

Original Article

Stakeholders' Perceptions of Technology Integration on Early Childhood Program Outcomes

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Abstract. This study investigated the influence of technology integration on early childhood outcomes, specifically focusing on effective integration for diverse learners, the impact on language and literacy skills, the drawbacks of excessive screen time, and strategies for equitable access. Employing a convergent parallel mixed-methods design, qualitative data were gathered through semi-structured interviews, while quantitative data were collected via researcher-developed questionnaires. The integrated findings demonstrated strong convergence between stakeholder experiences and statistical trends. Qualitative themes identifying the effectiveness of sensory-rich multimedia and interactive applications, such as Khan Academy Kids and Duolingo, were validated by “Strongly Agree” quantitative ratings for early vocabulary ($M = 4.23$) and high agreement for alphabet knowledge ($M = 4.16$). Conversely, a critical divergence was noted regarding complex cognitive skills; qualitative “warnings” regarding shortened attention spans and reduced social interaction provided essential context for the lower means in narrative skills ($M = 3.99$) and the “Neutral” quantitative stance ($M = 3.36$) toward providing individual devices for every child. Furthermore, the qualitative emphasis on adult mediation converged with quantitative results showing that the most supported strategy for equity was providing continuous technical support for educators ($M = 4.16$) and embedding technology into the curriculum ($M = 4.09$) rather than simple hardware distribution. The synthesized evidence suggests that technology’s role in ECE is not as a standalone driver of achievement but as a mediated tool whose effectiveness is entirely dependent on a well-supported, educator-led framework. The study concludes that true digital equity and successful literacy outcomes are achieved when schools prioritize systemic, human-centered strategies over hardware access. Ultimately, the cognitive and linguistic benefits of technology can only be sustained if digital engagement is purposefully balanced with non-screen activities to mitigate the social-emotional and behavioral risks identified by stakeholders.

Keywords: *Early childhood education; Educational technology; Digital literacy; Screen time; Technology access.*

The integration of technology has fundamentally transformed the landscape of early childhood education (ECE), shifting pedagogical focuses toward digital tools that facilitate communication and developmental growth. In the context of learners aged birth to eight years, technology is increasingly employed to foster essential twenty-first-century skills, including creativity, collaboration, and cognitive development. However, the efficacy of these tools is not merely a product of their availability; rather, it is deeply influenced by stakeholders' perceptions, which shape how technology is accepted and implemented within learning environments. While

technology offers a "silver lining" for education in contexts like the Philippines, where it bridged significant gaps during the pandemic, its integration remains a complex phenomenon characterized by both transformative opportunities and persistent challenges.

Current research underscores a dualistic view of technology in early childhood education, balancing its immense developmental potential against practical and health-related concerns. Scholars emphasize that the appropriate integration of digital tools is essential for cultivating "twenty-first-century learners" who are both effective digital consumers and creators. Research indicates that when technology is employed intentionally, it fosters essential skills such as confidence, creativity, and collaboration. Specifically, Davidson (2021) notes that these tools keep learners engaged and motivated while building academic skills. Innovative approaches, such as the exploration of robot learning discussed by Su et al. (2023), show promise in enhancing children's thinking and problem-solving abilities. These findings are supported by Werling (2020) and Quesenberry et al. (2016), who argue that appropriate technological use significantly enhances children's learning and development across social, emotional, and cognitive domains. Furthermore, Sharapan (2012) and Sharkins et al. (2016) describe technology as a vital tool for growth in a technology-driven future. More recently, Llurag and Kilag (2024) highlighted the specific success of educational apps in improving language acquisition and early literacy milestones, such as phonics and vocabulary building.

Despite these benefits, the literature suggests that the success of technology integration is contingent upon educators' competency and attitudes. Alotaibi (2023) emphasizes that robust teacher preparation is a prerequisite for effectively incorporating media and technology into preschool settings. This is echoed by Sulistyaningtyas et al. (2023), who argue that professional development programs are crucial for helping teachers move beyond basic use toward meaningful classroom integration. In the Philippine context, OpenGov Asia (2021) suggests that the successful introduction of technology depends on merging digital tools with established best teaching practices. Furthermore, Ventouris et al. (2021) advocate for continuous training that goes beyond technical skills to improve teachers' underlying attitudes and confidence, ensuring they feel competent to use technology as an instructional tool.

A significant focus of the current literature is the interplay between different stakeholders' beliefs. During the COVID-19 pandemic, technology was viewed by Childhope Philippines (2021) and Dr. Ethel Agnes P. Valenzuela as a "silver lining" that bridged the gap between quarantine and active teaching through online classes and mobile device distribution. However, sustaining this progress requires alignment between home and school environments. Gjelaj et al. (2020) identify a critical disparity where parental support for technology often clashes with the cautious, and sometimes skeptical, attitudes of preschool teachers. This divergence in educational philosophies can create conflicting experiences for children, leading to calls for increased collaboration to maximize technological advantages while mitigating risks.

Finally, the literature highlights systemic and physical challenges that remain unaddressed. Scott (2021) points to a significant gap in early years policy regarding "digital play," noting that educational frameworks often overlook how to build upon the digital experiences children bring from home. To address these complexities, Hatzigianni et al. (2023) propose a holistic and dynamic understanding of technology, viewing it as an evolving element that enriches educational programs rather than a static tool. This balanced perspective is vital, as Nurdiantami and Meriyandah Agil (2020) warn that while digital platforms enhance skills, they also present risks such as decreased physical activity and potential health concerns. Consequently, the literature calls for a synthesized approach, combining teacher training, stakeholder collaboration, and policy development, to ensure technology supports rather than hinders holistic child development.

To analyze these perceptions, this study is anchored in the Technology Acceptance Model (TAM) and Constructivist Learning Theory. TAM is utilized to investigate how the "perceived usefulness" and "perceived ease of use" among teachers and parents directly influence their willingness to integrate digital tools. This is complemented by Constructivist Learning Theory, which posits that children actively build knowledge through exploration and guided interaction; thus, technology is viewed as a medium for active construction rather than passive consumption. Other frameworks, such as Bronfenbrenner's Ecological Systems Theory and TPACK, serve as secondary lenses to interpret how environmental factors and pedagogical knowledge intersect with stakeholder beliefs.

Despite the documented advantages of digital tools, a critical contextual and empirical gap exists regarding sustainable implementation in resource-constrained environments, such as underserved areas in the Philippines. Methodologically, there is a lack of focus on how conflicting stakeholder perceptions (e.g., parent vs. teacher) affect the consistency of technology integration. Furthermore, a theoretical and policy gap persists concerning "digital play," which is often overlooked in early years frameworks despite its potential for social and cognitive development. This study addresses these gaps by shifting the focus from the mere presence of technology to the perceptions of those who mediate its use, arguing that understanding stakeholder attitudes is the first step toward equitable and effective integration.

By investigating the influence of technology through the lens of those most involved in the child's development, this research seeks to provide educational leaders and policymakers with the insights necessary to design targeted professional development and curricula. Consequently, this study addresses several critical problems: determining the most effective integration strategies to support diverse learning styles, evaluating the impact of digital tools on language and literacy skills, identifying the drawbacks of excessive screen time on social interaction, and establishing strategies to ensure equitable access to technology resources for all children regardless of their socio-economic context.

Methodology

Research Design

This study utilized a convergent parallel mixed-methods design to examine the complex interplay between technology integration and early childhood education outcomes. The rationale for this approach was to achieve complementarity and expansion, merging the statistical breadth of quantitative ratings with the explanatory depth of qualitative stakeholder narratives. By collecting both strands concurrently and analyzing them independently before merging, the study ensured integration validity, providing a more comprehensive understanding than either method could offer alone. The research is theoretically anchored in the Technology Acceptance Model (TAM) and Constructivist Theory, while further integrating the TPACK framework, Gardner's Multiple Intelligences, and Bronfenbrenner's Ecological Systems Theory to interpret how digital tools interact with children's developmental ecosystems.

The design employed a merging integration strategy and cross-strand validation to facilitate the development of unified meta-inferences. Qualitative data were gathered through semi-structured interviews to identify effective integration strategies and explore behavioral shifts associated with screen dependence. Simultaneously, quantitative data were collected via researcher-developed Likert-scale questionnaires to assess the reported impact of digital tools on children's language and literacy domains, alongside the perceived effectiveness of equity strategies. This methodology incorporated a legitimation procedure that allowed researchers to triangulate statistical trends with lived experiences. This integrated approach ensured that the final conclusions were grounded in both measurable perceptions and the contextual realities of early childhood learning environments.

Population and Locale of the Study

The study was conducted within the University of Baguio (UB) Laboratory Elementary School and UB-adopted schools, identified through the University of Baguio Research Innovation Extension and Community Outreach (RIECO). This locale provides a unique environment for examining the mesosystemic link between institutional education and community-based learning. Kindergarten, as part of Early Childhood Care and Education (ECCE), serves as the focal point of the research because it represents a critical stage for brain development, language acquisition, and foundational literacy. The study utilized a convergent parallel mixed-methods design, involving a total of forty-five (45) participants to ensure that findings were grounded in both measurable trends and lived experiences.

For the qualitative phase, all forty-five (45) participants were engaged, consisting of five (5) Kindergarten teachers and forty (40) Kindergarten parents. The teachers were selected through purposive sampling to provide in-depth professional perspectives on pedagogical-technological strategies, specifically addressing how digital tools cater to visual and auditory learning styles. Given the small total population of kindergarten teachers across the partner schools ($N = 5$), quantitative surveying was methodologically unfeasible for this subgroup; thus, teacher insights were captured exclusively through qualitative inquiry to maximize thematic depth over numerical aggregation. This group included one teacher from School A, one from School B, and three from School C. The forty (40) parents

contributed qualitative data through semi-structured interviews and open-ended survey responses, with thirteen (13) from School A, thirteen (13) from School B, and fourteen (14) from School C. This dual-stakeholder approach allowed the researchers to examine the child's microsystem from both the home and classroom perspectives.

The quantitative phase focused exclusively on the forty (40) Kindergarten parents, serving an exploratory and descriptive role to identify baseline trends rather than broad population-wide statistical generalizability. These participants completed researcher-developed questionnaires measuring perceptions of technology's impact on literacy and the effectiveness of equity strategies. Parents were recruited through voluntary response sampling to accommodate scheduling constraints, minimize participation barriers, and adhere to institutional privacy guidelines regarding mandatory data collection. To maintain a specialized focus on the kindergarten developmental stage, teachers not assigned to kindergarten and parents without children currently enrolled in the level were excluded from the study.

Limitations of the Study

Several limitations should be considered when interpreting the findings of this research. First, the study utilized a relatively small sample of forty-five (45) participants. While this size allowed for a rich, in-depth thematic analysis of stakeholder concerns, the results may not fully represent the broader perspectives of all early childhood educators and parents beyond the study group.

Second, the study was localized exclusively to the UB Laboratory Elementary School and RIECO-adopted schools. Because the findings are context-specific, they may not be directly transferable to educational settings with different resource levels or cultural frameworks. The quantitative results may specifically reflect the localized awareness of social-emotional risks identified by this specific community.

Additionally, the quantitative phase relied on voluntary response sampling, which introduces potential self-selection bias. Conversely, the qualitative findings reflect the specific concerns of a purposively selected group regarding behavioral mimicry and social withdrawal. Consequently, these results should be interpreted as providing a localized, multi-dimensional understanding of technology integration rather than findings that can be universally generalized to all early childhood contexts.

Data Gathering Tool

To facilitate a convergent mixed-methods analysis, the study utilized two researcher-developed instruments: semi-structured interview guides for the qualitative strand and a structured questionnaire for the quantitative strand. These tools were designed to achieve integration validity by capturing both the statistical breadth of literacy gains and the explanatory depth of stakeholder lived experiences. Within the qualitative strand, separate semi-structured interview guides were prepared for teachers and parents to address Research Problems 1 and 3. The teacher guide explored pedagogical-technological strategies and classroom observations regarding student engagement and screen time management challenges. Meanwhile, the parent guide focused on home technology ecosystems, observed behavioral shifts, and specific digital applications perceived to support language and literacy development. To identify recurring patterns, qualitative interview responses were supplemented by open-ended survey entries and analyzed using reflexive thematic analysis.

Addressing Research Problems 2 and 4, the quantitative strand centered on a structured questionnaire containing three distinct sections designed to build a robust dataset for cross-strand validation. The first section, a Language and Literacy Subscale, comprised 34 Likert-scale items adapted from Liu et al. (2024), including 20 items measuring language skills (phonological awareness, early vocabulary, and narrative skills) and 14 items measuring literacy skills (print knowledge and alphabet knowledge). The second section, an Equity Strategies Subscale, consisted of 10 items assessing stakeholder support for initiatives and offering continuous technical support. Finally, a qualitative expansion section collected open-ended participant suggestions regarding digital equity, which were merged into the qualitative strand to elaborate on and contextualize the quantitative findings.

To guarantee high inference quality, all instruments underwent rigorous validation, pilot testing, and reliability procedures. Content validation for the quantitative questionnaire was established through review by an expert panel ($N = 5$) comprising early childhood educators, instructional technology experts, and psychometricians. The panel evaluated items for clarity, construct relevance, and alignment with the study's multi-theoretical framework, achieving a Content Validity Index (CVI) of 0.92, indicating strong content appropriateness. The

instrument was subsequently pilot-tested with 30 non-sample respondents to assess readability and comprehension. Reliability analysis yielded an overall Cronbach's alpha coefficient of 0.95, demonstrating excellent internal consistency across subscales. Construct validity was further substantiated during pilot testing through item-total correlation analysis, where all retained items met the minimum threshold ($r > 0.30$), confirming that individual items measured their intended underlying dimensions. Construct validity was additionally supported by mapping scale constructs to the Technology Acceptance Model (TAM) regarding perceived usefulness, Constructivist Learning Theory regarding active knowledge construction, TPACK, and Gardner's Multiple Intelligences.

To ensure the rigor of the qualitative instruments, the semi-structured interview guides underwent preliminary pilot testing with a non-sample group of two teachers and three parents, after which prompts were refined to eliminate technical jargon (simplifying pedagogical terminology into accessible, lay parent language) and to optimize question ordering for conversational flow. Furthermore, qualitative trustworthiness was established following Lincoln and Guba's criteria: credibility was maintained through data source triangulation integrating teacher interviews, parent interviews, and open-ended survey responses; dependability was ensured by utilizing a standardized interview protocol and maintaining a detailed audit trail of all data collection and thematic coding decisions; confirmability was addressed through researcher reflexivity logs and peer debriefing sessions to minimize subjective bias during data analysis; and transferability was facilitated by providing rich, thick descriptions of the educational setting, participant characteristics, and research context.

Data Gathering Procedure

Before commencing data collection, the researchers finalized the dual-strand instrumentation required for the convergent mixed-methods design. This included developing semi-structured interview guides to explore qualitative themes as well as researcher-developed Likert-scale questionnaires to quantify perceptions of literacy gains and equity strategies. The researchers identified 45 key stakeholders, comprising 5 teachers and 40 parents, ensuring the participant pool represented both home and school perspectives. Formal permission was secured from school administrations through letters outlining the study's focus on balancing educational gains with developmental risks. To ensure ethical compliance and integration validity, informed consent forms were distributed, explicitly detailing that interviews would be recorded for thematic analysis and that questionnaire data would remain confidential.

During the active gathering phase, qualitative and quantitative data were collected simultaneously to maintain the integrity of the convergent parallel design. Interviews with the 45 participants were conducted in settings chosen for participant comfort, either in person or virtually. Researchers utilized the semi-structured guides to delve into the "how" and "why" of technology use, allowing participants to provide the rich narratives found in the sources. These sessions were recorded with consent. Concurrently, the Likert-scale questionnaires were administered electronically or on paper. The researchers remained available to assist participants, ensuring that the quantitative data regarding the ten specific equity strategies and various literacy domains were collected systematically and accurately.

Following the collection phase, the researchers organized the datasets for independent analysis. Interview recordings were transcribed and compiled for reflexive thematic analysis, where they were coded for recurring patterns. Simultaneously, quantitative responses from the questionnaires were cleaned and prepared for descriptive statistical analysis. All data were stored in secure, password-protected digital environments to uphold the confidentiality promised during the consent process. The final step involved the systematic review of both strands to facilitate the merging integration strategy, allowing the researchers to create Joint Display Tables that triangulated statistical means with the lived experiences of the participants.

Data Analysis

To achieve a comprehensive understanding of technology integration, this study employed a merging integration strategy consistent with a convergent parallel mixed-methods design. Qualitative and quantitative data were collected concurrently and analyzed independently using strand-specific analytical procedures before being synthesized during the interpretation phase through a joint display matrix to facilitate cross-strand integration and generate overarching meta-inferences.

For Research Problems 1 and 3, qualitative data were analyzed using Braun and Clarke's Reflexive Thematic

Analysis framework to examine the perceived effects of technology integration and implementation strategies. First, the researchers achieved data familiarization by transcribing interviews verbatim, reading transcripts repeatedly, and taking initial reflexive notes. Second, initial coding was conducted using an inductive open-coding process to identify semantic and latent meaning units across teacher and parent responses. Third, initial codes were candidate-grouped into broader potential themes. Fourth, themes were reviewed and refined against candidate extracts and the entire dataset to ensure analytical coherence. Fifth, themes were formally defined and named to reflect the core essence of participants' lived experiences regarding children's developmental and behavioral changes. Sixth, the final thematic narrative was compiled. To maintain qualitative rigor and trustworthiness throughout this process, researcher reflexivity was operationalized through reflexivity logs to bracket subjective assumptions regarding digital media usage. Methodological dependability and confirmability were secured by maintaining an explicit audit trail documenting codebook evolution, raw transcripts, and analytical memoing. Credibility was established through data source triangulation—integrating insights across teacher interviews, parent interviews, and open-ended survey responses—alongside peer debriefing sessions within the research team to cross-verify thematic interpretations and ensure analytical accuracy.

For Research Problems 2 and 4, quantitative data were analyzed using comprehensive descriptive statistics to evaluate stakeholder perceptions and establish baseline trends. To maximize the depth of the quantitative evaluation, analysis was conducted across both item and subscale levels: individual item means (*M*) and standard deviations (*SD*) were computed alongside overall composite grand means for the Language/Literacy and Equity Strategies subscales to assess central tendency and response dispersion. Scores were interpreted using a five-point scale (1.00–1.79 = Very Weak Impact/Support; 1.80–2.59 = Weak; 2.60–3.39 = Moderate; 3.40–4.19 = Strong; 4.20–5.00 = Very Strong Impact/Support). Given the exploratory design and localized sample size (*N* = 40) of the quantitative strand, descriptive statistics were intentionally prioritized to provide a granular profile of parental perceptions and variability without making unrepresentative population-level inferential claims.

Following independent strand analyses, the qualitative and quantitative findings were methodologically integrated using a weaving approach within a Joint Display Table. Quantitative statistical metrics (item means, subscale grand means, and standard deviations) and qualitative themes were arrayed side-by-side, mapped directly to corresponding research questions. The integration process systematically analyzed the data for patterns of convergence (agreements), expansion (qualitative insights elaborating on statistical trends), and discordance (contradictions). Rather than presenting qualitative results as a sequential afterthought, synthesis occurred at the analytical level by cross-referencing quantitative score profiles against qualitative narrative themes. This integrated cross-strand comparison directly generated unified meta-inferences that provided a multi-dimensional understanding of technology's role in early childhood literacy.

Table 1. *Scale of Interpretation for the Impact of Technology on Language Development and Literacy Skills*

Arbitrary Values	Statistical Limit	Descriptive Equivalent	Interpretation
5	4.20-5.00	Strongly Agree	Respondents strongly agree, indicating a very strong impact.
4	3.40-4.19	Agree	Respondents agree, indicating a strong impact.
3	2.60-3.39	Neutral	Respondents are neutral, indicating a moderate impact.
2	1.80-2.59	Disagree	Respondents disagree, indicating a weak impact.
1	1.00-1.79	Strongly Disagree	Respondents strongly disagree, indicating a very weak impact.

Table 2. *Scale of Interpretation for Equitable Access to Technology*

Arbitrary Values	Statistical Limit	Descriptive Equivalent	Interpretation
5	4.20-5.00	Strongly Agree	Respondents strongly agree, indicating a very high level of support for the strategy.
4	3.40-4.19	Agree	Respondents agree, indicating a high level of support for the strategy.
3	2.60-3.39	Neutral	Respondents are neutral, indicating a moderate or uncertain level of support.
2	1.80-2.59	Disagree	Respondents disagree, indicating a low level of support for the strategy.
1	1.00-1.79	Strongly Disagree	Respondents strongly disagree, indicating a very low level of support for the strategy.

Ethical Considerations

The researchers upheld ethical integrity throughout the study to ensure the protection, rights, and well-being of all participants. Prior to data collection, ethical approval was obtained from the appropriate Institutional Review

Board (IRB) or ethics committee to ensure compliance with established research ethics standards. Informed consent was secured from all participating kindergarten teachers and parents after they were provided with clear information regarding the study's purpose, procedures, potential risks, and expected benefits. Specifically, participants were briefed on the study's dual focus: the potential for academic and developmental gains and the documented risks of excessive screen time; they were also informed about how their observations of their children's digital behaviors and literacy progress would be used, alongside the measures implemented to protect their privacy. Participation was entirely voluntary, and all participants were informed of their right to withdraw from the study at any stage without penalty or adverse consequences.

To safeguard confidentiality and anonymity, all collected data were coded to remove identifying information, with records securely stored and accessible only to the research team. Findings were presented in aggregate form, utilizing mean scores and standard deviations for quantitative strands and categorized themes for qualitative strands, to prevent the identification of individual participants or their children. During interviews, the researchers maintained a respectful, culturally sensitive, and supportive environment, encouraging stakeholders to share candid insights regarding both the successes of digital tools and the challenges without fear of judgment.

Upon completion of the study, the results were compiled into a comprehensive research report, and a summary of the findings was shared with participants and relevant stakeholders to promote transparency and ethical awareness. The findings were also disseminated through appropriate academic and community platforms, including journals, conferences, and workshops, to support evidence-based technology integration and advocate for systemic, human-centered strategies such as continuous professional support for educators.

Results and Discussion

Effective Integration of Technology in Early Childhood Education for Diverse Learning Styles and Needs

To examine the most effective ways to integrate technology in early childhood education, this study conducted a thematic analysis of insights provided by parents and teachers. The findings revealed a range of strategies and tools that support the diverse needs and learning styles of young learners, moving beyond simple content delivery to enhance engagement, reinforce learning, and provide individualized support. Key themes emerged regarding multi-device accessibility, the use of multimedia and interactive apps, and the necessity of structured reinforcement through digital tools. Central to these findings is the role of adult mediation, as both parents and teachers emphasized the importance of tailoring technology use to a child's developmental stage. By merging these qualitative insights with quantitative data on literacy gains and equity strategies, this study demonstrates how well-integrated educational technology can lead to significant academic and developmental improvements.

Multi-device Accessibility and the Logic of Choice

The integration of technology begins with providing a diverse array of digital tools to support personalized learning. Quantitatively, participants expressed a high level of agreement with the strategy of providing a range of technology tools to cater to different learning styles ($M = 4.00$, $SD = 0.8528$). However, there was a notable "Neutral" stance regarding the provision of individual devices for every child ($M = 3.36$, $SD = 1.0035$). Qualitative responses enrich this finding, as parents highlighted a preference for multi-device environments—including cellphones, tablets, and TVs—rather than a single-device focus. For instance, AP1 noted, *"Cellphone, tablet, and books help support my child's learning needs,"* while BP15 added that *"Tablet, computer, and television are types of technology that are helpful..."*.

There is a clear convergence on the need for tool variety but a divergence on the method of access. The quantitative "Neutral" rating for 1:1 device suggests concerns over financial costs and developmental appropriateness, which is validated by qualitative insights suggesting that shared or varied devices are more practical for early learners. This reflects Bronfenbrenner's mesosystem, where the interlinked environments of home and school provide a varied technological ecosystem for the child.

As Haleem et al. (2022) note, digital technologies such as tablets and e-books do not merely replace traditional instructional materials; they fundamentally increase student engagement and motivation by catering to varied cognitive and sensory preferences. By favoring a multi-device strategy, parents intuitively align with Haleem et al.'s insights, leveraging tool variety to drive learner engagement while avoiding the developmental and financial constraints of an enforced single-device model.

Multimedia Support for Visual and Auditory Learning Styles

Multimedia tools are perceived as the primary drivers for sensory-based engagement and foundational literacy. Quantitatively, the impact of technology on Early Vocabulary received the highest possible rating ($M = 4.23$, $SD = 0.6515$), interpreted as "Strongly Agree". This statistical success is directly mirrored in the qualitative reports, where participants described how multimedia caters to visual and auditory modalities. AT1 stated that these tools *"cater to visual and auditory learners and enable flipped classroom models,"* while BP16 observed that music and arts helped their child follow steps *"perfectly... through visual learning"*. BP2 specifically mentioned that *"YouTube for Kids has educational videos that keep my child interested"*.

The "Strongly Agree" rating for vocabulary is practically illustrated by qualitative reports of children learning the alphabet easily via nursery rhymes and educational videos. This demonstrates complementarity, where technology acts as a sensory-rich vehicle for language acquisition, specifically aligning with Gardner's visual-spatial and musical intelligences. As Abdulrahman et al. (2020) establish, multimedia tools, featuring dynamic combinations of audio, video, animation, and 3D elements, substantially improve teaching and learning outcomes because they engage multi-sensory channels to reinforce comprehension.

Within an early learning context, this multimodal approach directly operationalizes Gardner's Theory of Multiple Intelligences, specifically tapping into visual-spatial and musical-rhythmic modalities. By pairing auditory cues (rhymes, rhythms, audio instruction) with dynamic visual stimuli (animations, bright graphics), multimedia platforms bridge the gap between passive reception and active cognitive processing, creating sensory-aligned pathways that accelerate early vocabulary mastery.

Interactive Apps, Gamification, and Hands-on Learning

Interactive and gamified platforms bridge the gap between digital play and structured academic skill-building. Quantitative data showed high agreement that technology supports Alphabet Knowledge ($M = 4.16$) and Print Knowledge ($M = 4.03$). Qualitative themes expanded on this by identifying specific apps as the catalysts for these gains. Participants cited tools like Khan Academy Kids, Duolingo, and TinyTap. CT5 explained that *"gamified applications... provide practical experiences and engaging ways to practice skills through movement and interaction,"* and AP7/AP12 highlighted the use of *"ABC games apps... [and] Math for Kids"*.

The qualitative findings provide expansion for the quantitative data; while the numbers show literacy gains, the themes identify the specific "ABC games" and "gamified platforms" as the essential tools. This reflects Constructivist Learning Theory, as children are not just passive viewers but are actively constructing meaning through interactive, playful engagement.

This pattern is strongly corroborated by Vaiopoulou et al. (2022), who emphasize that widely used early childhood educational apps achieve high learning efficacy precisely because they are intentionally evaluated and designed for high pedagogical value, intuitive usability, and developmental suitability. Expanding on this, Alotaibi (2024) affirms that game-based learning exerts a moderate-to-large positive effect across children's cognitive, social, emotional, and motivational domains. Taken together, these studies clarify *why* gamified tools translate into early literacy success: well-designed app architecture paired with game-based mechanics optimizes student engagement while driving core cognitive outcomes.

Reinforcement of Lessons and Adult Mediation

The effectiveness of technology integration is fundamentally contingent upon adult guidance and curriculum alignment. Quantitatively, the strategy that received the highest agreement was providing continuous technical support for educators ($M = 4.16$, $SD = 0.7965$). This is reinforced by high agreement for embedding technology into the curriculum ($M = 4.09$). Qualitatively, both parents and teachers emphasized that technology must be "strategized" rather than used randomly. AP4 suggested that educators should *"strategize when to use technology... perhaps once a week, or they can combine traditional learning methods,"* while BP17 emphasized the need to *"guide every child on the proper way to use technology"*.

Integration and Meta-Inference: There is strong convergence between the need for teacher support (quant) and the demand for knowledgeable mediation (qual). Stakeholders believe technology is only integrated effectively when diverse tools are paired with a well-supported, educator-led framework. This highlights TPACK's Pedagogical Knowledge (PK), where the adult's role is to ensure technology is used in a developmentally

appropriate manner.

When digital tools are strategically selected, they serve as powerful mechanisms for lesson reinforcement. As Alabi (2024) observes, visual and interactive digital modalities, such as videos, infographics, and structured digital tools, support memory retention and deepen understanding by translating abstract concepts into concrete representations. However, maximizing the cognitive benefits of these visual tools depends heavily on active facilitation. This perspective is strongly reinforced by Courage and Troseth (2016), who emphasize that co-viewing and active adult scaffolding optimize children's learning potential. Whether in the classroom or at home, young learners benefit most from technology when adults actively participate—guiding focus, interpreting content, and extending digital experiences into real-world, meaningful learning contexts.

Cross-Strand Comparison: Benefits vs. Developmental Risks

While technology offers significant academic gains, the qualitative data presents a cautionary expansion to the quantitative success. Although vocabulary gains were high ($M=4.23$), Narrative Skills ($M=3.99$) and Phonological Awareness ($M=3.98$) showed lower means and higher variability. The qualitative data explains this variability through concerns about shortened attention spans and irritability. AT1 noted that fast-paced digital content promotes “*short bursts of attention*,” and CT4 warned that “*too much screen time... can affect the performance inside the classroom*”. Furthermore, AP4 observed that her child “*no longer socializes with her friends or family members*” due to screen use.

The divergence in literacy scores (high vocabulary vs. lower narrative skills) suggests that while screens are excellent for basic word recognition, they may hinder the sustained attention required for complex cognitive tasks. The qualitative reports of “late reactions” and “irritability” provide the behavioral evidence for why some literacy domains show less consistent progress than others.

This empirical tension directly reflects the framework outlined by Clemente-Suárez et al. (2024), who weigh the potential of digital devices to enhance information processing against significant developmental risks—specifically cognitive overload, diminished attention spans, and impaired social skills. Crucially, Clemente-Suárez et al. stress that avoiding these pitfalls requires structured digital engagement and parental guidance, validating participants' concerns that screen media must be carefully managed to support, rather than hinder, holistic child development.

The value of intentional, structured technology is further illuminated by Tsayang et al. (2020), who report that interactive tools, such as SMART boards, create dynamic learning experiences that enhance student motivation, active participation, and academic achievement. When synthesized with the present study, Tsayang et al.'s findings illustrate that technology's impact is not inherently negative; rather, the key lies in shifting from passive, high-velocity screen consumption to structured, interactive platforms. By pairing interactive educational tools (Tsayang et al., 2020) with active adult mediation (Clemente-Suárez et al., 2024), early childhood educators can harness digital benefits for foundational literacy while safeguarding children against attention fatigue and social isolation.

The Joint Display Table for Objective 1 reveals a robust convergence between quantitative statistical data and qualitative participant insights, where the “Strongly Agree” rating for Early Vocabulary ($M=4.23$) and high agreement for Alphabet Knowledge ($M=4.16$) are directly supported by accounts of children learning effectively through nursery rhymes and “ABC games”. While there is strong consensus on the strategy of providing a range of technology tools ($M=4.00$), the “Neutral” stance toward individual device provision ($M=3.36$) is explained by qualitative concerns regarding shortened attention spans, irritability, and reduced social interaction. This synthesis highlights a complementarity between the highest-rated equity strategy, continuous technical support for educators ($M=4.16$), and qualitative themes emphasizing adult mediation, confirming that stakeholders believe technology is integrated most effectively when it is curriculum-embedded ($M=4.09$) and guided by a technologically competent adult. Ultimately, the meta-inference suggests that successful integration is achieved through a hybrid ecosystem of varied devices—such as tablets for interactive apps and TVs for animated content—that stimulate multi-sensory learning styles while remaining developmentally grounded.

Table 3. *Integration of Quantitative and Qualitative Findings for Objective 1*

Research Domain	Quantitative Finding (Mean/Descriptive)	Qualitative Theme / Response	Meta-Inference (Integration)
Tool Accessibility	Range of tools for styles (M=4.00, Agree); 1:1 devices (M=3.36, Neutral)	Use of phones, tablets, and TV for "personalized and flexible" learning (AP1, BP15)	Convergence: Stakeholders prefer a variety of tools over high-cost 1:1 hardware to maintain flexibility and limit screen risks.
Language & Literacy	Early Vocabulary (M=4.23, Strongly Agree); Alphabet Knowledge (M=4.16)	Nursery rhymes and videos help "learning the alphabet easily" (AP10, BP2)	Complementarity: Sensory-rich multimedia is the most effective vehicle for foundational literacy and word acquisition.
Interactive Learning	Embedding tech in curriculum (M=4.09, Agree)	Use of specific apps like Khan Academy and "gamified applications" (CT5, AT1)	Expansion: Quantitative curriculum support is driven by the perceived effectiveness of interactive, "hands-on" digital games.
Adult Mediation	Technical support for teachers (M=4.16, Highest Agreement)	Teachers must be "mindful of students' limitations" and "guide every child" (BT2, BP17)	Convergence: Effective integration is defined not by hardware availability but by the competency and mediation of adults.
Developmental Balance	Narrative Skills (M=3.99, Lower Mean/Higher SD)	Screens lead to "shortened attention span" and "reduced social interaction" (AT1, AP4)	Divergence: High engagement in vocabulary is offset by qualitative concerns that overstimulation hinders complex cognitive and social skills.

The integrated findings for Objective 1 demonstrate that the most effective integration of technology in early childhood education is multi-modal, educator-led, and curriculum-embedded. While digital tools significantly enhance foundational literacy and vocabulary through visual and auditory stimulation, their success is highly contingent on the quality of adult mediation. Stakeholders prioritize systemic, human-centered strategies, such as continuous teacher training and curriculum integration, over the mere provision of hardware. Furthermore, the study highlights a critical need for balance; while technology offers clear academic gains, unregulated use presents risks to a child's attention span and social-emotional development. Ultimately, equitable and effective technology integration is achieved by empowering a technologically competent workforce capable of balancing digital engagement with essential non-screen, interactive learning experiences.

Impact of Educational Apps and Digital Tools on Young Children's Language and Literacy Skills

Educational apps and digital tools exert a significant and multi-faceted influence on young children's language and literacy development, demonstrating high effectiveness in rote recognition but showing limitations in complex cognitive tasks. Research indicates that these tools are most successful in promoting early vocabulary acquisition (recorded as the highest mean score among language skills) and alphabet knowledge, largely due to the multi-sensory nature of modern applications that utilize synchronized visuals, sound, and repetition. Interactive features such as letter-tracing and digital e-books with read-along functions serve as "bridge-builders" for foundational concepts, allowing children to learn "easily" through playful engagement.

However, the impact of technology is less consistent regarding phonological awareness and narrative skills, where higher variability in developmental outcomes is observed. Qualitative feedback suggests that while digital platforms provide high engagement for isolated exercises, they can also lead to shortened attention spans, "late reactions," and difficulty following instructions during more complex tasks. Consequently, the source material emphasizes that digital tools are most impactful when they serve as a complement to teacher-led instruction rather than a replacement, highlighting that their success is contingent upon active adult mediation and intentional pedagogical design.

Impact of Technology on the Language Skills of Young Children

Table 4. *Language Skills*

Language Skills	Mean	SD	Descriptive Equivalent
Phonological Awareness	4.03	0.6292	Agree
Early Vocabulary	4.23	0.6515	Strongly Agree
Narrative Skills	3.99	0.7879	Agree

Technology is perceived as particularly effective in the domain of vocabulary acquisition, largely driven by the multi-sensory nature of modern applications. In quantitative findings, early vocabulary development recorded the highest mean score among all evaluated language skills ($M = 4.23$, $SD = 0.6515$), which translates to an overall rating of "Strongly Agree." This reflects a robust consensus among participants that digital platforms exert a highly positive influence on early word acquisition and recognition.

Qualitative feedback from parents and teachers strongly enriches these statistical findings, attributing the high scores to interactive platforms and nursery rhymes that encourage imitation. For example, one participant observed that dynamic content "helps in learning the alphabet easily by watching nursery rhymes" (AP10), while another shared that "YouTube for Kids has educational videos that keep my child interested" (BP2). Teachers similarly cited reliance on diverse tools, pointing to apps like "Duolingo... Khan Academy for Math... Khan Academy Kids... YouTube Kids" (BT2).

Ultimately, a strong convergence exists between the quantitative results ($M = 4.23$) and qualitative accounts of children learning "easily" through digital media. The resulting meta-inference suggests that the dynamic use of visuals, sound, and repetition in digital platforms facilitates faster word recognition than traditional methods alone. This finding directly aligns with research by Liu et al. (2024), who noted that digital technologies embedded with animations and questions effectively promote vocabulary acquisition. Theoretically, this reflects Gardner's verbal-linguistic and musical intelligences, as children process and engage with language through synchronized rhythmic and visual channels.

Impact of Technology on the Literacy Skills of Young Children

Table 5. Literacy Skills

Literacy Skills	Mean	SD	Descriptive Equivalent
Print Knowledge	4.03	0.7549	Agree
Alphabet Knowledge	4.16	0.7323	Agree
Phonological Awareness	3.98	0.8588	Agree

Digital tools serve as effective bridge-builders for foundational literacy concepts, particularly through interactive features such as letter-tracing and e-book read-alongs. In the quantitative evaluation, participants indicated positive outcomes for both alphabet knowledge ($M = 4.16$, $SD = 0.7323$) and print knowledge ($M = 4.03$, $SD = 0.7549$), both falling within the "Agree" benchmark. Print knowledge in particular was strongly linked to digital storybooks and interactive e-books equipped with read-along functions that guide early readers visually and audibly.

Qualitative feedback enriches these statistical findings, as parents and educators highlighted specific applications providing the hands-on experience necessary for literacy growth. Participants cited noticeable progress in early reading ability, with one parent sharing that "the child can now read... is more knowledgeable than before" (AP13). Respondents frequently attributed these advances to tailored applications, mentioning "Kids' apps... ABC games apps... English for Kids..." (AP7, AP12) along with "digital games for hands-on learning, audiobooks, and interactive e-books" (CT4).

Synthesizing these data sources reveals a strong complementarity: while quantitative ratings validate high overall effectiveness, qualitative accounts explicitly identify interactive ABC games and e-books as the specific catalysts driving these gains. The resulting meta-inference suggests that playful digital interaction directly boosts early print and letter familiarity. These outcomes align with findings by Neumann (2018), whose research demonstrated that iPad-based programs incorporating letter tracing and matching yielded significantly higher gains in letter-name and sound knowledge than traditional instruction alone. Theoretically, this underscores Constructivist Learning Theory, demonstrating how young learners actively construct literacy understanding through interactive, playful engagement with digital media.

While technology effectively supports basic word recognition, more complex cognitive tasks demonstrate greater variability and require higher levels of adult mediation. Quantitatively, phonological awareness ($M = 4.03$ in Table 3; $M = 3.98$ in Table 4) and narrative skills ($M = 3.99$) recorded the lowest mean scores among the language domains, accompanied by notably higher standard deviations ($SD = 0.8588$ for phonological awareness). This statistical spread highlights less consensus and greater variance in children's developmental outcomes when

engaging with digital media for advanced skills.

Qualitative feedback offers crucial context for this variability, pointing to behavioral disruptions and reduced engagement that can hinder complex cognitive tasks. Parents and educators observed that digital screens often compromise sustained focus, noting that "screen-based activities often promote short bursts of attention... while in non-screen activities, children have a longer attention span" (AT1). Others similarly reported that "attention is better without [screen]... It is hard to follow instructions" (CP29, CP30), with some specifically citing a "late reaction of the child" (CP26) during digital interaction.

These findings reveal a significant divergence between the high engagement observed in isolated vocabulary exercises and the qualitative reports of short attention spans during broader tasks. The resulting meta-inference suggests that while technology excels at rote word recognition, it can hinder the sustained focus required for complex narrative sequencing and phonological processing if used without structured guidance. This aligns with research by Verhoeven et al. (2020) and Liu et al. (2024), who emphasized that digital benefits materialize only when tools are embedded within a broader curriculum and supported by active educators. Theoretically, this underscores Bronfenbrenner's Ecological Systems Theory, illustrating how overexposure to rapid digital stimulation in the exosystem can disrupt cognitive functioning, attention, and responsiveness within the child's immediate classroom microsystem.

The following Joint Display Table facilitates a convergent integration of the study's findings regarding the impact of educational apps and digital tools on young children's language and literacy skills. This display explicitly links the quantitative statistical ratings—such as the "Strongly Agree" consensus on vocabulary development (M = 4.23) and high scores for alphabet knowledge (M = 4.16)—with qualitative evidence from parents and teachers that identifies specific catalysts like Khan Academy Kids, Duolingo, and nursery rhymes.

By presenting these datasets side-by-side, the table illustrates the complementarity between high-engagement digital tools and foundational literacy gains while highlighting a critical divergence in more complex domains. Specifically, it demonstrates how qualitative observations of "shortened attention spans" and "late reactions" provide a necessary behavioral explanation for the lower means and higher variability observed in narrative skills and phonological awareness. Ultimately, this display synthesizes these strands into unified meta-inferences, underscoring that while technology is a powerful aid for rote recognition, its effectiveness for complex cognitive development is contingent upon structured adult mediation and intentional pedagogical design.

Table 6. *Integration of Quantitative and Qualitative Findings for Objective 2*

Research Aspect	Quantitative Result (Mean/Equivalent)	Qualitative Theme/ Evidence	Meta-Inference (Unified Conclusion)
Vocabulary Development	M = 4.23 (Strongly Agree)	Reports of "learning alphabet easily" via nursery rhymes and YouTube Kids (AP10, BP2)	Convergence: Multi-sensory digital content is highly effective for rapid word acquisition and recognition.
Foundational Literacy	Alphabet (M=4.16); Print (M=4.03)	Use of "ABC games," "tracing," and "interactive e-books" (AP7, CT4, AP13)	Complementarity: Digital tools bridge traditional literacy gaps by providing interactive, self-paced "hands-on" practice.
Phonological & Narrative Skills	Narrative (M=3.99); Phonological (M=3.98)	Observations of "late reactions," "short bursts of attention," and "difficulty following instructions" (CP26, AT1)	Divergence: Lower scores in complex skills are explained by the cognitive overstimulation and attention deficits caused by rapid digital content.
Educator & Parent Role	Highest strategy agreement for "Continuous technical support" (M=4.16)	"Educators should strategize when to use tech" and "guide every child" (AP4, BP17)	Expansion: Technological effectiveness is not inherent in the tool but is contingent upon "active mediation" and structured curriculum integration.

The integrated analysis for Objective 2 concludes that educational apps and digital tools significantly enhance early vocabulary and foundational literacy through multi-sensory stimulation and interactive engagement. However, the study identifies a "cognitive ceiling" where the benefits of technology diminish for complex skills like phonological awareness and narrative storytelling due to observed decreases in attention span and delayed responsiveness. Digital tools are most impactful when they serve as complements to, rather than replacements

for, teacher-led instruction. The perceived success of these tools is strictly contingent upon a hybrid approach that balances high-engagement digital platforms with adult-mediated strategies to mitigate the risks of shortened attention spans and social-emotional irritability.

Potential Drawbacks of Excessive Screen Time on Attention Span and Social Interactions in Young Children

In the modern digital landscape, the rapid pace of media exposure is increasingly recognized as a primary driver behind declines in children's sustained focus and the displacement of essential human-to-human interactions. While digital tools can facilitate rote recognition skills, such as basic vocabulary acquisition, evidence suggests a "cognitive ceiling" where excessive screen time yields diminishing returns for more complex cognitive tasks. This shift is characterized by a transition from the deep engagement required for learning to "short bursts of attention" that hinder a child's ability to follow instructions or process narrative sequences.

The impact of unregulated screen use extends beyond cognitive strain into the realm of social-emotional development. Stakeholders express significant concern regarding the potential for social withdrawal, noting that children may become more responsive to digital screens than to their peers or family members. This interpersonal detachment directly challenges the foundations of collaborative learning and social meaning-making. Consequently, the following sections explore how these dual pressures of cognitive overstimulation and social displacement pose a significant threat to the holistic development of young learners.

Attention Span and Cognitive Engagement

The rapid pace of digital content is increasingly perceived as a primary driver behind declines in children's sustained focus during structured learning tasks. In the quantitative evaluation, while basic vocabulary recognition remains high, more complex cognitive skills demonstrated significant variability and lower average ratings. Specifically, narrative skills ($M = 3.99$, $SD = 0.7879$) and phonological awareness ($M = 3.98$, $SD = 0.8588$) recorded the lowest mean scores across the literacy domain. This statistical pattern points toward a potential "cognitive ceiling," suggesting that excessive digital media exposure yields diminishing returns for advanced language competencies.

Qualitative feedback directly contextualizes these lower quantitative scores, with educators and parents attributing focus challenges to fast-paced digital stimulation. Participants frequently noted that digital screens alter children's engagement habits, observing that "screen-based activities often promote short bursts of attention... while in non-screen activities, children have a longer attention span" (AT1). Others highlighted broader issues with instruction-following and hyper-fixation, noting that "attention is better without [screen]... It is hard to follow instructions" (CP29, CP30), while one parent described scenarios where her "daughter focuses on what she is watching that sometimes you cannot call her" (AP10).

These data points reveal a strong convergence between the statistical variability in complex literacy tasks and participant accounts of delayed responsiveness and instructional difficulties. The resulting meta-inference suggests that while excessive digital engagement favors rote recognition skills like vocabulary acquisition, it can undermine the sustained executive functioning required for deeper narrative sequencing and phonological processing. These findings align with Bronfenbrenner's Ecological Systems Theory, illustrating how overexposure to media in the exosystem can negatively affect cognitive functioning within the child's immediate classroom or home microsystem. Furthermore, this aligns with research by Muppalla et al. (2023), who corroborated that frequent media multitasking and high digital consumption are closely related to poorer executive functioning outcomes in early learners.

Social Interaction and the Risk of Withdrawal

Excessive technology use is increasingly perceived as a primary factor displacing the human-to-human interactions essential for healthy social development. Quantitatively, stakeholders expressed a hesitant "Neutral" stance regarding the provision of individual devices for every child ($M = 3.36$, $SD = 1.0035$). Representing the lowest-rated strategy within the digital equity domain, this score reflects widespread statistical reluctance toward unrestricted personal screen access and 1:1 hardware deployment.

Qualitative accounts directly explain this numerical neutrality, pointing to deep-seated anxieties surrounding social withdrawal and diminished face-to-face communication. Participants highlighted alarming patterns of interpersonal detachment, with one parent noting that her child "no longer socializes with her friends or family

members" (AP4). Educators echoed these concerns, observing that "children are more responsive to screens than to people" (CT4), while another respondent noted that screen-absorbed children "dislike being interrupted" and routinely "avoid playmates" (BP21).

These findings reveal clear complementarity between datasets: the quantitative neutral rating serves as the direct statistical manifestation of qualitative fears regarding social displacement. The resulting meta-inference indicates that stakeholders prioritize structured, curriculum-embedded technology over individual device ownership specifically to mitigate the risk of children becoming more responsive to screens than to peers. This dynamic directly challenges the principles of Constructivism, which emphasize collaborative peer interaction as a foundation for meaning-making. Furthermore, these empirical observations align with research by Gath et al. (2023), who demonstrated that children with high daily screen use score significantly lower in parent-child closeness and overall language production.

Emotional Instability and Behavioral Mimicry

The lack of emotional scaffolding in many digital platforms is increasingly linked to heightened irritability and the passive imitation of inappropriate behaviors in early learners. From a quantitative perspective, high standard deviations in key literacy domains—such as phonological awareness ($SD = 0.8588$) and narrative skills ($SD = 0.7879$)—suggest that children's performance remains highly inconsistent across digital contexts. This statistical variance indicates that non-academic, external factors may be interrupting stable learning and skill application during screen-based tasks.

Qualitative feedback provides essential context for this statistical inconsistency, identifying emotional dysregulation and negative behavioral shifts as major disruptions to learning routines. Parents and educators routinely reported sudden mood changes following screen use, noting that children "are always grumpy after using phones" (BP23) or highlighting cases where a child "became rude... there was a change in attitude" (CP30). Furthermore, participants expressed deep concern over unmonitored behavioral mimicry, observing that "there are apps where people use profanity... and he imitates them" (CP32), with another parent adding, "like my child, he becomes wild/aggressive" (CP38).

These strands reveal a clear expansion across datasets: while the quantitative data documents inconsistent literacy progress, the qualitative accounts isolate emotional irritability and aggressive mimicry as the primary behavioral barriers to academic stability. The resulting meta-inference suggests that unregulated digital exposure undermines Gardner's intrapersonal intelligence by disrupting a child's developing emotional self-control. These findings align directly with research by İnanlı and Metindoğan (2023), who found that preschool aggression increases alongside screen and video game time, confirming children's vulnerability to modeling digital behaviors. Similarly, Choi et al. (2021) linked excessive smartphone use to heightened emotional difficulties, highlighting the need for active behavioral monitoring alongside digital media integration.

The following Joint Display Table provides a convergent integration of the study's findings regarding the adverse effects of unregulated digital exposure on young learners. This synthesis achieves integration validity by triangulating qualitative themes of behavioral shifts, such as shortened attention spans, emotional instability, and social withdrawal, with quantitative data regarding literacy gains and technological strategies. By presenting these datasets side-by-side, the table illustrates how qualitative observations of "shortened attention spans" and "late reactions" offer a direct behavioral explanation for the quantitative results where Narrative Skills ($M = 3.99$) and Phonological Awareness ($M = 3.98$) yielded lower means and higher variability than basic vocabulary recognition.

Furthermore, the display highlights a critical complementarity between the qualitative reports of children becoming "more responsive to screens than to people" and the quantitative "Neutral" stance ($M = 3.36$) stakeholders took regarding the provision of individual devices for every child. Ultimately, this integration facilitates the development of meta-inferences regarding the "cognitive ceiling" of technology, where the high effectiveness for rote acquisition is offset by risks of cognitive overstimulation and social-emotional displacement if digital engagement is not balanced with non-screen, educator-led interactions.

Table 7. Integration of Quantitative and Qualitative Findings for Objective 3

Drawback Theme	Quantitative Finding (Context)	Qualitative Evidence (Response)	Meta-Inference (Unified Conclusion)
Cognitive Strain	Lower scores in Narrative Skills (M=3.99) vs Vocabulary (M=4.23)	"Short bursts of attention" and "late reactions" (AT1, CP26)	Divergence: High engagement in rote tasks masks a decline in the sustained focus needed for complex cognitive tasks.
Social Withdrawal	Lowest agreement for 1:1 Individual Devices (M=3.36)	"No longer socializes with friends or family" (AP4)	Convergence: Stakeholders resist individual devices to prevent the displacement of human interaction by screen media.
Emotional Dysregulation	High SD (0.8588) in Phonological Awareness indicates instability	"Always grumpy" and "rude" changes in attitude (BP23, CP30)	Expansion: Inconsistent academic gains are linked to the irritability and lack of emotional scaffolding in digital environments.
Behavioral Mimicry	Preference for educator-led curriculum integration (M=4.09)	Imitation of "profanity" and "aggression" from apps (CP32, CP38)	Complementarity: Educators favor curriculum-embedded tech to filter the "exosystem" influences that lead to inappropriate behavior mimicry.

The integrated analysis for Objective 3 reveals that the potential drawbacks of excessive screen time, specifically shortened attention spans, emotional instability, and social withdrawal, pose a significant threat to holistic development. While quantitative data shows that technology is a powerful tool for basic recognition, the qualitative findings warn that this success is "contingent on avoiding the irritability and social withdrawal associated with unregulated use". The most effective integration strategy is not the provision of hardware, but a competent, well-supported teaching workforce that can balance digital engagement with non-screen activities (like storytelling and outdoor play), which are observed to promote "longer focus" and "brighter moods". Successful early childhood education must therefore prioritize human-centered mediation to protect children from the cognitive and social-emotional risks of the digital ecosystem.

Strategies for Ensuring Equitable Access to Technology in Early Childhood Education Programs

Achieving digital equity in early childhood education (ECE) requires a fundamental shift from simple hardware distribution toward human-centered capacity building. Research indicates that providing continuous technical support and structured training for educators is the most critical strategy for success, as meaningful technology integration depends on the pedagogical expertise and active mediation of the workforce. Rather than prioritizing universal 1:1 device deployment, which stakeholders view with caution due to developmental risks like social withdrawal and cognitive strain, equity is best realized by embedding digital tools into the core curriculum and leveraging community partnerships. This holistic approach extends to the home environment through parental training and inclusive accessibility features, reinforcing the connection between the home and school microsystems. Ultimately, digital equity is defined by the quality of adult mediation over the quantity of hardware, ensuring that technology use remains developmentally grounded and inclusive for all young learners.

Table 8. Strategies to Ensure Equitable Access to Technology Resources for All Children in Early Childhood Education Programs

Strategies	Mean	SD	Descriptive Equivalent
1. Ensure that all children in early childhood programs have access to individual devices, such as tablets or laptops, to support personalized learning.	3.36	1.0035	Neutral
2. Prioritize providing reliable internet access for all early childhood education programs to enable consistent use of digital resources.	3.64	1.0259	Agree
3. Implement training programs for educators to help them effectively integrate technology into their teaching and support diverse learning needs.	4.13	0.8146	Agree
4. Develop partnerships with community organizations to secure technology resources for underserved children in early childhood education.	4.02	0.8115	Agree
5. Advocate for increased funding to ensure that all children have equitable access to technology resources.	3.89	0.8848	Agree
6. Engage parents in technology training sessions to promote equitable access and support their children's learning at home.	4.02	0.8657	Agree
7. Provide a range of technology tools that cater to different learning styles to ensure equitable access for all children in early childhood education.	4.00	0.8528	Agree
8. Incorporate technology resources with accessibility features to support children with diverse needs.	4.02	0.8115	Agree
9. Embed technology into the curriculum to enhance learning experiences for all children.	4.09	0.8481	Agree

10. Provide Continuous technical support for educators to help them effectively use technology in their teaching.	4.16	0.7965	Agree
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Prioritizing Human-Centered Capacity Building: Technical Support and Training

Stakeholders strongly perceive that digital equity is achieved through a competent, well-supported workforce rather than through simple hardware provision. In the quantitative findings, the strategy receiving the highest level of overall agreement was providing continuous technical support for educators ($M = 4.16$, $SD = 0.7965$). This was followed closely by implementing structured training programs for teachers ($M = 4.13$, $SD = 0.8146$). These top-tier ratings reflect a robust statistical consensus that empowering educators with ongoing professional development is the cornerstone of effective technology integration in early childhood settings.

Qualitative feedback enriches these numerical findings, as participants emphasized that access to technology must be meaningful, requiring teachers to possess deep pedagogical and technological expertise. Stakeholders highlighted the need for deliberate teacher guidance, noting that "educators should be more knowledgeable about different apps... and should be mindful of the students' limitations" (BT2). Furthermore, parents underscored the proactive role educators must play in shaping children's digital habits, stressing the importance of efforts to "guide every child on the proper way to use technology" (BP17).

These empirical strands reveal a clear convergence between the highest quantitative priorities ($M = 4.16$ and $M = 4.13$) and qualitative demands for enhanced teacher capacity. The resulting meta-inference suggests that digital equity is fundamentally a human-centric issue, where simply distributing devices without continuous technical and pedagogical support proves ineffective. These results align with research by Theodorio (2024), who argued that successful technology integration relies on proactive technical assistance to foster confident, innovative instruction. Theoretically, this dynamic reflects the Pedagogical Knowledge (PK) dimension of the Technological Pedagogical Content Knowledge (TPACK) framework, emphasizing the educator's vital role in scaffolding responsible, age-appropriate digital engagement.

Strategic Curriculum and Community Integration

Integrating technology directly into existing educational frameworks is widely perceived as a far more equitable approach than treating digital tools as standalone or isolated activities. Quantitatively, participants assigned strong endorsement to strategies that embed technology into the core curriculum ($M = 4.09$, $SD = 0.8481$) and leverage broader community partnerships ($M = 4.02$). These high ratings demonstrate a clear consensus that digital media achieves its greatest developmental value when thoughtfully aligned with established learning objectives and supported by local community structures.

Qualitative insights enrich this statistical consensus by clarifying that "embedding" technology requires using digital tools to reinforce—rather than replace—traditional instructional methods. Stakeholders emphasized the importance of intentional pedagogical planning, with one participant advocating that "educators should strategize when to use technology. Perhaps once a week, or they can combine traditional learning methods..." (AP4). Others suggested practical, shared classroom applications, noting that media "can be shown on TV... to present the learning" (CP33) as a collective instruction tool rather than an isolated personal device exercise.

These empirical strands reveal clear complementarity across the findings: the quantitative consensus supporting curriculum integration is practically operationalized through qualitative strategies centered on blended instruction and deliberate usage. The resulting meta-inference indicates that equitable digital access is most effectively realized within structured, educator-led environments that utilize community resources to bridge equity gaps in underserved areas. These findings align with reporting by the OECD (2023), which underscores that the early childhood workforce is central to advancing digitalization, even while noting that specialized technology training often remains limited in initial teacher preparation programs.

The 1:1 Device Debate: Hardware vs. Developmental Appropriateness

A significant area of divergence within the findings surrounds the provision of individual hardware for young children versus age-appropriate, collective digital engagement. In the quantitative evaluation, providing individual devices received the lowest rating among all proposed equity strategies ($M = 3.36$, $SD = 1.0035$), translating to a "Neutral" benchmark. In stark contrast, stakeholders expressed strong support for offering a

diverse range of technological tools tailored to different learning styles ($M = 4.00$). This statistical distinction highlights a clear reluctance toward universal 1:1 device deployment in early childhood environments.

Qualitative accounts offer crucial behavioral context for this statistical hesitation, explicitly citing the risks associated with unmediated, individual screen exposure. Participants frequently highlighted developmental drawbacks such as social detachment and shortened focus, with one parent observing that her daughter "no longer socializes with her friends or family members" (AP4). Educators similarly warned that "too much screen time can lead to shorter attention span..." (CT4). To address these concerns without discarding digital tools entirely, respondents emphasized structured integration, suggesting that educators focus on "implementing personalized learning strategies... utilizing adaptive platforms... while also fostering digital literacy" (BP15).

These data point reveals a notable divergence between general support for educational technology and specific pushback against individual hardware allocation. The resulting meta-inference suggests that stakeholders strongly favor a hybrid digital ecosystem, where shared, mediated tools such as classroom tablets and smart displays are guided by adults, over unrestricted individual device access, which is widely linked to social withdrawal and cognitive strain. These findings align with conclusions drawn by Clemente-Suárez et al. (2024), who argue that educational technology implementation must remain balanced and explicitly responsive to young learners' developmental needs, rather than prioritizing pure hardware distribution.

Family Engagement and Inclusive Accessibility

Equitable access to educational technology extends beyond classroom walls and into the home environment, primarily facilitated through structured parental training and inclusive assistive features. In the quantitative evaluation, strategies focused on engaging parents through specialized training sessions ($M = 4.02$) and incorporating accessibility features for learners with diverse needs ($M = 4.02$) received robust and equal support. These strong statistical ratings demonstrate a widespread consensus that achieving digital equity requires extending technological support and inclusive design directly into children's primary home environments.

Qualitative feedback offers crucial context for these numerical findings, illustrating how specific digital platforms and assistive features facilitate home-school collaboration and inclusive learning. Participants highlighted practical tools for bridging the gap between educators and families, citing platforms like "Google Classroom – for parent/teacher communication" (BP21) alongside creative applications such as Canva for tailored instruction. Parents and educators further emphasized the necessity of "helping children through assistive technologies... and ethical awareness" (BP15), indicating that inclusive access requires both functional adaptations and active guidance in digital citizenship.

These empirical strands demonstrate a clear expansion across datasets, as qualitative examples of specific communication and learning tools provide practical depth to the quantitative support for parent engagement and accessibility. The resulting meta-inference highlights that true digital equity requires a technologically supported connection between the home and school environments. Theoretically, this reinforces Bronfenbrenner's Ecological Systems Theory, illustrating how seamless communication and shared digital practices within the mesosystem, connecting the home and school microsystems, foster a cohesive and supportive developmental environment for young learners.

The following Joint Display Table provides a convergent integration of the study's findings regarding strategies for ensuring equitable access to technology. This display achieves integration validity by triangulating the quantitative hierarchy of stakeholder priorities with qualitative insights that explain the pedagogical rationale behind these choices. The table explicitly links high-scoring quantitative strategies – such as providing continuous technical support for educators ($M = 4.16$) and implementing teacher training ($M = 4.13$) – with qualitative themes emphasizing that "access" is only meaningful when mediated by a technologically competent and "mindful" educator.

Furthermore, the display illustrates a significant divergence between the general support for technology and the specific "Neutral" stance ($M = 3.36$) toward the provision of individual devices for every child. By presenting this alongside qualitative evidence regarding shortened attention spans, irritability, and reduced social interaction, the table provides a behavioral explanation for why stakeholders prioritize curriculum-embedded tech ($M = 4.09$) over unrestricted hardware access. Ultimately, this integration facilitates a unified meta-inference: stakeholders

perceive digital equity as a human-centered capacity building issue rather than a hardware distribution challenge, where true access is defined by a well-supported workforce capable of guiding responsible and developmentally appropriate technology use.

Table 9. *Integration of Quantitative and Qualitative Findings for Objective 4*

Strategy Domain	Quantitative Finding (Mean/Equivalent)	Qualitative Theme / Evidence	Meta-Inference (Unified Conclusion)
Workforce Capacity	Technical Support (M=4.16); Teacher Training (M=4.13)	Educators must be "more knowledgeable" and "guide every child" (BT2, BP17)	Convergence: Equity is primarily achieved through professional competency rather than hardware density.
Curricular Integration	Curriculum Embedding (M=4.09, Agree)	Educators should "strategize" and combine tech with traditional methods (AP4)	Complementarity: Technology is integrated most equitably when it reinforces existing pedagogical goals.
Access Methods	1:1 Devices (M=3.36, Neutral); Range of tools (M=4.00, Agree)	Use of varied tools (TV, tablets) for "personalized" learning (BP15, AP1)	Divergence/Expansion: Stakeholders resist individual devices due to social/cognitive risks, preferring a varied tool ecosystem.
Community & Family	Parent Training (M=4.02); Partnerships (M=4.02)	Use of Google Classroom for communication (BP21)	Convergence: Digital equity requires an inclusive community approach that extends teacher knowledge to parents.

The integrated analysis for Objective 4 establishes that equitable access in early childhood education is defined by quality of mediation over quantity of hardware. The findings demonstrate a clear consensus: stakeholders prioritize systemic, human-centered strategies, specifically continuous professional development and strategic curriculum integration, as the most effective means of achieving digital equity. Access is only "equitable" when it is developmentally grounded and mediated by technologically competent adults. By favoring a hybrid ecosystem of shared tools over universal 1:1 device provision, stakeholders aim to harness the academic benefits of technology while actively mitigating the risks of social withdrawal and cognitive overstimulation.

Conclusion

The study concludes that technology in early childhood education (ECE) functions not as an autonomous driver of achievement, but as a mediated vehicle whose efficacy is strictly contingent upon developmental safeguards and adult-led pedagogy. The overall meta-inference generated from the integrated evidence reveals a "cognitive ceiling" for digital tools: while quantitative data indicates a "Strongly Agree" impact on rote foundational skills like early vocabulary (M = 4.23) and alphabet knowledge (M = 4.16), this success is qualitatively validated by children's engagement with specific visual-auditory stimuli such as YouTube Kids and interactive "ABC games". However, the statistical variability and lower means in complex domains like narrative skills (M = 3.99) and phonological awareness (M = 3.98) are directly enriched by qualitative "warnings" regarding shortened attention spans, irritability, and late reactions caused by rapid digital overstimulation. Methodologically, the study demonstrates the rigor of mixed-methods triangulation, where stakeholder "neutrality" (M = 3.36) regarding 1:1 hardware provision is not merely a statistical middle ground but a calculated caution rooted in the observed qualitative risks of social withdrawal and behavioral mimicry, specifically the imitation of aggression or profanity, found in unregulated digital "exosystems". Theoretically, these findings advance Bronfenbrenner's Ecological Systems Theory by illustrating how digital influences in the exosystem can disrupt the microsystem of the classroom, and they reinforce Gardner's Multiple Intelligences by showing that digital tools are most effective when they cater to visual and auditory modalities under active adult guidance. Practically, this synthesized evidence indicates that digital equity is fundamentally a human-centered capacity building issue, prioritizing continuous technical support (M = 4.16) and teacher training (M = 4.13), rather than a hardware distribution challenge.

In light of these integrated findings, it is recommended that educational stakeholders move beyond simple hardware procurement to prioritize systemic professional development that enhances the pedagogical-technological knowledge of both teachers and parents. Schools should implement a "hybrid ecosystem" model that embeds diverse, shared tools, such as smart TVs and tablets, strategically into the curriculum (M = 4.09) to reinforce core lessons while maintaining a purposeful balance with traditional, non-screen activities like storytelling and outdoor play, which were observed to promote longer attention spans and "brighter moods". To ensure equitable access, funding and community partnerships should be directed toward establishing reliable internet infrastructure and continuous technical support to bridge existing digital disparities, rather than focusing

solely on 1:1 device provision. Finally, the selection of digital tools must shift toward curated, multimodal storytelling environments and interactive platforms like Khan Academy Kids, Duolingo, or TinyTap that provide the necessary emotional scaffolding and instructional feedback. This approach ensures that the linguistic benefits of technology are sustained while proactively mitigating the risks of social-emotional displacement and cognitive strain identified by stakeholders.

Contributions of Authors

All authors contributed equally to the conceptualization, design, data collection, analysis, interpretation of findings, and preparation of the manuscript. All authors reviewed and approved the final version for publication.

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Conflict of Interests

The authors declare that there are no conflicts of interest regarding the publication of this study.

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