy is enacted under everyday institutional conditions. The primary theoretical contribution lies in conceptualizing digital technology as pedagogical positioning rather than as an instructional intervention or innovation outcome. Rather than foregrounding innovation or effectiveness, the findings contribute an interpretive understanding of digital practice as a negotiated balance between pedagogical values, professional capacity, and structural constraints. From a policy and teacher education perspective, the findings suggest that strengthening digital pedagogy in early childhood requires attention to pedagogical coherence, assessment literacy, and institutional guidance rather than increased tool provision alone.

6. Conclusion

This study advances research on digital pedagogy in early childhood education by foregrounding pedagogical positioning as a central analytical lens for understanding how digital technology is enacted in early literacy and numeracy instruction. Drawing on qualitative evidence from multiple institutional contexts, the findings demonstrate that early childhood teachers consistently position digital tools as engagement-oriented instructional entry points and substitution-based supports, embedded within established routines and regulated by developmental considerations, informal assessment practices, and institutional constraints. The main scientific contribution of this study lies in shifting the focus of digital pedagogy research from questions of adoption or effectiveness toward an interpretive analysis of pedagogical judgment and instructional decision-making, revealing how digital practices are shaped by bounded pedagogical ecologies rather than by technological availability alone.

Practically, the findings suggest that efforts to strengthen digital literacy and numeracy instruction should prioritize pedagogical design, assessment integration, and sustain professional guidance over the provision of digital tools in isolation. Future research should examine how structured professional development and institutional frameworks enable teachers to move beyond engagement-oriented and substitution-based digital practices, explore longitudinal changes in pedagogical positioning across career stages, and investigate how digital literacy and numeracy instruction is negotiated across diverse early childhood governance and socio-cultural contexts.

7. Conflict of Interest, Acknowledgements, etc.

The authors declare no conflict of interest.

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