Exploring technology devices' role in learners' cognitive growth

Salathiel Villamor[1]*, Marcelo Palero[2], John Leo Evardo[3], Rejamae Sabio[4], Jeniza Adeser[5], Raffy Allego[6]
[1]Bawo Elementary School Deped, Sogod District Division of Cebu Province, Philippines; salathielvillamor@gmail.com (S.V.).
[2]SOUTHERN LEYTE STATE UNIVERSITY TOMAS OPPUS, San Isidro, Tomas Oppus, Southern Leyte, Philippines; marcelopalero@gmail.com (M.P.).
[3]Mayor Catalino Y. Casoyla Memorial High School, Purok 2, Suba, Talibon, Bohol, Philippines; johnleoevardo@gmail.com (J.L.E.).
[4]Bulwang Elementary School Deped, Tuburan District I Division of Cebu Province, Philippines; rejamaesabio@gmail.com (R.S.).
[5]Elementary School Teacher Loblob Elementary School Kauswagan, Trinidad, Bohol, Philippines; jenizaadeser@gmail.com (J.A.).
[6]Bulwang Elementary School DepEd, Tuburan District 1 Division of Cebu Province, Philippines; raffyallego@gmail.com (R.A.).

Abstract: This study explored the role of technological devices in supporting the cognitive development of young learners. Specifically, it examined how access to educational content, learning ability, and digital literacy relate to improvements in numeracy skills, literacy skills, memory and recall, attention and concentration, social and emotional development, and problem-solving abilities. A descriptive-correlational design was used, involving 72 teachers and 342 learners from selected schools. Data were gathered through validated survey questionnaires and analyzed using descriptive statistics and correlation analysis. Findings revealed that teachers strongly agreed on the positive influence of technology, with high mean scores across all areas. Notably, digital tools were perceived as most effective in enhancing literacy skills and problem-solving abilities. The results showed significant positive correlations between the quality of educational content, learning ability, digital literacy, and all dimensions of cognitive development, with the strongest relationships observed in literacy and social-emotional skills. These findings align with recent studies highlighting the benefits of interactive and adaptive digital resources in fostering engagement, motivation, and skill acquisition. The study suggests that integrating well-designed technology into instruction can enrich learning experiences and build essential cognitive competencies. It recommends continuous professional development for teachers, improved access to devices, and the implementation of structured digital literacy programs. This output includes an enhanced instruction plan as a proposal to the Department of Education to guide effective and equitable technology integration. Overall, the research underscores technology's vital role in shaping learners' readiness for success in a rapidly changing, digital-driven world.

Keywords: Cognitive development, Digital literacy, Educational technology, Technology integration.

1. Introduction

In recent years, the integration of technology in education has transformed traditional teaching and learning methods. Modern classrooms, even in early childhood education, increasingly utilize digital tools to enhance the educational experience, offering interactive and personalized learning environments tailored to young learners (Gleason & Greenhow, 2020; Liu & Long, 2022). This shift towards technology-enabled education aims to engage students more effectively, cater to diverse learning styles, and provide access to a vast array of resources that were previously unavailable (Hwang, Lai, & Wang, 2020; Neumann & Neumann, 2019). Research indicates that technology can significantly improve student outcomes, even for learners, by fostering a more engaging and interactive learning atmosphere

(Kim, 2021; Palaigeorgiou & Papadopoulou, 2021). At the learner's level, technology helps to introduce foundational skills in a manner that is both fun and educational, supporting the development of cognitive, social, and emotional skills (Daniel, 2023; Liu, Peng, & Chen, 2021).

The use of digital tools, such as tablets and interactive whiteboards, allows young children to explore, create, and learn in ways that are more aligned with their natural curiosity and developmental needs (Kucirkova, 2021; Lim, 2023). This early exposure to technology not only makes learning more enjoyable but also prepares young learners for the increasingly digital world they will navigate as they progress in their education (Barzilai & Blau, 2021; Wu & Huang, 2022). Moreover, these devices provide learners with access to a wide range of educational apps, e-books, and online resources that support various learning activities. For instance, in the literature, the use of electronic devices has been shown to enhance learners' engagement and motivation by making learning more dynamic and interactive (Gleason & Greenhow, 2020; Liu & Long, 2022; Liu et al., 2021; Neumann & Neumann, 2019). Thus, incorporating multimedia elements such as videos, animations, and interactive quizzes, electronic devices cater to different learning preferences and promote a more inclusive learning environment.

The role of electronic devices in developing cognitive abilities among learners is profound. These devices facilitate the acquisition of essential cognitive skills such as numeracy, literacy, memory, attention, and problem-solving. Adaptive learning technologies, which adjust the difficulty level based on the learner's progress, help in addressing individual learning needs and challenges (Daniel, 2023; Kucirkova, 2021; Mace & Lee, 2021; Zhang, Trussell, Gallegos, & Asam, 2020). Interactive features such as educational games and simulations enhance engagement and retention, thereby improving cognitive outcomes. Studies have demonstrated that learners who utilize electronic devices in their education perform better in cognitive tasks compared to those who rely solely on traditional methods (Barzilai & Blau, 2021; Lim, 2023; Palaigeorgiou & Papadopoulou, 2021; Wu & Huang, 2022).

Cognitive abilities are crucial in the early stages of a child's education, particularly in learners, where foundational skills are developed. These abilities include numeracy, literacy, memory, attention, and problem-solving, which are essential for academic success and overall intellectual development (Blair & Raver, 2019; Diamond & Ling, 2020; Meltzoff, Kuhl, Movellan, & Sejnowski, 2021; Zelazo, 2015). Strong cognitive abilities enable children to process information more efficiently, adapt to new learning situations, and solve problems effectively. Early development of these skill sets the stage for lifelong learning and academic achievement, making it imperative to support cognitive growth from a young age (Best, 2020; Morrison, 2022; Richland, Burchinal, & Schneider, 2019; Schmitt, Pratt, & McClelland, 2021).

Despite the evident benefits, there are still research gaps in understanding the full impact of electronic devices on the cognitive abilities of learners. Most studies have focused on the general benefits of technology in education, with less emphasis on specific cognitive outcomes such as numeracy, literacy, memory and recall, attention and concentration, social and emotional development, and problem-solving skills (Garcia, 2023; Herodotou, 2019; Kim, 2021; Singh, 2022). Additionally, the influence of educational content accessibility, learning ability, and digital literacy on these cognitive abilities remains underexplored. More research is needed to determine how different types of electronic content and usage patterns specifically impact each area of cognitive development in early childhood education (Chou, 2022; Noland, 2024; Ponce, 2021; Revelle, 2020).

This research aims to fill these gaps by examining the specific effects of electronic devices on the cognitive abilities of learners. Focusing on the dimensions of educational content accessibility, learning ability, and digital literacy, this study will provide a comprehensive understanding of how these factors influence cognitive skills such as numeracy, literacy, social and emotional development, and problem-solving. The findings contribute to the body of knowledge on early childhood education and offer practical insights for educators and policymakers on integrating electronic devices effectively to support cognitive development. Ultimately, this research helps shape strategies for enhancing the educational experiences and outcomes of young learners in a digital age.

2. Methodology

The study employed a descriptive-correlational research design to examine the influence of technology devices on the cognitive abilities of learners in selected elementary schools within the Tuburan School District. Using validated questionnaires adapted from previous studies on educational technology and cognitive development, data were collected from 72 teachers and 342 learners chosen through purposive sampling. The INPUT-PROCESS-OUTPUT (IPO) framework guided the study, where the input included demographic profiles and measures of technology influence (educational content accessibility, learning ability, and digital literacy), as well as learners' cognitive dimensions (numeracy, literacy, social-emotional development, and problem-solving skills). The process involved questionnaire administration, data consolidation, and statistical analysis using software at a 0.05 level of significance to determine relationships between technology influence and cognitive abilities. The output of the study was an enhanced instructional plan designed to promote effective technology integration and foster a globally competitive learning environment.

3. Results and Discussion

Table 1.
Educational Content Accessibility.

Educational Content Accessibility	Mean	SD	VD
Electronic devices provide access to a wide range of learning materials, including apps, eBooks, and educational videos, catering to different learning styles and preferences.	4.36	0.50	SA
Learners can access educational content anytime and anywhere, making learning opportunities more flexible and ubiquitous.	4.18	0.56	A
Many electronic resources offer interactive features, such as games and quizzes, which can enhance engagement and retention of information.	4.29	0.60	SA
Adaptive learning technologies can tailor content to the individual learning pace and level of each student, addressing their specific needs and challenges.	4.29	0.72	SA
Devices can integrate text, audio, visuals, and animation, providing a rich, multisensory learning experience that can aid in the understanding of complex concepts.	4.29	0.65	SA
Grand Mean	4.28	0.61	SA

The data indicate that teachers perceive technology devices as having a very high level of influence on educational content accessibility, reflected by a grand mean of 4.28, interpreted as strongly agree. The statement that electronic devices provide access to a wide range of learning materials, such as apps, ebooks, and videos, received the highest mean score of 4.36, underscoring their pivotal role in diversifying instructional resources and supporting varied learning styles. This finding aligns with recent evidence that digital tools expand the breadth and depth of instructional content, enabling more personalized and differentiated instruction (Li & Lalani, 2020). Likewise, the capacity of devices to deliver content anytime and anywhere (M=4.18) highlights their contribution to ubiquitous learning environments, which have been shown to increase learner autonomy and motivation (Huang, Teo, & Zhou, 2020). The strong agreement regarding adaptive learning technologies (M=4.29) reflects recognition that these tools can address individual learners' needs by tailoring content and pacing, an approach supported by studies demonstrating improved academic performance when adaptive platforms are used (Pane, 2020). The integration of multisensory elements, text, audio, visuals, and animation, was also highly rated (M=4.29), emphasizing how rich multimedia environments can facilitate the comprehension of complex concepts and sustain learner engagement (Mayer, Fiorella, & Stull, 2020). These findings suggest that schools should prioritize investments in reliable digital infrastructure, training programs, and instructional design support to fully leverage technology's potential for enhancing content accessibility and inclusivity. Additionally, policies encouraging the integration of adaptive and multimedia resources can bridge learning gaps and support diverse learner profiles. As educational contexts increasingly embrace hybrid and blended modalities, the strategic use of

technology remains a critical factor in shaping equitable and effective learning experiences (Trust & Whalen, 2020).

Table 2.
Learning Ability.

Learning Ability	Mean	SD	VD
Learners are willing to spend more time on learning activities when engaged with interactive and multimedia content.	4.27	0.62	SA
Learners demonstrate active participation in tasks involving technological devices, indicating increased interest and engagement.	4.03	0.70	A
There is a noticeable eagerness among learners to engage with new digital learning materials.	4.32	0.65	SA
Children develop positive attitudes towards learning when they experience it through fun and interactive means.	4.18	0.60	A
Encourage children to persist with challenging tasks, boosting their resilience in learning.	4.29	0.68	SA
Grand Mean	4.22	0.65	SA

The data indicate that teachers perceive technology integration as having a very strong positive impact on learners' ability and disposition to learn, with a grand mean of 4.22, interpreted as strongly agree. The highest-rated statement, "There is a noticeable eagerness among learners to engage with new digital learning materials" (M=4.32), highlights how novelty and interactivity in technology tools spark curiosity and intrinsic motivation. Findings that are consistent with recent research demonstrate that digital resources can stimulate learner engagement and sustained attention (Bond, Zawacki-Richter, & Nichols, 2020). Notably, the statement about technology encouraging persistence with challenging tasks (M=4.29) suggests that digital tools help build resilience and a growth mindset, as interactive platforms often incorporate immediate feedback and adaptive support, fostering learners' confidence and perseverance (Lai & Bower, 2020). Active participation in technology-mediated tasks (M=4.03) and the development of positive attitudes through fun and interactive means (M=4.18) further affirm that technology not only enhances engagement but also promotes positive affect and social-emotional connections to learning (Yeh, Hung, & Hsu, 2021). These results imply that educators and school leaders should continue to prioritize the integration of technology-rich instructional strategies, especially those involving interactive and adaptive content.

Table 3.
Digital Literacy.

Digital Literacy	Mean	SD	VD
Learners become familiar with operating devices, using touchscreens, and navigating interfaces.	4.11	0.58	A
Even at a basic level, children learn to access information online under guidance, laying the groundwork for research skills.	4.00	0.74	A
Introduction to discerning reliable from unreliable digital content, fostering critical evaluation skills from an early age.	4.03	0.68	A
Opportunities to use simple digital tools for creating art, music, or stories develop creative skills and digital fluency.	4.32	0.60	SA
Education on using devices safely can begin, including understanding privacy settings and recognizing inappropriate content.	4.21	0.62	A
Grand Mean	4.13	0.64	A

The data suggest that teachers perceive technology use as having a high positive impact on developing learners' digital literacy, with a grand mean of 4.13, interpreted as agree. Among the indicators, the statement that technology provides opportunities for creating art, music, or stories using digital tools received the highest rating (M=4.32, strongly agree), underscoring how creative activities are effective for cultivating digital fluency and self-expression. This is consistent with findings that integrating digital creativity into the curriculum builds confidence and transferable skills for future learning (Falloon, 2020). The strong agreement on teaching safe device use (M=4.21) highlights that educators value early instruction on responsible digital citizenship, such as understanding privacy

settings and recognizing inappropriate content, an essential competency as children increasingly access online environments (Livingstone, Stoilova, & Nandagiri, 2021). Similarly, familiarity with basic device operation (M=4.11) and early guidance on accessing online information (M=4.00) reflect teachers' recognition that foundational digital skills are becoming as important as traditional literacy. Notably, the emphasis on introducing critical evaluation skills (M=4.03) demonstrates awareness that even young learners need support in developing discernment to navigate the overwhelming volume of digital content, a skill that researchers have linked to improved academic outcomes and reduced susceptibility to misinformation (Ng, 2021). These findings have important implications: schools should provide structured, age-appropriate digital literacy programs that integrate creative digital projects, guided exploration, and explicit lessons on online safety and information evaluation. Professional development for teachers is also essential to build their capacity to model and teach these competencies effectively. Finally, ensuring equitable access to devices and safe digital environments is critical so all learners can develop the skills and confidence to thrive in increasingly digital classrooms and societies (Smahel, Machackova, & Mascheroni, 2020).

The results in Table 4 show that teachers perceive technology-supported learning as having a very strong positive influence on developing early numeracy skills, reflected by a grand mean of 4.28, interpreted as strongly agree. Among the indicators, the highest-rated was the ability to identify and create simple patterns (M=4.36), emphasizing how digital tools and visual aids effectively support pattern recognition and sequencing, key foundational competencies for later mathematical understanding (Papadakis, Kalogiannakis, & Zaranis, 2021). The high mean scores for counting objects (M=4.32) and number recognition up to 20 (M=4.26) further illustrate that interactive technologies are perceived to help solidify children's understanding of quantity and number symbols, which are essential early numeracy milestones (Zhang & Xin, 2022). Similarly, statements related to grasping simple addition and subtraction (M=4.24) and understanding measurement concepts (M=4.24) show strong agreement that technology through apps, games, and manipulatives can make abstract mathematical ideas more concrete and engaging.

Table 4.
Numeracy Skills.

Digital Literacy	Mean	SD	VD
Demonstrating the ability to count objects and understanding that the last number represents the total quantity.	4.32	0.64	SA
Being able to recognize and name numbers up to at least 20.	4.26	0.70	SA
Starting to grasp simple addition and subtraction using physical objects or visual aids.	4.24	0.72	SA
Ability to identify and create simple patterns, recognizing sequences in their environment.	4.36	0.68	SA
Basic understanding of measurement concepts such as big/small, more/less, and comparisons between objects.	4.24	0.70	SA
Grand Mean	4.28	0.69	SA

This aligns with research indicating that digital learning environments, especially those with visual and interactive elements, can significantly improve young children's mathematical skills, confidence, and engagement (Kucirkova, 2021). The findings imply that early childhood programs should integrate high-quality, evidence-based digital resources designed to support numeracy development. Teachers need professional development to select and effectively use tools that reinforce counting, number sense, and pattern recognition while maintaining developmentally appropriate practices. Moreover, access to tablets, interactive whiteboards, and educational apps should be prioritized, particularly in under-resourced settings, to ensure equitable opportunities for all learners to build strong foundational numeracy (Cheung & Slavin, 2021).

Table 5.
Literacy Skills.

Literacy Skills	Mean	SD	VD
Recognizing and naming letters of the alphabet in both uppercase and lowercase forms.	4.29	0.65	SA
Understanding that words are made up of sounds and being able to play with sounds (e.g., rhyming, beginning sounds).	4.32	0.60	SA
Starting to read simple words or sentences, and recognizing some sight words.	4.46	0.68	SA
Writing their own name and other simple words with assistance.	4.39	0.60	SA
Demonstrating understanding of simple stories through pictures or texts, answering questions about what they have read or heard.	4.32	0.72	SA
Grand Mean	4.36	0.65	SA

The results presented in Table 5 indicate that teachers perceive a very strong positive impact of technology-supported learning on developing early literacy skills, as shown by the grand mean of 4.36, interpreted as strongly agree. Among the statements, the highest mean score was for learners starting to read simple words or sentences and recognizing sight words (M=4.46), underscoring how digital tools like interactive ebooks and literacy apps are particularly effective in supporting early decoding skills and sight word recognition (Neumann, 2020). Similarly, high ratings for writing their own name and simple words with assistance (M=4.39) reflect the value of digital platforms that scaffold early writing and letter formation through engaging, multisensory experiences (Kucirkova & Falloon, 2020). Teachers also strongly agreed that technology helps children understand that words are made up of sounds and practice phonological awareness (M=4.32), which is essential for later reading success. This aligns with recent evidence showing that technology-enhanced phonics instruction can accelerate literacy acquisition, especially when combined with traditional methods (Horner & Shwery, 2021). Recognition of letters in both uppercase and lowercase forms (M=4.29) and comprehension of simple stories (M=4.32) were also highly rated, highlighting the role of multimedia storytelling tools and alphabet apps in supporting letter knowledge, vocabulary development, and listening comprehension (Bus, Takacs, & Kegel, 2020). These findings imply that schools should integrate high-quality, research-informed digital resources into early literacy instruction. Professional development for teachers should focus on evidence-based strategies for using technology to reinforce phonics, print awareness, and comprehension skills while maintaining developmentally appropriate practices. Furthermore, policies to improve access to tablets and literacy apps can help ensure that all children, including those in under-resourced communities, benefit from technology's potential to accelerate foundational literacy (Cheung & Slavin, 2021).

Table 6.
Memory and Recall.

Memory and Recall	Mean	SD	VD
Ability to remember information over short periods, such as following simple instructions or recalling recently learned words.	4.05	0.68	A
Remembering the sequence of daily activities or routines.	4.12	0.60	SA
Being able to retell a simple story in their own words after hearing it.	4.18	0.68	A
Recognizing previously seen items or images when presented among new ones.	4.25	0.60	SA
Remembering where objects are usually stored or where they were last placed.	4.21	0.65	SA
Grand Mean	4.16	0.64	A

The findings in Table 6 indicate that teachers perceive technology-supported learning activities as having a high positive impact on children's memory and recall abilities, with a grand mean of 4.16, interpreted as agree. Among the indicators, the highest mean was observed in recognizing previously seen items or images when presented among new ones (M=4.25), reflecting how visual-rich digital content and interactive games can strengthen recognition memory, an important foundation for comprehension and learning (Yeh et al., 2021). Similarly, remembering where objects are stored (M=4.21) and recalling sequences of daily activities (M=4.12) suggest that structured digital activities,

such as sequencing games and interactive routines, support children's working memory and executive function (Blasiman & Was, 2018).

Teachers also agreed that technology can help learners retell stories in their own words (M=4.18), demonstrating how multimedia storybooks and digital storytelling apps promote narrative memory and expressive language (Bus et al., 2020). Although the mean score for remembering information over short periods, such as following instructions (M=4.05), was slightly lower, it still indicates that teachers recognize the potential of technology to reinforce short-term recall and attention. These findings imply that incorporating well-designed digital tools into early childhood programs can effectively support memory development by providing engaging, multisensory experiences that reinforce encoding and retrieval processes. Professional development should help teachers select and integrate memory-enhancing digital activities into daily lessons. Additionally, ensuring equitable access to interactive technology, especially in underserved schools, will help close opportunity gaps and give all learners the chance to build essential memory and recall skills that underpin academic success (Papadakis, Zaranis, & Kalogiannakis, 2022).

Table 7.
Attention and Concentration.

Memory and Recall	Mean	SD	VD
Can focus on a task or activity for increasing periods, showing interest in details.	4.05	0.65	A
Ability to switch attention from one activity to another with minimal adult assistance.	4.10	0.70	A
Can concentrate on a specific task even with distractions present in the environment.	3.86	0.62	A
Capable of following two- to three-step directions.	4.10	0.74	A
Shows ability to listen and participate in group settings, like story time or group discussions.	4.11	0.68	A
Grand Mean	4.04	0.68	A

The results in Table 7 indicate that teachers perceive technology-integrated activities as having a high positive impact on developing children's attention and concentration, as reflected by the grand mean of 4.04, interpreted as agree. Among the indicators, the highest rating was for listening and participating in group settings (M=4.11), suggesting that interactive digital tools, such as shared storybook reading apps and group learning platforms, can successfully engage children in collective learning experiences (Neumann, 2020). Teachers also agreed that learners are able to follow two- to three-step directions (M=4.10) and switch attention from one activity to another with minimal assistance (M=4.10), highlighting how structured digital learning tasks can scaffold executive function skills like cognitive flexibility and self-regulation (Dore, Hopkins, & Toub, 2021). Interestingly, while the ability to focus on a task for increasing periods was rated highly (M=4.05), the capacity to concentrate even with distractions received a comparatively lower mean score (M=3.86), indicating that although digital tools can improve engagement, environmental distractions still pose a challenge for sustained attention. This finding aligns with research suggesting that while technology can enhance focus when appropriately designed and implemented, excessive or poorly structured screen time can sometimes fragment attention (Gunes & Gokcearslan, 2021). These results imply that educators should carefully select digital resources that balance engagement with opportunities to practice sustained concentration, particularly in settings with multiple stimuli. Professional development can help teachers design blended activities that combine digital and traditional strategies to foster children's attentional control and persistence. Furthermore, classroom management strategies such as minimizing background noise and clearly structuring transitions are essential complements to technology use for supporting attention and concentration (Segers & Verhoeven, 2020).

The results in Table 8 show that teachers perceive technology-integrated learning activities as having a high positive impact on learners' social and emotional development, with a grand mean of 4.15, interpreted as agree. Among the indicators, the highest mean score was given to engaging in play that involves sharing, taking turns, and collaborating with peers (M=4.28), suggesting that digital games and interactive platforms are seen as effective tools for practicing social rules and cooperative behaviors.

This finding aligns with studies showing that well-designed digital environments can scaffold social interaction, promote perspective-taking, and reinforce pro-social skills (Herodotou, 2020). Teachers also agreed that technology helps children recognize facial expressions and social cues (M=4.20) and show understanding or concern for others' feelings (M=4.18), indicating that multimedia content such as story apps and role-play simulations can build emotional literacy and empathy (Dore et al., 2021). The capacity for learners to manage emotions with some support (M=4.08) and increasingly demonstrate independence in personal care and decision-making (M=4.00) underscores that technology can complement traditional approaches by offering scenarios that model self-regulation and responsible choices.

Table 8.
Attention and Concentration.

Attention and Concentration	Mean	SD	VD
Beginning to manage emotions with some support, can express feelings using words.	4.08	0.74	A
Showing understanding or concern for the feelings of others.	4.18	0.54	A
Engaging in play that involves sharing, taking turns, and collaborating with peers.	4.28	0.62	SA
Recognizing basic facial expressions and social cues of others.	4.20	0.68	A
Showing increasing independence in personal care and in making choices.	4.00	0.72	A
Grand Mean	4.15	0.66	A

These findings suggest that digital tools can play a constructive role in supporting social-emotional learning (SEL), especially when integrated purposefully within broader classroom routines and adult guidance. Educators should be encouraged to blend technology with active, in-person social experiences, ensuring that screen-based interactions reinforce rather than replace real-life social practice (Neumann, 2020).

Table 9.
Problem-Solving Skills.

Problem-Solving Skills	Mean	SD	VD
Can recognize a simple problem and express it in their own words.	4.12	0.68	A
Comes up with basic solutions to simple problems, often through trial and error.	4.07	0.72	A
Making choices between two or more options in play or learning tasks.	4.05	0.62	A
Beginning to use tools or materials (e.g., puzzles, building blocks) for their intended purpose in problem-solving.	4.25	0.68	SA
Recognizing when they need help and asking for it appropriately.	4.14	0.60	A
Grand Mean	4.13	0.66	A

The results in Table 9 reveal that teachers perceive technology and structured activities as having a high positive impact on learners' problem-solving skills, with a grand mean of 4.13, interpreted as agree. The highest mean score was for beginning to use tools or materials (e.g., puzzles, building blocks) for their intended purpose in problem-solving (M=4.25), underscoring how digital apps and manipulatives can scaffold early reasoning and spatial skills. This observation is supported by recent studies demonstrating that digital games and interactive simulations promote exploratory learning, strategic thinking, and persistence (Papadakis et al., 2022). Teachers also strongly agreed that children are able to recognize when they need help and ask appropriately (M=4.14) and express simple problems in their own words (M=4.12), reflecting how technology-supported environments can foster metacognitive awareness and self-regulation (Verschaffel, Depaepe, & Torbeyns, 2020). The mean ratings for making choices between options (M=4.05) and generating basic solutions through trial and error (M=4.07) indicate that teachers value how technology-enhanced tasks can provide safe spaces for experimentation and decision-making, which are key competencies for lifelong learning (Blanchard, Vandenbroeck, & Perrenoud, 2021). These findings imply that integrating interactive digital tools, such as problem-solving apps, coding games, and virtual manipulatives, can effectively strengthen children's early

problem-solving abilities. Professional development should focus on helping educators design and facilitate activities that balance guided exploration with opportunities for independent thinking. Additionally, ensuring equitable access to technology resources is critical so all learners, regardless of socioeconomic background, can build the confidence and skills needed to solve problems creatively and collaboratively (Cheung & Slavin, 2021).

Table 10.
Significant Relationship Between Education Content quality and dimension of cognitive abilities.

Cognitive Ability	r-value	t-value	p-value	Remarks	Decision
Numeracy Skills	0.613836	10.42465	0.000	Significant	Reject
Literacy Skills	0.989039	10.8172	0.000	Significant	Reject
Memory and Recall	0.870361	9.012255	0.000	Significant	Reject
Attention and Concentration	0.564087	8.057658	0.000	Significant	Reject
Social and Emotional Development	0.749646	8.748932	0.000	Significant	Reject
Problem-Solving Skills	0.512432	11.42501	0.000	Significant	Reject

Table 10 shows that all dimensions of cognitive abilities have statistically significant relationships with the quality of educational content, as indicated by the very low p-values (p=0.000) across all domains. This means that improvements in the quality of educational content, such as richer multimedia resources, better instructional design, and more engaging activities, are consistently linked with stronger development in children's cognitive skills. Among the results, literacy skills showed the strongest association (r=0.989), highlighting that well-designed educational content can almost perfectly predict improvements in early reading and writing abilities. This finding reinforces the conclusion that technology-enhanced literacy materials, such as interactive storybooks and phonics applications, are highly effective in supporting foundational literacy (Bus et al., 2020). Similarly, memory and recall (r=0.870) and social and emotional development (r=0.749) also demonstrated very strong relationships with content quality, suggesting that high-quality digital learning resources not only enhance academic skills but also support children's socio-emotional competencies, including empathy, self-regulation, and collaboration (Herodotou, 2020). The correlations between educational content and numeracy skills (r=0.614), attention and concentration (r=0.564), and problem-solving skills (r=0.512) were also substantial. These results imply that interactive and adaptive educational technologies play an essential role in maintaining focus, building reasoning abilities, and promoting persistence in solving challenges (Cheung & Slavin, 2021). The consistent significance across all domains indicates that content quality should be a priority in curriculum design and classroom integration. Practically, these findings suggest several implications for educators and policymakers. Schools should prioritize the curation and use of evidence-based digital materials that are developmentally appropriate, engaging, and aligned with learning objectives.

Table 11.
Significant Relationship Between Learning Ability and the dimension of cognitive abilities.

Cognitive Ability	r-value	t-value	p-value	Remarks	Decision
Numeracy Skills	0.955131	12.41415	0.000	Significant	Reject
Literacy Skills	0.642582	14.25507	0.000	Significant	Reject
Memory and Recall	0.749555	10.89282	0.000	Significant	Reject
Attention and Concentration	0.643629	8.42456	0.000	Significant	Reject
Social and Emotional Development	0.593085	7.242699	0.000	Significant	Reject
Problem-Solving Skills	0.924730	11.22536	0.000	Significant	Reject

Table 11 demonstrates that learning ability has a statistically significant positive relationship with all measured dimensions of cognitive abilities, as shown by p-values of 0.000 for each variable. These results confirm that as learners' general ability to engage, persist, and apply themselves in learning activities increases, so do their core cognitive skills. The strongest relationships were observed for

numeracy skills (r=0.955) and problem-solving skills (r=0.925). These very high correlations suggest that learners who show higher engagement, motivation, and persistence are far more likely to develop robust mathematical understanding and effective strategies for tackling new challenges. These findings align with evidence showing that motivation and active learning are among the most important predictors of numeracy development and problem-solving success (Papadakis et al., 2022). Literacy skills (r=0.643) and memory and recall (r=0.750) also showed strong associations, underscoring that students with higher learning ability more effectively acquire language, reading, and memory-related competencies. This is consistent with research showing that engagement in literacy activities, particularly those incorporating technology and interactive approaches, enhances phonological awareness, vocabulary, and recall (Bus et al., 2020). Similarly, the significant relationships with attention and concentration (r=0.644) and social and emotional development (r=0.593) suggest that learning ability also contributes to the development of self-regulation, focus, collaboration, and emotional understanding. These capacities are vital for overall school readiness and success (Blanchard et al., 2021). Collectively, the results imply that fostering learning ability through strategies like creating positive learning environments, offering engaging materials, and providing differentiated instruction is a critical lever for enhancing children's overall cognitive development. Educators should prioritize practices that strengthen motivation, persistence, and confidence in learning. Professional development should support teachers in using adaptive, interactive methods that build both engagement and skills. Finally, school leaders and policymakers must ensure equitable access to resources and training so all children benefit, especially those at risk of disengagement or learning delays.

Table 12 demonstrates that digital literacy has a statistically significant and positive relationship with all measured dimensions of cognitive abilities, as shown by consistently low p-values (p=0.000). This indicates that as children's familiarity with using digital tools, navigating interfaces, and applying basic digital skills increases, their cognitive development in multiple domains also improves. The strongest associations were observed for social and emotional development (r=0.953) and literacy skills (r=0.932). These very high correlations suggest that digital literacy skills such as navigating story apps, engaging with multimedia content, and participating in digital communication are especially effective at enhancing children's understanding of language and social-emotional concepts.

Table 12.
Significant Relationship Between Digital Literacy and dimension of cognitive abilities

Cognitive Ability	r-value	t-value	p-value	Remarks	Decision
Numeracy Skills	0.672163	8.774721	0.000	Significant	Reject
Literacy Skills	0.932247	8.846529	0.000	Significant	Reject
Memory and Recall	0.576526	7.935277	0.000	Significant	Reject
Attention and Concentration	0.762041	6.094677	0.000	Significant	Reject
Social and Emotional Development	0.952581	6.545816	0.000	Significant	Reject
Problem-Solving Skills	0.823371	8.72521	0.000	Significant	Reject

This is consistent with evidence showing that interactive media and digital storytelling can strengthen early literacy, empathy, and collaborative skills when used intentionally (Bus et al., 2020; Herodotou, 2020). Problem-solving skills (r=0.823) and attention and concentration (r=0.762) also showed strong relationships, highlighting the role of technology in promoting sustained focus and supporting logical reasoning. Interactive apps, educational games, and coding platforms can provide developmentally appropriate challenges that encourage experimentation and perseverance (Papadakis et al., 2022). Similarly, the positive correlations with numeracy skills (r=0.672) and memory and recall (r=0.577) suggest that digital literacy contributes to children's ability to acquire and retain knowledge, understand number concepts, and apply learning in different contexts. Recent research emphasizes that when digital tools are designed with clear pedagogical goals, they can scaffold counting, sequencing, and working memory (Cheung & Slavin, 2021). These findings underscore the importance of supporting digital literacy from early childhood. Schools should integrate purposeful technology use into the

curriculum and provide high-quality, evidence-based digital resources that align with instructional objectives. Professional development for teachers should build capacity to use digital tools effectively and responsibly while promoting critical evaluation and safe online behavior. Lastly, policymakers and school leaders should address barriers to access so that all learners, regardless of background, can benefit from the cognitive gains associated with strong digital literacy skills.

4. Conclusion

The study shows that technology, good learning habits, and strong digital skills all help improve children's thinking and learning abilities. When students use quality educational tools and stay engaged, they perform better in reading, counting, problem-solving, and even understanding emotions. Teachers observe that digital devices make lessons more engaging and assist students in focusing and retaining information more effectively. To support this growth, schools should provide training for teachers, ensure access to quality technology, and create positive learning environments. By doing so, all children, regardless of their background, can develop the skills necessary to succeed in school and in life.

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

Copyright:

References

Barzilai, S., & Blau, I. (2021). Fostering children's critical thinking and learning through digital media: A developmental perspective. *Computers & Education, 172*, 104268.

Best, J. R. (2020). Executive functions and academic achievement in early childhood: A review. *Early Childhood Research Quarterly, 54*, 61–71.

Blair, C., & Raver, C. C. (2019). School readiness and self-regulation: A developmental psychobiological approach. *Annual Review of Psychology, 70*, 711–735.

Blanchard, S., Vandenbroeck, M., & Perrenoud, M. (2021). Problem-solving in early childhood: Integrating play and technology for 21st-century learning. *Early Education and Development, 32*(8), 1264–1280.

Blasiman, R. N., & Was, C. A. (2018). Why is working memory performance unstable? A review of 21 factors. *Europe's Journal of Psychology, 14*(1), 188-231. https://doi.org/10.5964/ejop.v14i1.1472

Bond, M., Zawacki-Richter, O., & Nichols, M. (2020). Revisiting five decades of educational technology research: A content and authorship analysis. *Educational Technology Research and Development, 68*(5), 2301–2324.

Bus, A. G., Takacs, Z. K., & Kegel, C. A. (2020). Affordances and limitations of electronic storybooks for young children's emergent literacy. *Developmental Review, 62*, 100911.

Cheung, A. C. K., & Slavin, R. E. (2021). The effectiveness of educational technology applications on mathematics achievement in K–12 classrooms: A meta-analysis. *Educational Research Review, 32*, 100384.

Chou, M. (2022). Digital learning and young children's cognitive outcomes: A meta-analytic review. *Computers in Human Behavior, 134*, 107291.

Daniel, G. (2023). Digital tools in early education: Enhancing cognitive and emotional development. *Journal of Early Childhood Research, 21*(2), 145–160.

Diamond, A., & Ling, D. S. (2020). Review of the evidence on the importance of executive functions for early learning. *Child Development Perspectives, 14*(1), 12–19.

Dore, R. A., Hopkins, E. J., & Toub, T. S. (2021). Technology and executive function in early childhood. *Developmental Psychology, 57*(5), 693–706.

Falloon, G. (2020). From digital literacy to digital competence: the teacher digital competency (TDC) framework. *Educational Technology Research and Development, 68*, 2449-2472. https://doi.org/10.1007/s11423-020-09767-4

Garcia, L. (2023). Technology and cognitive learning outcomes: Evidence from early education programs. *Journal of Educational Research and Practice, 13*(2), 65–78.

Gleason, B., & Greenhow, C. (2020). Hybrid education: The potential of teaching and learning with social media. *New Directions for Teaching and Learning, 144*, 37–54.

Gunes, E., & Gokcearslan, S. (2021). Digital distraction and attention in young learners: Effects of screen time on cognitive control. *Computers in Human Behavior, 123*, 106857.

Herodotou, C. (2019). Young children's learning with touchscreen technologies: The role of parental engagement. *British Journal of Educational Technology, 50*(2), 814–828.

Herodotou, C. (2020). Social-emotional learning through digital play: Lessons from touchscreen technology use. *Computers & Education, 146*, 103751.

Horner, S. L., & Shwery, C. S. (2021). Interactive phonics and literacy acquisition in digital learning contexts. *Reading Research Quarterly, 56*(4), 801–819.

Huang, R., Teo, T., & Zhou, M. (2020). Ubiquitous learning environments: Pedagogical foundations and applications. *Educational Technology & Society, 23*(2), 1–14.

Hwang, G. J., Lai, C. L., & Wang, S. Y. (2020). Trends and research issues of mobile learning studies in early childhood education: A review of selected journals from 2010 to 2019. *Interactive Learning Environments, 28*(4), 385–403.

Kim, J. (2021). The impact of digital learning on students' cognitive engagement and achievement: A meta-analysis. *Journal of Educational Computing Research, 59*(3), 496–519.

Kucirkova, N. (2021). *The future of early literacy in a digital world*. Cambridge, UK: Cambridge University Press.

Kucirkova, N., & Falloon, G. (2020). Digital storytelling and early literacy: A meta-analysis. *Early Child Development and Care, 190*(3), 406–418.

Lai, J. W. M., & Bower, M. (2020). How is the use of technology in education evaluated? A systematic review. *Computers & Education, 153*, 103896.

Li, C., & Lalani, F. (2020). *The COVID-19 pandemic has changed education forever*. Geneva, Switzerland: World Economic Forum Report.

Lim, S. (2023). Interactive whiteboards and learner engagement in early childhood education. *Journal of Educational Technology Development and Exchange, 16*(1), 45–59.

Liu, H., & Long, Y. (2022). Digital learning environments and early childhood cognitive development. *Journal of Learning Analytics, 9*(1), 87–102.

Liu, Y., Peng, P., & Chen, X. (2021). Digital literacy and cognitive development in early learners: A longitudinal study. *Early Education and Development, 32*(6), 879–893.

Livingstone, S., Stoilova, M., & Nandagiri, R. (2021). *Children's data and privacy online: Growing up in a digital age*. London, UK: The London School of Economics and Political Science.

Mace, R., & Lee, J. (2021). Adaptive learning systems and cognitive development in elementary education. *Computers & Education, 174*, 104310.

Mayer, R. E., Fiorella, L., & Stull, A. (2020). *Multimedia learning in the digital age*. Cambridge, UK: Cambridge University Press.

Meltzoff, A. N., Kuhl, P. K., Movellan, J., & Sejnowski, T. J. (2021). Foundations for a new science of learning. *Science, 325*(5938), 284–288.

Morrison, F. J. (2022). *Cognitive development and early education: Integrating theory, research, and practice*. London: Routledge.

Neumann, M. M. (2020). Using tablets and apps to support emergent literacy. *Early Child Development and Care, 190*(1), 97–107.

Neumann, M. M., & Neumann, D. L. (2019). Digital technology use by and with young children: A systematic review for early childhood education. *Computers & Education, 128*, 227–242.

Ng, W. (2021). Critical digital literacy in the early years: A framework for teaching and learning. *Computers & Education, 168*, 104176.

Noland, K. (2024). Digital media and cognitive development: A review of new evidence. *Contemporary Educational Psychology, 70*, 102121.

Palaigeorgiou, G., & Papadopoulou, A. (2021). The use of interactive media to support early learning: A systematic review. *Early Childhood Education Journal, 49*(4), 589–602.

Pane, J. F. (2020). *Adaptive learning in K–12 education: Evidence and opportunities*. Santa Monica, CA: RAND Corporation.

Papadakis, S., Kalogiannakis, M., & Zaranis, N. (2021). Teaching mathematics with mobile devices and the Realistic Mathematical Education (RME) approach in kindergarten. *Advances in Mobile Learning Educational Research, 1*(1), 5-18.

Papadakis, S., Zaranis, N., & Kalogiannakis, M. (2022). Digital games and problem-solving in early childhood: A systematic review. *Educational Media International, 59*(2), 93–111.

Ponce, C. (2021). Technology-enhanced learning and early cognitive outcomes: Challenges and opportunities. *Computers in the Schools, 38*(3), 220–238.

Revelle, G. (2020). Technology and cognitive development in early childhood: A design-based research approach *Early Education and Development, 31*(2), 152–170.

Richland, L. E., Burchinal, M. R., & Schneider, W. (2019). Educational neuroscience and early cognitive development. *Child Development, 90*(4), 1108–1125.

Schmitt, S. A., Pratt, M. E., & McClelland, M. M. (2021). Linking cognitive and social–emotional development in early childhood. *Child Development Perspectives, 15*(3), 166–172.

Segers, E., & Verhoeven, L. (2020). Technology and reading comprehension: Effects of adaptive digital learning tools. *Journal of Computer Assisted Learning, 36*(5), 732–744.

Singh, R. (2022). Understanding the digital divide: Implications for early cognitive development. *Early Child Development and Care, 192*(5), 733–748.

Smahel, D., Machackova, H., & Mascheroni, G. (2020). *Digital childhoods: Technology, the Internet, and children's well-being in the modern world.* London: Routledge.

Trust, T., & Whalen, J. (2020). Should teachers be trained in digital instruction? Lessons from COVID-19. *Journal of Technology and Teacher Education, 28*(2), 189–199.

Verschaffel, L., Depaepe, F., & Torbeyns, J. (2020). Problem-solving in early mathematics education: The role of digital tools. *Educational Psychologist, 55*(3), 155–168.

Wu, Y. T., & Huang, Y. M. (2022). Interactive learning environments and cognitive development among primary students. *British Journal of Educational Technology, 53*(4), 1076–1090.

Yeh, Y. C., Hung, C. M., & Hsu, S. H. (2021). Digital games and memory retention in young learners: Evidence from a quasi-experimental study. *Computers & Education, 166*, 104151.

Zelazo, P. D. (2015). Executive function: Reflection, iterative reprocessing, complexity, and the developing brain. *Developmental Review, 38*, 55-68. https://doi.org/10.1016/j.dr.2015.07.001

Zhang, D., & Xin, Y. (2022). Digital learning tools and early numeracy development: A meta-analysis. *Early Education and Development, 33*(7), 1158–1175.

Zhang, J., Trussell, R. P., Gallegos, B., & Asam, R. R. (2020). Using technology to engage students with learning disabilities in early education. *Journal of Research on Technology in Education, 52*(2), 1–17.