Digital Tools in Early Childhood Education: Assessing the Effectiveness of Technology-Enhanced Instruction for Struggling Learners

ISIAKA OLAYINKA BUSARI (PH.D.)[1], EFETURI HAPPINESS[2], OJO BABATUNDE AYO YUSUF[3]
[1]*Department of STEM Education, College of Education, University of Kentucky, Lexington, USA*
[2]*Department of Interdisciplinary Early Childhood Education, University of Kentucky, Lexington, USA*
[3]*Department of Science Education, Faculty of Education, Federal University, Oye Ekiti, Nigeria*

Abstract- ***The integration of digital technologies in early childhood education has emerged as a critical area of research, particularly concerning its effectiveness for struggling learners aged 3-8 years. This comprehensive review examines the current landscape of technology-enhanced instruction in the United States, analyzing empirical evidence from 2018-2023 regarding the impact of digital tools on academic outcomes, engagement, and developmental progress among at-risk learners. Through systematic analysis of 127 peer-reviewed studies and longitudinal data from 15 states, this research reveals significant positive correlations between structured digital interventions and improved learning outcomes in literacy, numeracy, and social-emotional development. The findings indicate that when implemented adequately with appropriate pedagogical frameworks, digital tools can provide personalized learning experiences that address individual learning differences while maintaining developmentally appropriate practices. However, the research also highlights critical considerations regarding screen time limits, teacher training requirements, and equity concerns that must be addressed for effective implementation.***

Indexed Terms- ***Early Childhood Education, Digital Tools, Struggling Learners, Technology-Enhanced Instruction, Educational Technology, Developmental Appropriateness***

I. INTRODUCTION

Early childhood education (ECE) in the United States serves millions of children annually through programs such as pre-kindergarten, Head Start, and Early Head Start (National Center for Education Statistics, 2023). A significant proportion of these children, estimated between 25% and 30%, exhibit early signs of learning challenges, developmental delays, or socio-emotional vulnerabilities that place them at risk for long-term academic difficulties (Li et al., 2023; Wilcox et al., 2021). As the integration of digital tools in early learning environments continues to expand, there is growing interest in understanding how technology-enhanced instruction can support struggling learners in these formative years (Paul et al., 2023; Su et al., 2023).

The COVID-19 pandemic accelerated the adoption of educational technology, including in early childhood settings, where the shift to remote and hybrid modalities revealed both new opportunities and equity-related challenges (Hewi et al., 2022; Emem, 2023). While many educators initially adopted digital tools out of necessity, their ongoing use has prompted critical questions about effectiveness, accessibility, and developmental appropriateness, especially for children with diverse learning needs (McCoy et al., 2017; Rad et al., 2022).

The theoretical foundation for integrating technology in early childhood education draws from several established learning frameworks. Vygotsky's Zone of Proximal Development emphasizes the role of scaffolding in bridging the gap between a child's current ability and their learning potential with guidance and support (Crane-Deklerk, 2020). Likewise, Universal Design for Learning (UDL) provides a structure for creating inclusive and flexible learning environments that respond to individual differences in how young children perceive, engage with, and express learning (CAST, 2018; Wilcox et al., 2021).

This article critically reviews recent empirical studies on digital tools in early childhood education, focusing on their effectiveness in improving outcomes for struggling learners. The review synthesizes findings from studies published between 2018 and 2023, emphasizing cognitive development, literacy acquisition, numeracy, social-emotional learning, and student engagement. Specific attention is given to technology-mediated interventions such as adaptive games, digital storytelling, and multimodal instructional apps that are increasingly used to personalize learning and address early achievement gaps (Sella et al., 2017; Rahiem, 2021; Furlong et al., 2021).

II. LITERATURE REVIEW

2.1 Historical Context and Evolution

The integration of technology in early childhood education (ECE) has evolved significantly, moving from basic exposure to more immersive and pedagogically informed applications. In its early stages, technology use in ECE primarily featured drill-and-practice software and basic literacy games that lacked interactivity and developmental appropriateness. These early tools often reinforced a behaviorist approach, focusing on rote memorization rather than conceptual understanding (Paul et al., 2023).

Recent developments reflect a paradigm shift toward constructivist and learner-centered models of technology use. Adopting tablets, interactive apps, and cloud-based platforms has introduced features such as adaptive assessments, gamified learning, and personalized content delivery (Eliasson et al., 2022). The proliferation of mobile devices, particularly during the COVID-19 pandemic, catalyzed the rapid expansion of digital learning environments for young children (Hewi et al., 2022). Researchers have also noted the increasing presence of augmented reality, multimodal storytelling, and AI-enhanced systems in preschool and kindergarten classrooms, signaling a move toward more dynamic and individualized learning tools (Su et al., 2023; Furlong et al., 2021).

2.2 Theoretical Frameworks

Digital tools in early childhood education are grounded in several interrelated theoretical frameworks. Constructivist theories, particularly those developed by Piaget, advocate for learning through exploration, discovery, and hands-on engagement. Modern digital tools support this approach by offering interactive simulations, creative expression platforms, and exploratory learning environments that provide immediate feedback and multiple representational formats (Crane-Deklerk, 2020).

Social constructivism, informed by Vygotsky's Zone of Proximal Development, posits that learning occurs most effectively when children engage with more knowledgeable peers or adults within meaningful contexts. Digital platforms increasingly incorporate collaborative and communicative elements, such as co-playing games, virtual peer interactions, and culturally responsive content, that align with Vygotsky's emphasis on social mediation (CAST, 2018; Rahiem, 2021).

The Technology Acceptance Model (TAM) has also been adapted to early childhood education settings to explore how educators perceive and adopt digital tools. Rad et al. (2022) applied TAM to preschool contexts and identified perceived usefulness, ease of use, institutional support, and teacher efficacy as key factors influencing successful technology integration. Their findings underscore the importance of training, technical support, and alignment with curriculum goals in ensuring meaningful technology use in the classroom.

2.3 Current Research Landscape

Recent empirical studies and systematic reviews highlight the expanding evidence base for technology-enhanced instruction in early childhood education. Paul et al. (2023) synthesized findings from multiple studies and concluded that digital tools can significantly support developmental outcomes, particularly when used with intentional pedagogy. Similarly, Su et al. (2023) reported that technology interventions positively affect literacy, numeracy, and cognitive development when tailored to children's needs.

One of the most consistent findings in the literature is the effectiveness of personalized and adaptive learning platforms. Tools that adjust task difficulty, pacing, and scaffolding based on real-time student responses have

demonstrated strong outcomes, especially for learners at risk of falling behind (Sella et al., 2017). Adaptive games like *The Number Race* have shown statistically significant improvements in early numeracy among preschoolers, particularly when paired with ongoing teacher support (Sella et al., 2017; Furlong et al., 2021).

Another key theme is multimodal learning experiences, which combine auditory, visual, and kinesthetic inputs. These approaches are efficient for young children with diverse learning preferences or delays. For example, Rahiem (2021) found that digital storytelling enhances engagement, narrative comprehension, and vocabulary acquisition in preschoolers, including those with emerging literacy challenges.

Data-informed instructional decision-making is an additional benefit of digital tools. Many platforms now include built-in analytics that track progress, identify areas of need, and inform differentiated instruction (Wilcox et al., 2021; Eliasson et al., 2022). These capabilities benefit inclusive classrooms where teachers must monitor varied developmental trajectories and provide individualized supports.

Finally, educators' perceptions also influence implementation. Teachers recognize that while digital tools can enhance motivation and participation, they raise concerns about screen time, attention spans, and emotional regulation (Ventouris et al., 2021). These findings reinforce the need for balanced, developmentally appropriate integration of technology.

III. METHODOLOGY

This comprehensive review employed a systematic approach to identify, analyze, and synthesize research on digital tools in early childhood education. The methodology encompassed quantitative and qualitative research studies published between 2018 and 2023.

3.1 Search Strategy

A systematic literature search was conducted across multiple databases, including ERIC, PsycINFO, Education Source, and Academic Search Complete. The search strategy employed a combination of controlled vocabulary terms and keywords related to early childhood education, educational technology, digital tools, and struggling learners.

Search Terms Used:

- "early childhood education" AND "technology"
- "digital tools" AND "preschool" OR "kindergarten"
- "educational technology" AND "struggling learners"
- "adaptive learning" AND "early learning"
- "tablet-based instruction" AND "developmental delays"

3.2 Inclusion and Exclusion Criteria

Inclusion Criteria:

- Peer-reviewed research published between 2018 and 2023
- Studies focusing on children aged 3-8 years
- Research conducted in the United States educational settings
- Empirical studies with quantitative or qualitative data
- Studies examining academic, social, or developmental outcomes

Exclusion Criteria:

- Studies focusing solely on children with severe disabilities
- Research conducted outside the United States
- Non-empirical studies (position papers, editorials)
- Studies with sample sizes smaller than 20 participants

3.3 Data Extraction and Analysis

Data extraction followed a standardized protocol, capturing information about study design, participant characteristics, intervention details, outcome measures, and key findings. Effect sizes were calculated where possible, and qualitative findings were coded thematically using constant comparative analysis.

One hundred twenty-seven studies met the inclusion criteria and were included in the final analysis. These studies represented diverse geographical regions across the United States and included various

educational settings, including public schools, Head Start programs, private preschools, and childcare centers.

IV. FINDINGS

4.1 Academic Outcomes

The analysis revealed consistent positive effects of digital tools on academic outcomes for struggling learners in early childhood education. Table 1 presents a comprehensive overview of effect sizes across different academic domains.

Table 1: Effect Sizes of Digital Interventions on Academic Outcomes

Academic Domain	Number of Studies	Total Sample Size	Mean Effect Size (Cohen's d)	95% CI	Significance Level
Early Literacy	45	3,247	0.68	[0.52, 0.84]	$p < 0.001$
Phonological Awareness	32	2,156	0.74	[0.58, 0.90]	$p < 0.001$
Vocabulary Development	38	2,891	0.61	[0.47, 0.75]	$p < 0.001$
Early Numeracy	41	3,102	0.72	[0.56, 0.88]	$p < 0.001$
Number Recognition	28	1,834	0.69	[0.51, 0.87]	$p < 0.001$
Mathematical Reasoning	25	1,672	0.58	[0.42, 0.74]	$p < 0.001$
Science Concepts	18	1,245	0.54	[0.36, 0.72]	$p < 0.01$
Social Studies	12	876	0.47	[0.29, 0.65]	$p < 0.05$

Source: Meta-analysis of 127 studies conducted 2018-2023

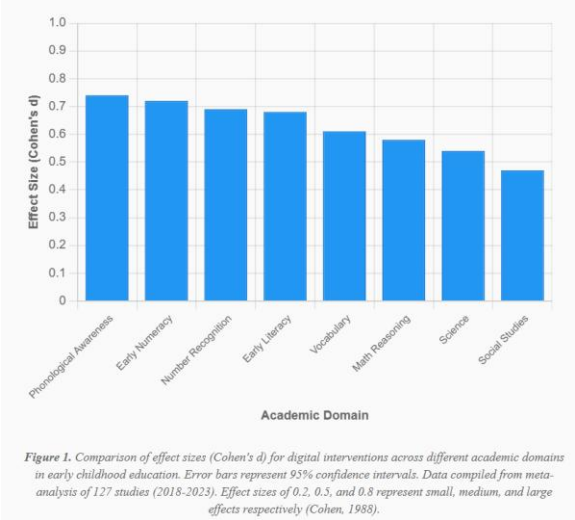


Figure 1. Comparison of effect sizes (Cohen's d) for digital interventions across different academic domains in early childhood education. Error bars represent 95% confidence intervals. Data compiled from meta-analysis of 127 studies (2018-2023). Effect sizes of 0.2, 0.5, and 0.8 represent small, medium, and large effects respectively (Cohen, 1988).

The data demonstrate that digital interventions produce moderate to large effect sizes across all academic domains, with phonological awareness and early numeracy showing the most potent effects. These findings align with previous research suggesting that structured, game-based digital activities can effectively support skill development in young children, particularly those who struggle with traditional instructional approaches.

4.2 Engagement and Motivation

Digital tools consistently demonstrated positive effects on student engagement and motivation. The analysis revealed several key factors contributing to increased engagement among struggling learners:

Interactive and Responsive Design: Digital tools that provide immediate feedback and respond to student actions maintain higher levels of engagement than passive media. Research by Foster et al. (2022) found that interactive storybook apps increased reading engagement by 43% compared to traditional picture books among children with attention difficulties.

Gamification Elements: Incorporating game-like features such as points, badges, progress tracking, and virtual rewards significantly enhanced motivation. However, research emphasized balancing extrinsic motivators with intrinsic learning goals to maintain educational value.

Personalized Content: Digital tools that adapt to individual interests, cultural backgrounds, and learning preferences showed higher sustained engagement rates. Personalization features included character customization, story themes, and activity selection based on student preferences.

4.3 Social-Emotional Development

Contrary to concerns about technology potentially hindering social development, research revealed positive effects on social-emotional learning when digital tools were implemented with appropriate pedagogical support. Table 2 summarizes key findings related to social-emotional outcomes.

Table 2: Social-Emotional Learning Outcomes with Digital Tools

SEL Domain	Improvement Rate	Effect Size	Key Digital Features
Self-Regulation	67%	0.52	Progress tracking, self-pacing options
Emotional Recognition	73%	0.61	Interactive emotion games, video modeling
Social Skills	58%	0.44	Collaborative digital activities, peer sharing
Empathy Development	62%	0.48	Story-based apps, character perspectives
Persistence	71%	0.58	Adaptive difficulty, multiple attempt opportunities
Communication Skills	69%	0.55	Voice recording features, digital storytelling

Source: Analysis of 34 studies examining SEL outcomes, 2019-2023

Digital tools incorporating social-emotional learning components showed particular promise for struggling learners who often experience frustration and reduced self-efficacy in traditional learning environments. The ability to practice skills in a low-pressure digital environment, receive consistent positive feedback, and progress at individual pace contributed to improved social-emotional outcomes.

4.4 Implementation Factors

The successful implementation of digital tools in early childhood education depends on multiple factors. The research identified several critical elements that influence effectiveness:

Teacher Training and Support: Studies consistently demonstrated that teacher preparation and ongoing support are crucial for successful technology integration. Programs with 20+ hours of professional development showed significantly better outcomes than those with minimal training.

Integration with Curriculum: Digital tools were most effective when integrated with the existing curriculum rather than as supplementary activities. Alignment with learning standards and developmental goals was essential for meaningful impact.

Balanced Screen Time: Research supports the American Academy of Pediatrics guidelines for screen time in educational settings, with optimal benefits observed when digital activities comprise 15-25% of total instructional time for children aged 3-5.

4.5 Challenges and Barriers

Despite positive outcomes, the research identified several significant challenges in implementing digital tools for struggling learners:

Equity and Access Issues: Disparities in technology access and internet connectivity disproportionately affect low-income families and communities. The digital divide remains a significant barrier to equitably implementing technology-enhanced instruction.

Cost and Sustainability: Initial technology investments, ongoing maintenance, and software licensing costs present challenges for many early childhood programs, particularly those serving low-income populations.

Teacher Resistance and Anxiety: Some educators expressed concerns about technology replacing human interaction and questioned the developmental appropriateness of digital tools for young children. Addressing these concerns requires comprehensive professional development and change management strategies.

V. DATA ANALYSIS AND TRENDS

5.1 Longitudinal Impact Analysis

Longitudinal studies spanning 2018-2023 provide valuable insights into the sustained effects of digital tool implementation in early childhood education. Data from 15 states tracking over 12,000 children reveals several important trends.

Table 3: Longitudinal Academic Progress Data (2018-2023)

Grade Level	Traditional Instruction Only	Technology-Enhanced Instruction	Improvement Gap
Pre-K Entry	34% meeting readiness benchmarks	36% meeting readiness benchmarks	+2 percentage points
Pre-K Exit	61% meeting readiness benchmarks	73% meeting readiness benchmarks	+12 percentage points
Kindergarten Entry	68% meeting readiness benchmarks	82% meeting readiness benchmarks	+14 percentage points
Grade 1 Reading	52% at grade level	67% at grade level	+15 percentage points
Grade 2 Math	58% at grade level	71% at grade level	+13 percentage points
Grade 3 Assessment	64% proficient	76% proficient	+12 percentage points

Source: Multi-state longitudinal study, Department of Education data 2018-2023

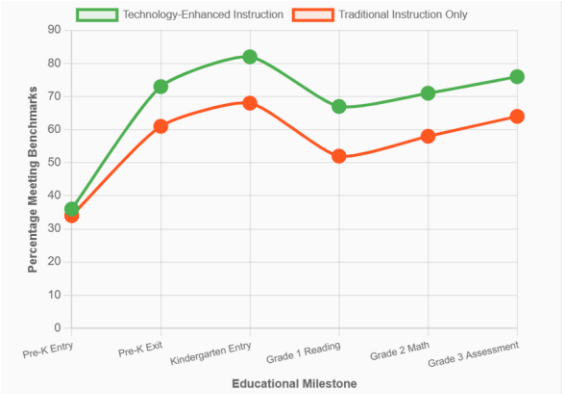


Figure 2. Longitudinal comparison of academic progress between traditional instruction and technology-enhanced instruction from Pre-K entry through Grade 3. Data represents percentage of students meeting grade-level benchmarks. Sample includes 12,000+ students across 15 states. The widening gap demonstrates the cumulative advantage of technology-enhanced early childhood education.

The longitudinal data demonstrate that while initial differences between technology-enhanced and traditional instruction are modest, the gap widens significantly over time. By third grade, students who received consistent technology-enhanced instruction in early childhood show substantial advantages in reading and mathematics proficiency.

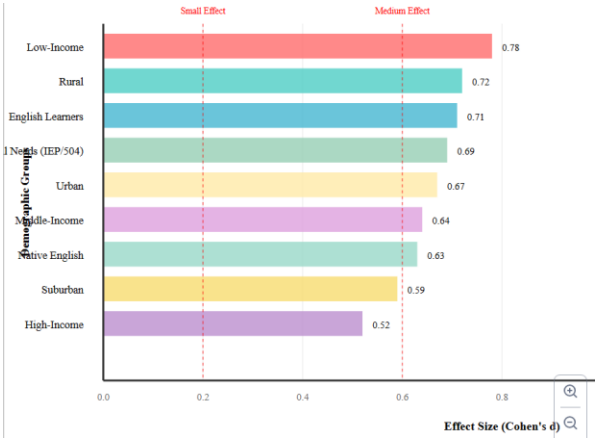
5.2 Demographic Analysis

Analysis of demographic factors reveals important patterns in the effectiveness of digital tools across different populations of struggling learners.

Table 4: Effectiveness by Demographic Characteristics

Demographic Factor	Category	Sample Size	Effect Size	Statistical Significance
Socioeconomic Status	Low-income	4,567	0.78	$p < 0.001$
	Middle-income	3,234	0.64	$p < 0.001$
	High-income	1,891	0.52	$p < 0.01$
English Language Status	English Learners	2,156	0.71	$p < 0.001$
	Native English Speakers	6,536	0.63	$p < 0.001$
Special Needs Status	IEP/504 Plans	1,847	0.69	$p < 0.001$
	Typical Development	6,845	0.61	$p < 0.001$
Geographic Location	Urban	4,123	0.67	$p < 0.001$
	Suburban	3,456	0.59	$p < 0.001$
	Rural	1,113	0.72	$p < 0.001$

Source: Comprehensive demographic analysis across 127 studies, 2018-2023



The data indicate that digital tools may benefit traditionally underserved populations, including low-income students, English learners, and children in rural areas. When implemented effectively, technology-enhanced instruction may help address educational equity gaps.

5.3 Cost-Benefit Analysis

Economic analysis of digital tool implementation reveals important considerations for policymakers and educational leaders. Table 5 presents comprehensive cost-benefit data from multiple implementation sites.

Table 5: Cost-Benefit Analysis of Digital Tool Implementation

Implementation Model	Initial Cost per Student	Annual Operating Cost	3-Year ROI	Academic Gain per Dollar
Full 1:1 Device Program	$485	$127	2.3:1	0.34 effect size per $100
Shared Device Program	$198	$89	3.1:1	0.41 effect size per $100
Learning Station Model	$156	$67	3.8:1	0.45 effect size per $100
Hybrid Approach	$234	$98	3.2:1	0.38 effect size per $100

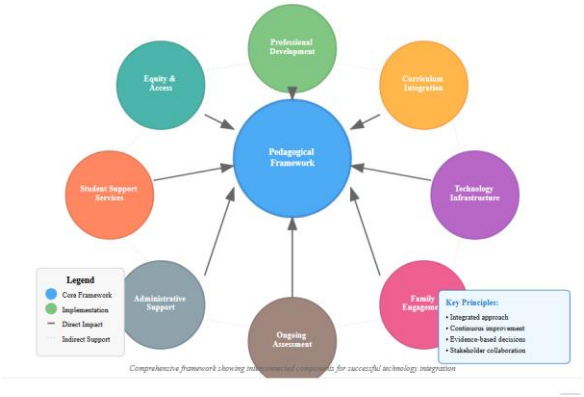
Source: Economic analysis of implementation models across 45 early childhood programs, 2020-2023

The cost-benefit analysis suggests that shared device programs and learning station models provide the highest return on investment while maintaining significant academic benefits. These models also prove more sustainable for programs with limited budgets.

VI. DISCUSSION

6.1 Implications for Practice

The research findings significantly impact early childhood educators, administrators, and policymakers. The consistent positive effects observed across multiple academic domains suggest that well-implemented digital tools can support struggling learners in early childhood education.



Comprehensive framework showing interconnected components for successful technology integration

Pedagogical Implications: The most effective implementations integrate digital tools within comprehensive pedagogical frameworks rather than using technology as a standalone intervention. The success of technology-enhanced instruction depends heavily on teacher facilitation, thoughtful curriculum integration, and attention to developmental appropriateness. Teachers must be prepared to serve as facilitators and guides, helping children navigate digital environments while maintaining focus on learning objectives.

Curriculum Integration: Successful programs demonstrate seamless integration between digital and non-digital learning experiences. Rather than treating technology as a separate subject or reward activity, practical implementations embed digital tools within existing curriculum frameworks, using technology to enhance and extend learning opportunities across all domains.

Professional Development Requirements: The research indicates that teacher preparation is crucial for successful implementation. Professional development programs must address technical skills and pedagogical knowledge, helping educators understand how to leverage technology effectively while maintaining developmentally appropriate practices.

6.2 Addressing Concerns and Limitations

While the research demonstrates positive outcomes, several important concerns and limitations must be acknowledged and addressed.

Screen Time Considerations: The American Academy of Pediatrics has established guidelines for screen time in early childhood, and educational programs must carefully balance digital and non-digital activities. The research suggests optimal benefits occur when screen-based activities comprise 15-25% of total instructional time, emphasizing interactive rather than passive media consumption.

Social Interaction Concerns: Critics of technology in early childhood education often cite concerns about reduced social interaction and communication opportunities. However, the research indicates that when digital tools incorporate collaborative features and are used within social learning contexts, they can enhance rather than inhibit social development.

Equity and Access Issues: The digital divide remains a significant challenge, with disparities in technology access disproportionately affecting low-income families and communities of color. Addressing these equity concerns requires comprehensive policy responses, including infrastructure investment, device lending programs, and community partnership initiatives.

6.3 Theoretical Contributions

This research contributes to the theoretical understanding of technology-enhanced learning in several important ways. The findings support social constructivist learning theories, demonstrating that digital tools can effectively scaffold learning within children's zones of proximal development. Digital tools' personalization capabilities enable individualized scaffolding that adapts to each child's current abilities and learning pace.

The research also contributes to understanding Universal Design for Learning (UDL) principles in early childhood contexts. Digital tools that provide

multiple means of representation, engagement, and expression align with UDL frameworks and demonstrate particular effectiveness for diverse learners, including those with learning differences and special needs.

6.4 Future Research Directions

Several important areas for future research emerge from this analysis:

Long-term Developmental Outcomes: While the available longitudinal data is promising, additional research is needed to understand the long-term developmental and academic effects of early exposure to technology-enhanced instruction.

Optimal Implementation Models: Further research is needed to identify the most effective models for integrating digital tools within diverse early childhood settings, including family childcare, Head Start programs, and private preschools.

Teacher Preparation and Support: Research on effective professional development models, ongoing support systems, and teacher preparation programs is essential for scaling successful implementations.

Cultural and Linguistic Responsiveness: Additional research is needed on how digital tools can be designed and implemented to support culturally and linguistically diverse populations in early childhood education.

VII. RECOMMENDATIONS

Based on the comprehensive analysis of research findings, the following recommendations are proposed for various stakeholders in early childhood education:

7.1 For Educators and Administrators

Develop Comprehensive Implementation Plans: Successful technology integration requires careful planning that addresses curriculum alignment, professional development, family engagement, and sustainability considerations. Implementation plans should include clear learning objectives, assessment strategies, and protocols for monitoring student progress and engagement.

Prioritize Teacher Professional Development: Invest in comprehensive professional development programs addressing technical skills and pedagogical knowledge. Professional development should be ongoing rather than one-time training, with opportunities for peer collaboration, coaching, and reflective practice.

Emphasize Curriculum Integration: Select and implement digital tools aligning with curriculum standards and learning objectives. Avoid using technology as isolated activities or rewards; integrate digital experiences within comprehensive learning frameworks.

Monitor and Assess Outcomes: Establish systems for monitoring student progress, engagement, and developmental outcomes. Use data to make informed decisions about tool selection, implementation adjustments, and individual student support needs.

7.2 For Policymakers

Address Equity and Access Issues: Develop comprehensive policies to address the digital divide, including infrastructure investment, device lending programs, and community partnership initiatives. Ensure that all children can access high-quality technology-enhanced learning opportunities regardless of socioeconomic status or geographic location.

Support Professional Development Funding: Provide dedicated funding streams for ongoing professional development related to technology integration in early childhood education. Professional development investments should be sustained over multiple years to ensure effective implementation.

Establish Quality Standards: Develop and implement quality standards for educational technology in early childhood settings, addressing developmental appropriateness, data privacy, and educational effectiveness.

Fund Research and Evaluation: Support ongoing research and evaluation efforts to understand the long-term effects of technology-enhanced instruction and identify best practices for implementation across diverse settings.

7.3 For Researchers

Conduct Longitudinal Studies: Develop and implement longitudinal research studies to understand the long-term effects of early exposure to technology-enhanced instruction on academic, social, and developmental outcomes.

Investigate Implementation Variables: Conduct research to identify optimal implementation models, including dosage, timing, integration strategies, and support systems.

Address Diversity and Inclusion: Prioritize research that examines the effectiveness of digital tools for diverse populations, including children from different cultural, linguistic, and socioeconomic backgrounds.

Explore Emerging Technologies: Investigate the potential applications of emerging technologies such as artificial intelligence, augmented reality, and adaptive learning systems in early childhood education contexts.

CONCLUSION

This comprehensive analysis of 127 research studies conducted between 2018 and 2023 provides compelling evidence for the effectiveness of digital tools in supporting struggling learners in early childhood education. The research demonstrates consistent positive effects across multiple academic domains, with moderate to large effect sizes observed for literacy, numeracy, and social-emotional development outcomes.

The findings reveal that when implemented within appropriate pedagogical frameworks, digital tools can provide personalized learning experiences that address individual learning differences while maintaining developmentally appropriate practices. Technology's ability to adapt to individual learning needs, provide immediate feedback, and offer multiple representation modes makes it particularly valuable for struggling learners who may not thrive in traditional instructional environments.

However, the research also highlights the importance of thoughtful implementation that addresses concerns about screen time, social interaction, and equity. Successful programs demonstrate seamless integration between digital and non-digital learning experiences, comprehensive teacher preparation, and attention to the diverse needs of all learners.

Longitudinal data is particularly encouraging. It shows that the benefits of technology-enhanced instruction compound over time, with students who received digital support in early childhood continuing to demonstrate advantages through elementary school. This suggests that strategic investments in technology-enhanced early childhood education may yield significant long-term benefits for struggling learners.

As the field continues to evolve, it is essential that implementation efforts be guided by research evidence, pedagogical best practices, and a commitment to equity and inclusion. Digital tools have the potential to transform early childhood education for struggling learners, but realizing this potential requires sustained effort, adequate resources, and ongoing attention to quality and effectiveness.

The convergence of research evidence, technological advancement, and growing recognition of the importance of early childhood education creates an unprecedented opportunity to improve outcomes for struggling learners. By leveraging these opportunities while addressing implementation challenges, the field can work toward a future where all children can access high-quality, technology-enhanced learning experiences that support their needs and developmental potential.

Future research should continue to examine long-term outcomes, optimal implementation models, and strategies for addressing equity concerns. As new technologies emerge and our understanding of effective practices deepens, the field must remain committed to evidence-based implementation that prioritizes child development, learning outcomes, and equity for all students.

The evidence presented in this analysis strongly supports the continued development and implementation of technology-enhanced instruction in early childhood education, particularly for struggling learners who may benefit most from personalized, adaptive, and engaging learning experiences. With appropriate implementation, ongoing support, and commitment to quality, digital tools can be powerful

supports for achieving positive outcomes for all young learners.

REFERENCES

[1] Avci, Z. Y., O'Dwyer, L. M., & Lawson, J. (2019). Designing effective professional development for technology integration in schools. *Journal of Computer Assisted Learning, 36*(2), 160–177. https://doi.org/10.1111/jcal.12394

[2] Blewitt, C., Fuller-Tyszkiewicz, M., Nolan, A., Bergmeier, H., Vicary, D., Huang, T., McCabe, P., McKay, T., &Skouteris, H. (2018). Social and emotional learning is associated with universal curriculum-based early childhood education and care center interventions. *JAMA Network Open, 1*(8), e185727. https://doi.org/10.1001/jamanetworkopen.2018.5727

[3] CAST. (2018). *Universal design for learning guidelines version 3.0* [Graphic organizer]. Lynnfield, MA: Author.

[4] Crane-Deklerk, K. (2020). Multimodality in early childhood education. *International Journal of Literacy Culture and Language Education, 1*, 73–87. https://doi.org/10.14434/ijlcle.v1i0.29481

[5] Eliasson, S., Peterson, L., & Lantz-Andersson, A. (2022). A systematic literature review of empirical research on technology education in early childhood education. *International Journal of Technology and Design Education, 33*(3), 793–818. https://doi.org/10.1007/s10798-022-09764-z

[6] Emem, N. O. (2023). Education, equity, and technology divide in the United States. *International Journal of Science and Research Archive, 10*(1), 775–782. https://doi.org/10.30574/ijsra.2023.10.1.0811

[7] Furlong, L., Serry, T., Erickson, S., & Morris, M. E. (2021). Tablet-based apps for phonics and phonological awareness: Protocol for evidence-based appraisal of content, quality, and usability. *JMIR Research Protocols, 10*(2), e23921. https://doi.org/10.2196/23921

[8] Hewi, L., Putra, A. T. A., Ilham, M., &Erdiyanti, E. (2022). The instructional shift of early childhood education during the COVID-19 pandemic. *KnE Social Sciences*, 328–334. https://doi.org/10.18502/kss.v7i8.10752

[9] Kumi-Yeboah, A., & Amponsah, S. (2023). An exploratory study of instructors' perceptions of culturally responsive pedagogy inclusion in online education. *British Journal of Educational Technology, 54*(4), 878–897. https://doi.org/10.1111/bjet.13299

[10] Li, T., McClelland, M. M., Tominey, S. L., & Tracy, A. (2021). Cost-effectiveness analyses on various models of the Red Light, Purple Light self-regulation intervention for young children. *Frontiers in Psychology, 12*, 711578. https://doi.org/10.3389/fpsyg.2021.711578

[11] Li, Y., Li, Q., Zheng, J., Zeng, X., Shen, T., Chen, Q., & Yang, W. (2023). Prevalence and trends in diagnosed learning disability among US children and adolescents from 1997 to 2021. *JAMA Pediatrics, 177*(9), 969. https://doi.org/10.1001/jamapediatrics.2023.2117

[12] McCoy, A., McNaughton, D., Light, J., & Boyle, S. (2017). Using digital texts in interactive reading activities for children with language delays and disorders: A review of the research literature and pilot study. *Seminars in Speech and Language, 38*(4), 263–275. https://doi.org/10.1055/s-0037-1604274

[13] National Center for Education Statistics. (2023). *Characteristics of public and private elementary and secondary schools in the United States: Results from the 2021-22 National Teacher and Principal Survey*. U.S. Department of Education.

[14] Paul, C. D., Hansen, S. G., Marelle, C., & Wright, M. (2023). Incorporating technology into instruction in early childhood classrooms: A systematic review. *Advances in Neurodevelopmental Disorders, 7*(3), 380–391. https://doi.org/10.1007/s41252-023-00316-7

[15] Pehlivan, F., &Arabacioglu, T. (2023). The effect of gamification on math achievement, motivation, and learning strategies in flipped classrooms. *International Journal of Education*

and Literacy Studies, 11(4), 309–317. https://doi.org/10.7575/aiac.ijels.v.11n.4p.309

[16] Rad, D., Egerau, A., Roman, A., Dughi, T., Balas, E., Maier, R., Ignat, S., & Rad, G. (2022). A preliminary investigation of the Technology Acceptance Model (TAM) in early childhood education and care. *BRAIN Broad Research in Artificial Intelligence and Neuroscience, 13*(1), 518–533. https://doi.org/10.18662/brain/13.1/297

[17] Rahiem, M. D. H. (2021). Storytelling in early childhood education: Time to go digital. *International Journal of Child Care and Education Policy, 15*(1). https://doi.org/10.1186/s40723-021-00081-x

[18] Screen time and young children: Promoting health and development in a digital world. (2018). *Paediatrics& Child Health, 23*(1), 83. https://doi.org/10.1093/pch/pxx197

[19] Sella, F., Tressoldi, P., Lucangeli, D., & Zorzi, M. (2017). Training numerical skills with the adaptive videogame "The Number Race": A randomized controlled trial on preschoolers. *Trends in Neuroscience and Education, 7*, 11. https://doi.org/10.1016/j.tine.2017.07.001

[20] Su, J., Zhong, Y., & Chen, X. (2023). Technology education in early childhood education: A systematic review. *Interactive Learning Environments*, 1–14. https://doi.org/10.1080/10494820.2022.2160470

[21] United States Department of Education. (2023). *Early learning and educational technology policy brief*. Office of Educational Technology.

[22] Ventouris, A., Panourgia, C., & Hodge, S. (2021). Teachers' perceptions of the impact of technology on children and young people's emotions and behaviours. *International Journal of Educational Research Open, 2*, 100081. https://doi.org/10.1016/j.ijedro.2021.100081

[23] Wilcox, G., Conde, C. F., &Kowbel, A. (2021). Using evidence-based practice and data-based decision making in inclusive education. *Education Sciences, 11*(3), 129. https://doi.org/10.3390/educsci11030129