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Technology Use in Early Childhood

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A Literature Review Presented
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Abstract

This literature review examines the influence of technology on early childhood development. It uses scholarly journals and articles to show the benefits and risks of technology use and how it can be used to compliment growth, development, and learning of young children. It also examines how technology can impact the early childhood developmental domains of: (a) social emotional, (b) cognitive, (c) physical motor, (d) language and literacy, and (e) mathematics. The influence of technology use on teaching and the family are also addressed. Furthermore, this literature review includes implications for the future, continuing research, and recommendations from the American Academy of Pediatrics (AAP), The United States Department of Education (DoEd), and The National Association for the Education of Young Children (NAEYC) & The Fred Rogers Center for Early Learning and Children's Media.

Keywords: technology, early childhood, growth, and development

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Technology Use in Early Childhood

Easy access to technology has created new conditions for learning and development in the early childhood setting. The broad issue examined in this literature review is the use of technology in early childhood; its benefits and risks; and how it can be used to compliment growth, development, and learning. More and more children, even those in economically challenged homes, are using technology such as mobile devices daily (American Academy of Pediatrics [AAP], 2016). One study spanning 8 years, found that in 2009 almost every home had a computer with broadband internet; at least one television, mobile phone, or gaming console; and multiple forms of technology created specifically for kids such as dolls, toys, digital books, DVD's, video games, mp3 players, and cameras (McPake et al., 2013). This was prior to the influx of touchscreen devices such as iPads and smartphones. The prevalence of technology and media in the daily lives of young children and their families—in their learning and in their work—will continue to increase and expand in more ways than we can predict (National Association for the Education of Young Children [NAEYC] & The Fred Rogers Center, 2012).

Technology and media are omnipresent, and they are becoming an integral part of daily life. Technology use has increased radically in recent years because computer intelligence and the use of touch as a mode of interaction is becoming the norm in most households (Bedford et al., 2016). The proliferation of touch screen devices has made technology readily available and operational by children before they get to school. Research confirms the prevalence and rapid increase of touchscreen use over the first three years of life (Bedford et al., 2016). Children engage with technology from an early age. It is important to understand how they participate with others to solve problems, achieve goals, and learn new strategies and knowledge. In recent years, the production and availability of mobile devices has outpaced the research concerning

future developmental concerns and pedagogy in the classroom (Fleer, 2018). Teachers need to recognize and respond to the expertise children already have concerning technology (McPake et al., 2013), build upon the knowledge children come to school with, and realize that prior knowledge reflects the changes in the home due to technology. This is backed by the NAEYC & The Fred Rogers Center's (2012) statement that children's experiences with technology and interactive media are an increasingly part of the context of their lives, which must be considered as part of the developmentally appropriate framework.

The NAEYC & The Fred Rogers Center (2012) note in their position statement on technology that not all screens are created equal. With technology being prevalent in society, the debate now moves beyond the argument of whether children *should* use technology to how technology *can* be used to enhance growth and development. There are still multiple developmental and health concerns for young children using all forms of digital media in excess (AAP, 2016). Everyday participation in a global society demands communication through multiple modes of interaction and collaboration (Fantozzi et al., 2018). The United States Department of Education (DoEd, 2021) states that the thoughtful use of technology by parents and early educators can engage children in key skills such as play, self-expression, and computational thinking, all of which will support later success across all academic disciplines and help maintain young children's natural curiosity. Educators need the understanding, skills, and ability to use technology to improve learning and prepare young children for a lifetime of technology use (NAEYC & The Fred Rogers Center, 2012).

The purpose of this literature review is to gain knowledge in the ways technology is influencing development and learning and how to successfully implement technology with early childhood students and their families in ways to support learning. This knowledge will improve

teaching, learning, and collaboration with students and families. This literature review will examine several areas of early childhood development including social-emotional, cognitive, physical motor skills, language and literacy, and mathematics. The overall potential benefits and risks associated with technology use will be addressed for each developmental area. The literature pieces in this review are peer-reviewed research journal articles found in databases in the DeWitt Library, as well as suggestions and guidelines for home and classroom technology use from the American Academy of Pediatrics (AAP), the United States Department of Education (DoEd), and the National Association for the Education of Young Children (NAEYC) & The Fred Rogers Center for Early Learning and Children's Media.

Review of the Literature

Technology and Social-Emotional Development

Children today have been described as digital natives and viewed as a generation of digital technology and the internet (Sharkins et al., 2016). Recent studies concerning technology use in preschool have begun to show that learning occurs through social interaction and gameplay (Danby et al., 2018; McPake et al., 2013). Flewitt (2015) reported that making digital animation promotes self-regulation and other key psychosocial regulatory processes such as turn taking, which are critical in early childhood development. Early childhood is a critical time for social-emotional development, and researchers have indicated that creating digital animation enriched the play opportunities for students, which in turn promoted more complex play and increased social and cognitive demands on children (Fleer, 2018; Flewitt et al., 2015). Crompton et al.'s (2018) study provided an alternative perspective of technology using a humanoid robot in the classroom, and it was noted that the students displayed enthusiasm and excitement, as well as having to practice taking turns, cooperating, and other social skills. During the study the following of social rules was documented as the students knelt to the robot's level, made eye contact, and developed a two-way relationship with the robot (Crompton et al., 2018).

Another example of the intersection of social-emotional development and technology is from Maureen et al.'s (2020) study, where digital storytelling was shown to enhance the child's ability to communicate about his/herself to others. In that study, Maureen et al. (2020) also noted that digital storytelling helped self-identity development and conversation skills. Researchers agree that digital storytelling has been shown to encourage vocabulary knowledge in early childhood, which is essential for verbal expression and communicating with others (Maureen et al, 2018; Maureen et al, 2020; Teepe et al., 2017). Oakley (2020) also noted that technology

enables children to interact and collaborate with each other and give the students a voice.

Another study in agreement was conducted by O’Byrne et al. (2018) using *The Emerging Digital Storytellers* instructional model, which focused on social-emotional skills and finding student voice. The study noted that emergent digital methods are changing the nature of storytelling and opening new possibilities for collaborative approaches.

Digital storytelling can generate interest and motivation and facilitate learning of complex subject matter (Maureen et al., 2018). Research on this topic has indicated increased motivation, especially among children who were not easily engaged in traditional tasks (Miller, 2018; Ralph, 2018). The children in the studies were engaged and motivated in their learning and were observed helping each other (Miller, 2018; Ralph, 2018). A study by Ackermann (2017) showed children were motivated by technology and thoroughly enjoyed using the tablet as a drawing and writing tool. The opportunity to create digital stories allowed children to share what they know about themselves, how they learn, and how they perceive themselves within a community (Kervin & Mantei, 2016). Yet another example of student motivation came from Fokides’ (2018) study that reported student views, engagement, and motivation increased while using technology. Flewitt (2015) noted all the new possibilities using technology, mainly how imagination, storytelling, and role-playing, transformed into digital form is very motivational.

McPake (2013) demonstrated that whereas play and exploration in the early years enables children to become part of a small community, in today’s digital homes children become part of a larger social community. Research has shown that young children exhibit a sparked interest in media, technology, and screens and that their observations of siblings’, parents’, and older children’s’ interactions with technology facilitated exploration in content areas, such as reading (Maureen et al., 2020; McPake et al., 2013). Ralph conducted a study in 2018 that showed peers

have strong social influences during development and can sometimes determine actions. In early childhood, peers can include parents, teachers, siblings, and peers at school (Ralph, 2018). In a similar study that examined home technology use by Carson & Kuzik (2021), social-emotional development was documented using a parent survey (Child Self-Regulation and Social Behavior Questionnaire). The results revealed that electronics, especially phones interrupt parent-child conversations and activities multiple times per day (Carson & Kuzik, 2021). The research demonstrated that peer modeling can be motivating, but also reminds us that there are still concerns.

The AAP (2016) cautions about using technology to soothe or calm an upset child asserting that children need to experience daily disappointment and frustration, so they learn to regulate emotions independently. The AAP (2016) also recommends that children should not use technology alone. Research confirmed this assertion and stressed the importance of adult support to choose and monitor developmentally appropriate usage of technology (Carson & Kuzik, 2012; Danby et al., 2018; Fleeer, 2018; McPake et al., 2013). Research also suggested that avoiding social media and technology was becoming just as controversial as using media and technology in early childhood classrooms (Ralph, 2018). Kervin & Mantei's (2016) research provided insight on ways to help children transition to new communities like kindergarten and support children to ultimately make decisions about who they want to be in their communities.

Ralph's study in 2018 focused on social exchanges and social learning theories. The researchers were interested in possible negative effects of bullying, antisocial behavior, and overstimulation. The results did not reveal evidence of these negative effects; instead, positive social behavior was observed and documented (Ralph, 2018). Research has shown that technology does not isolate children, but that all participants exhibited prosocial and nonsocial

behaviors. The prosocial group behavior was the most common, with 73% of total behaviors. Antisocial behaviors were the least with 2.6%. Overall, prosocial behaviors outnumbered antisocial or nonsocial behaviors at about 80% to 20%, respectively (Ralph, 2018). It was noted that antisocial behaviors were mostly due to reactions and trying to control the device, and despite some antisocial moments, overall, there were more manifestations of prosocial behaviors, nearly four times more, than antisocial behaviors (Ralph, 2018). Although these results are positive, more research is needed in this area.

In general, the studies noted all children worked together toward solving problems (Danby et al., 2018; Flewitt, 2015; Miller, 2018). In such a peer-oriented culture, the students creatively explore, collaborate, and communicate while sharing knowledge and engaging in game playing activities (Danby et al., 2018). Miller (2018) also noted that children naturally gravitate towards each other to share what was on their iPad or to help each other advance their work or problem solve. Ralph (2018) confirmed the presence of peer culture while documenting that the children wanted to show their created drawings or animations to hear praise and feedback from their classmates or teacher. When some children observed the researcher praising one child for sharing, the other child would share as well, which demonstrated social learning (Ralph, 2018).

In summary, the research showed that creating digital stories using tablets appeared to increase children's confidence in themselves; increase their willingness and ability to collaborate with others; understand their surroundings; and develop a sense of community (Kervin & Mantei, 2016; Oakley et al., 2020). Similarly, making digital animation in the context of role-playing enriches play-based programs and provides new developmental conditions for learning (Fleer, 2018). Fantozzi (2018) described that at the intersection of play and technology lie

opportunities for children to become creators, collaborators, and communicators, which are crucial identities for 21st century digital literacies.

Technology and Cognitive Development

There have been debates amongst researchers, educators, and parents alike as to what and how much technology is appropriate for young children to be exposed to and the possible influences on their developing bodies and minds. Studies provide evidence that technology can provide opportunities to practice executive functioning skills, such as working memory, inhibitory controls, emotion regulation, and language (Bedford et al., 2016; Carson & Kuzik, 2021). Bedford et al.'s (2016) research implied that screens provide sensory and cognitive stimulation experiences and become easier and easier to use as children develop their cognitive executive functions and are able understand what is being manipulated on the screens. In the same way that communication and creative expression are precursors to literacy, digital technologies such as computers, mobile phones, technological toys, and games have been found to contribute to young children's operational skills, knowledge, and increased understanding of the world (McPake et al., 2013).

In early childhood, the development of critical thinking is supported by enhancing children's ability to plan and predict, and research shows that multimodal activities, like digital storytelling, encourages critical thinking skills (Maureen et al., 2020). Several researchers agreed that technology also created new cognitive demands and developmental conditions for learning, and that making digital animation and planning stories promoted self-regulation and motivation (Fleer, 2018; Flewitt et al, 2015; Maureen et al., 2020). It was also documented that these opportunities to explore objects in various learning areas promotes scientific thinking, as well as vocabulary development (Lippard et al., 2019). The cognitive skills dimension of digital literacy

includes critical thinking and multi-modality, indicating that communication and representation is more than just about language (Maureen et al., 2018). Research showed that in order to be literate, today's children need to develop a range of digital skills and knowledge (Maureen et al., 2018).

Jusienè et al. (2020) provided an alternative perspective on technology and cognitive learning. The study documented how the interactivity of content allowed children to experience digital realities as if they were part of their own realities. Flewitt et al. (2015) also noted that this type of *what if* play was evident in digital play and affords new thinking for children. In two different studies, children were observed interchanging or substituting different aspects of digital and real-life experiences. Video games would become playground games and real contexts would be transferred to creative play and digital animation (Danby et al., 2018; Fleeer, 2018). In Crompton et al.'s (2018) study, a robot was introduced into preschool classrooms, and students were intellectually curious about the robot, eager to talk with and generate questions, make eye contact, and learn more about the robot while developing a two-way relationship. In yet another study, children were motivated by their own cognitive development in which they understand the importance of sharing or sociocultural theory (Ralph, 2018).

Spatial input is important to early spatial language development. Spatial language is part of a symbolic system that embodies our thoughts and concepts. According to Ho et al. (2018), spatial language is a tool to direct children's learning to encoding and understanding spatial concepts such as location or features of an object and relations between items. A supporting and influential study by Lippard et al. (2019) looked at *Six Engineering Habits of Mind*, and how technology affects them. Systems thinking encourages higher order thinking as children seek to identify and understand interconnectedness and how materials relate to one another and the

whole system. Systems thinking is about identifying and exploring interconnectedness of materials, and Lippard et al.'s (2019) research showed how this is important for literacy and math because it relies on children's abilities to recognize individual parts. Lippard et al. (2019) documented that children's engineering habits of mind (pre-engineering thinking) occurred throughout the classroom and stressed the importance of providing adequate time to explore and combine a variety of materials. Another researcher concurred that the teacher's use of interactive whiteboards allows students to visualize multiple representations, compare, and map relationships between different variables (Sören & Gunilla, 2020). Miller's (2018) study asserts that in the next era of educational technology, the iPad will be a manipulative that children can choose from a host of other manipulatives to discover new concepts and develop pre-engineering thinking and cognitive executive functioning skills.

Despite fears of technology having a negative impact on cognitive development, empirical evidence is lacking to support any negative associations (Bedford et al., 2016). In contrast, Crompton et al.'s (2018) study found that technology use promoted learning in all early childhood developmental areas and provided a novel learning stimulus. Future research is necessary to consider both the time and content of screen-based media and to explore the developmental interactions between screen use and executive functioning from a longitudinal perspective (Jusiené et al., 2020).

Technology and Physical Motor Development

Research has confirmed that there has been an incredible increase in touchscreen usage in the first 3 years of life and many children have daily exposure (Bedford et al., 2016). Research has also begun to show evidence and insight into how technology could have a positive influence on physical development (Bedford et al., 2016). The Papadakis et al. (2018) study produced

evidence that devices permitted very young children to engage interactively in an intuitive fashion with actions as simple as touching, swiping, and pinching. Studies in agreement showed early touchscreen use, including functions such as scrolling, are associated with early fine motor development (Bedford et al., 2016; Fantozzi et al., 2018). Bedford et al.'s (2016) research documented no significant associations between the age of first touch screen use and either gross motor or language development. In the study, young children demonstrated motor development by: (a) 16% banging of the screen, (b) 71% tapping, (c) 41% dragging, (d) 20% swiping, and (e) 10% pinching (Bedford et al., 2016). Concerns were expressed about ease of use affecting fine motor development, but research showed a connection for children who used touchscreens and the ability to do fine motor skills like stacking blocks. However, it is not known if touchscreen use influenced development or if those naturally advanced are successful on touchscreens (Bedford et al., 2016).

The pencil has always been considered as the main tool for writing, but some children find it tiring and even challenging, so it may be an obstacle; however, writing with digital technology may engage those students (Dunn & Sweeney, 2018; Oakley et al., 2020). Research has found evidence that writing multimodally using tablets allowed children to express themselves and tell stories, even if their handwriting and drawing skills are not well developed, they experienced success (Oakley et al., 2020). Technology has also been found to help reluctant writers and students with various disabilities (Dunn & Sweeney, 2018). Gestural interfaces allowed for embodied interactions and the children used their fingers in naturalistic ways (Disney et al., 2019). The evidence showed that the children improved in all abilities after playing the highest-rated apps via a gestural interface device (Disney et al., 2019). From another perspective, students with autism spectrum disorder showed that virtual manipulatives may be

preferred because of their lack of fine motor skills. Evidence showed more rapid gains in independence with virtual manipulatives (Bouck et al., 2014).

While play supporting physical development is a concept many preschool teachers are familiar with and supportive of, technology in the preschool classroom may not be. This might be due to teachers' lack of experience or professional development in bringing technology into the classroom in meaningful ways or concerns about children's exposure to passive screen time (NAEYC & The Fred Rogers Center, 2012). However, the use of digital media is not always passive. Fantozzi et al.'s (2018) research showed young children are most likely have access to several screens and devices at any one time. The teachers in Crompton et al.'s (2018) study provided examples of integration for all domains of learning, including physical development. The students were eager to copy the robot's movements, dancing to the music and practicing balance and flexibility (Crompton et al., 2018). Research by De Vries (2013) documented that using technology for dancing, music, and movement is interactive music learning – drawing on multi-media for music learning experiences mirrors reality of home life and should be embraced by educators (De Vries, 2013).

Global readiness requires the use of technology that intentionally enhances play in the classroom and gives children opportunities to build new types of skills (Fantozzi et al., 2018). Studies have produced evidence that touchscreens have a positive effect on learning and preschoolers can learn from interactive gaming experiences on touchscreen devices (Fantozzi et al., 2018; Papadakis et al., 2018). An increasingly technological society affords children the opportunity to engage with new, exciting digital devices that can extend their learning in the home, the classroom, and the community. The DoEd (2021) suggests that children should acquire a certain technology 'readiness' – demonstrating basic skills in technology operations by

age 5. The NAEYC & The Fred Rogers Center (2012) suggest that while technology can afford a source for exploration and mastery, teachers and adults should provide a balance of activities that allow children to engage in authentic interactions in their surrounding environment.

Technology and Language and Literacy Development

A study by Fantozzi et al. (2018) on the effects of technology and literacy development noted that everyday participation in a global society demands communication through multiple modes and collaborative means, although these are often not reflected in the solitary acts of writing and reading that are common in most classrooms. Oakley et al.'s (2020) research indicated that there may be value in building the reading and writing connection in the early years, through the creation of multimodal texts using tablets. These results suggest that the use of tablets in the early years may have the potential to contribute to improving literacy skills (Fantozzi et al., 2018; Oakley et al., 2020). In this regard, technology is perceived to enhance understanding and increase meaning using symbols, pictures, and videos (McPake et al., 2013). Researchers are reporting that literacy development should no longer be limited to traditional text-based reading and writing (Maureen et al., 2020; McPake et al., 2013; Oakley et al., 2020) and digital technologies have the potential to facilitate communicative and creative tasks in young children's literacy learning experiences (Fantozzi et al., 2018; McPake et al., 2013). A study by Danby et al. (2018) concurs with these findings and adds that gaming is a rich resource for learning literacy.

Results from a study by Kervin & Mantei (2016) showed that the opportunity to create digital stories gave children the ability to grow in their language and literacy development. This study was backed up by Maureen et al.'s (2018) study, which found that digital storytelling enhances literacy development. Structured storytelling, both traditional and digital, significantly

enhances literacy skills for early childhood students, and contributes to future reading and writing skills (Maureen et al., 2020). Maureen et al. (2018) also noted that when storytelling is combined with play-based activities, it can provide an effective stimulus for early literacy growth. In Maureen et al.'s (2020) study, digital storytelling activities had a significant, positive effect on literacy skills development compared to the control group, and other researchers report that they observed many improvements in the children's literacy, mostly oral language skills, listening skills, and ability to construct and respond to questions and oral retelling (Kervin & Mantei, 2016; McPake et al., 2013).

Digital storytelling is supported by a variety of multimedia tools, as it combines a mixture of graphics, text, recorded audio narration, and video and music to present information on a specific topic using technology (O'Byrne et al., 2018). O'Byrne et al. (2018) suggests the ubiquity of digital texts and tools that can be used to manipulate information and improve student education is increasing every day. Results from O'Byrne et al.'s (2018) research shows that digital storytelling supports student learning by encouraging children to organize and express ideas and knowledge in an individual and meaningful way while developing voice and facility in child-computer interactions. O'Byrne et al. (2018) also found that digital storytelling helps develop traditional communication skills by learning to organize ideas, ask questions, express opinions, and construct narratives as children interact with others and computers in the creation of digital stories. A similar study by Teepe et al. (2017) found that technology-enhanced storytelling stimulated active engagement and created parent-child interactions and can be a promising tool for fostering parent-child interactions and vocabulary development.

Using iPads for teaching writing creates a fun and engaging mode of learning for the students (Dunn & Sweeney, 2018). In Dunn & Sweeney's (2018) study, the children were

vociferous in their views about using iPads to assist engagement in multimodal writing that was more exciting and meaningful. The study showed students were tired and bored with the typical tool (a pencil) when it came to writing, but when allowed to use digital tools, they were motivated and engaged (Dunn & Sweeney, 2018). Researchers noted that even reluctant writers were engaged, and poor spellers felt more confident because of the spell check support from the device (Dunn & Sweeney, 2018). Oakley et al.'s (2020) research supported the notion of higher confidence by documenting that the children were more likely to edit stories more readily in a digital form and were more motivated to complete tasks to a higher standard. Dunn & Sweeney's (2018) research shows that using iPads to teach compositional writing is beneficial in allowing children greater choice and creativity. Everyone has success with an iPad when it is there to scaffold learning.

Research indicates vocabulary development is very important for children, including expressive and receptive language (Vatalaro et al., 2018). The AAP (2016) states toddlers as young as 15 months can learn new vocabulary from educational apps. They also purport that video chat can be interactive and regular use can promote oral language development (AAP, 2016). Research by Teepe et al. (2017) documented that the use of technology significantly improved productive vocabulary in children. Other studies concur that using digital devices daily can enhance language abilities in young children (Crompton et al., 2018; Danby, 2018; Fantozzi, 2018). An alternate viewpoint by Fantozzi (2018) found that digital devices help students with speech delays interact cooperatively with peers. Another study on vocabulary growth by Crompton et al. (2018) asserted that non-humanoid robots are effective in helping students learn vocabulary in a natural and authentic manner, and research by Danby (2018) concluded the

children used multimodal resources and rich language to communicate while engaging in daily activities.

Flewitt et al.'s (2015) research revealed that another benefit of using technology is oral communication skills development and the ability to retell a story in sequential order, as students were observed setting the scene in sequence using a device. Similarly, pre- and post-tests of literacy scores in Oakley et al.'s (2020) study suggest that aspects of reading had improved by using iPads. For example, comprehension and learning sight words increased due to videos, animations, and sounds students saw and heard when using technology; children's oral language skills also improved (Oakley et al., 2020). Specifically, research confirmed the use of technology-enhanced storytelling stimulated active child verbal participation and positively affected children's vocabulary, as positive gains were evident after two sessions (Teepe et al., 2017). Technology-enhanced storytelling is simply an adult and child using a digital storybook, with the adult reading it to the child in a traditional way, asking stimulating questions and encouraging read-aloud interaction. Teepe et al.'s (2017) study found that technology-enhanced storytelling contributes to a more complete understanding of already receptively known word meanings. Receptive language is understanding words as they are heard or read and expressive language is when words are mentally retrieved and expressed aloud (Vatalaro et al., 2018). Teepe et al.'s (2017) research found that technology-enhanced storytelling was an effective learning context for both the parent/adult and child and lead to growth in both receptive and expressive language.

Dunn & Sweeney's research (2018) recommended rebalancing the teaching of reading and writing to be more multimodal. Vatalaro et al.'s (2018) research supports this by encouraging the use of apps that incorporate scaffolding-like lessons on vocabulary to increase

receptive and expressive vocabulary of children. Research by O’Byrne et al. (2018) claims that these skill sets should be developed at an early age to make these digital practices come alive in the classroom. Researchers documented young children using many digital tools including pictures, sound, music, camera, and scanners to create narratives (Dunn & Sweeney, 2018; O’Brien et al., 2018; O’Byrne et al., 2018). In addition, O’Brien et al.’s (2018) study found computer assisted instruction was effective in teaching letter-sound correspondence across participants, and frequency-building has potential benefits for teaching phonics to children diagnosed with autism spectrum disorder. O’Brien et al.’s (2018) study offers verification to the increasing empirical support for variations in instructional methods for all children including those diagnosed with autism spectrum disorder.

Although the AAP (2016) encourages technology use, they also warn frequent use may cause language delays, attention problems, and fewer daily lingual parent-child interactions. There is a general concern from researchers about the *displacement hypothesis*, which describes time spent on devices as time not spent doing other activities, including decreased physical and communicative interactions (Bedford et al., 2016; O’Brien et al., 2018). Bedford et al.’s study could not confirm or deny this hypothesis but suggested that language and literacy development hinderances may become a concern later in childhood.

The increasing integration of digital forms of reading and writing into everyday life suggests that the role of early digital literacy development is timely and important (Maureen et al., 2018). Maureen et al.’s (2018) study showed empirical evidence that a framework in which a blend of structured instruction with storytelling and play-based activities, both in oral and digital forms, can effectively support language and literacy development. The AAP (2016) asserts that Sesame Workshop and Public Broadcasting Service (PBS) applications have been shown to be

effective in teaching literacy skills to young children. Flewitt et al.'s (2015) research affirms this by asserting that iPad-based literacy activities offered opportunities for collaboration, communication, and independent learning, and stimulated motivation and concentration in the children. Research shows that incorporating touch screen devices into regular classroom routines offers promising opportunities for early literacy experiences (Flewitt et al., 2015).

Technology and Mathematics Development

The considerable potential of digital technologies to support students' learning of mathematics is well recognized by researchers (Bouck et al., 2014; Disney et al., 2019; Papadakis et al., 2018). Concepts of quantification, counting, and symbolic representation are important components of number sense that develop during the preschool and kindergarten years, and research has shown that these skills can be targeted in a games-based curriculum (Papadakis et al., 2018). The effectiveness of virtual manipulatives has been confirmed in typically developing students. Bouck et al. (2014) explored this research further and looked at whether virtual manipulatives are effective with special needs children. The results of the study concluded that both kinds of manipulatives helped all students accurately and independently solve math problems; however, participants demonstrated greater accuracy and faster independence with the virtual manipulatives compared to the concrete ones (Bouck et al., 2014). Bouck et al.'s research (2014) also found that beyond correctly solving problems, the students generalized their learning to more real-world applications, such as other classroom tasks and academic learning experiences.

Research by Papadakis et al. (2018) found that the link between mathematical practices and mathematical knowledge is strengthened in instructive situations that involve effective uses of technology with the use of developmentally appropriate software (Papadakis et al., 2018).

Disney et al.'s (2019) study agreed that play-based pedagogy and developmentally appropriate digital technology apps can influence each other and lead to digital play being integrated to enhance numeracy outcomes. Fokides (2018) researched the use of digital games for teaching math, and the results indicated that students in the games group outperformed, in most cases, students in other groups. Fokides (2018) also noted that the introduction of digital games in teaching did not disrupt the learning environment; rather it created a pleasant learning environment. Researchers reported that well-designed mathematics apps improved achievement and can support student learning (Disney et al., 2019; Fokides, 2018; Miller, 2018). The evidence also showed that guidance is necessary to promote selecting quality apps (AAP, 2016; Miller, 2018).

Research found many students have struggled in math and have a negative attitude about learning basic math facts and game-based learning could eliminate the negative mindset (Bouck et al., 2014; Fokides, 2018). In Bouck et al.'s (2014) study, the students showed excitement when using virtual manipulatives, and would request it, clap, smile, and point (Bouck et al., 2014). Papadakis et al. (2018) found evidence that the motivation and learning achievements of the tablet group were significantly better than those of the computer and control groups. Researchers also noted that iPads fostered small group and independent learning (Miller, 2018; Papadakis et al., 2018). There were small gains in achievement in Miller's (2018) study, but the results show using interactive technology promoted student collaboration and engagement, and enhanced mathematics learning. Research has shown that interactive whiteboards also have the potential to improve students' conceptual understanding and contributed to student discussion and collective construction of mathematical understanding (Papadakis et al., 2018).

Although there is still not enough empirical data to support claims that digital technology does or does not improve children's learning, digital technology can be used to support positive outcomes for early childhood numeracy learning (Disney et al., 2019). Despite the absence of significant gains between the two groups, Miller's (2018) study provides evidence that using technology in this context did not deter or lessen children's development of numeracy skills. Papadakis et al. (2018) assert that digital technologies may have the potential to transform the way mathematics could be taught and learned with the assimilation of the technologies to existing classroom practices. The findings support computers, especially tablets, when combined with the use of developmentally appropriate software and used in daily routines, may provide substantial contribution to early childhood students' comprehension of numbers and mathematical concepts (Papadakis et al., 2018).

Teaching with Technology

Research suggests that children's positive early Science Technology Engineering and Math (STEM) experiences in school are crucial to ensure that a more diverse population are prepared for careers in an increasingly technological world (Lippard et al., 2019). The data from Crompton et al.'s (2018) study showed that teachers believe exposing students to technology in the early childhood classroom positively impacts future academic success and career interests. Lippard et al. (2019) agreed early exposure is important, as research reveals the emergence of a STEM gap by kindergarten. The guidelines for developmentally appropriate use of technology promote opportunities for children to engage in creative, open-ended activities (NAEYC & The Fred Rogers Center, 2012), and creates pedagogical opportunities to promote learning in all domains (Crompton et al., 2018),

Increasing access to technology has created new modes of curricular and pedagogical engagement. Ackermann's (2017) study found that modeling is the key to helping kids understand the creative power of the technology. Teaching how to be a learner with technology increases the capabilities for learning. The AAP (2016) encourages teachers to use new technologies in creative ways to promote a healthy learning environment. Although technology use is widely encouraged, researchers' combined recommendations stressed that technology tools should not replace traditional methods (Ackermann, 2017; AAP, 2016; Dunn & Sweeney, 2018; NAEYC & The Fred Rogers Center). Dunn & Sweeney (2018), as well as the AAP (2016) believe technology use can be balanced in both the home and school environment and encourage teachers to take a balanced approach, using both traditional and new pedagogical approaches to instruction.

Most children will come to school with various amounts of knowledge from prior exposure and experiences, including technology (McPake et al., 2013). Oakley et al. (2020) noted that teachers always build on funds of knowledge that children come to school with, which should include technical knowledge. McPake et al. (2013) described how this shared learning through exploration and discovery can be compared to first interactions with any traditional tool of early childhood education such as paint, clay, and crayons. Fokides' (2018) research confirmed that technology provides an interesting, alternative learning method or style, and is a positive force in child development. Interestingly, Sören & Gunilla's (2020) research found that teachers' active participation and enjoyment were important steps in helping students fulfill learning activities in engaging ways, and scaffold children's learning at a higher level.

The possibilities of multimodal learning opportunities are very important for young children in communicating in ways that are meaningful and enabling (Dunn & Sweeney, 2018).

O'Byrne et al.'s (2018) research noted young children construct knowledge of their world through the stories they hear and participate in. O'Byrne et al. (2018) asserts that the creation of digital stories in the classroom is a powerful instructional technique that has the potential to transform learning for students. Flewitt et al.'s (2015) research agreed that digital play activity of children framed through pedagogical practices appeared to create new developmental conditions for learning (Flewitt et al., 2015). Researchers found that teachers talked about fun and enjoyment by pupils, and how digital learning is not seen as work by children because it is game based (Dunn & Sweeney, 2018; O'Byrne et al., 2018; Sören & Gunilla, 2020). A novel study by Crompton et al. (2018) explored teaching practices by using a humanoid robot in the preschool classroom. It was found that the robot provided opportunities for student development and learning in all early childhood developmental domains. Teachers in Crompton et al.'s (2018) study found the robot was a good tool in the classroom to align with curriculum requirements and to meet the development needs of the children.

Learning technology presents teachers with the challenge of equipping children with skills and knowledge needed to survive and thrive in current and future worlds (Fox-Turnbull, 2019). Fox-Turnbull (2019) explains that technology education is a learning area that deals with the ways people develop their technological environment to better suit their needs. Technology education should recognize and enable children to be mindful of the future as they use, critique, design, and develop technological outcomes. Kervin & Mantei (2016) concurred that technology allows opportunities for educators to make powerful pedagogical insights into children's learning, and for the children to give insights about their environment and learning to provide direction for future planning and teacher training. Lippard et al.'s (2019) research findings suggest that teachers may be best prepared to facilitate technology and engineering habits of

mind once they have had several years' experience and ongoing training. O'Byrne et al. (2018) also confirmed that ongoing professional development is needed to help educators build skill sets to understand digital tools, but also there needs to be a willingness of educators to play and explore uses on their own.

Many researchers agree that teachers need to continue professional development related to technology. There is a need for future teacher professional development in scaffolding and digital technology (Sören & Gunilla, 2020). Teachers need to continue their own learning about technology and how it affects children's positive engagement in literacy activities (Flewitt et al., 2015). Professional development is necessary for educators to stay up to date and confident (DeVries, 2013). Teachers lack experience and knowledge in the integration and operation of technology (Crompton et al., 2018), and thus require more training on the implementation of technology into everyday classroom experiences (Vatalaro et al., 2018). It is necessary to conduct further research into not only the teachers' attitudes and practices towards technology use, but also the children's learning when teachers are familiar with and trained to use it (Fox-Turnbull, 2019). Flear (2018) states that teachers' digital pedagogy and practices in free play settings need to be further researched to better understand the use and place of digital devices in the naturalistic preschool setting.

There is still much to learn about the quality and characteristics of apps that children gravitate to when left to choose in a play-based environment and their impact on children's learning (Miller, 2018). Sharkins et al. (2016) recommended that teachers make concerted efforts to assess the appropriateness of the types of media, technology, and screen time that children in their care are exposed to, and facilitate, when necessary, the education of parents regarding the critical benefits of parent-child interactive media, technology, and screen time engagement.

Research by Vatalaro et al. (2018) found that scaffolding-like apps worked well in the classroom because after the teacher introduced the apps to the children in small and whole group settings, the children could use them on their own or with peer assistance. Vatalaro et al. (2018) also noted that when apps are too difficult for children to use independently and have minimal embedded learning scaffolds, they may not be effective for learning. When choosing apps, educators should balance how much scaffolding is required to use an app both by adults and peers, and children should be observed using the apps (AAP, 2016; Vatalaro et al., 2018).

In summary, the evidence indicates that children's exposure to media, technology, and screen time has increased in the home and school settings (Sharkins et al., 2016). However, research has shown that using technology as a teaching tool benefits teachers and students in their understanding of technology, and an ability to have conversations with children enhances learning (Fox-Turnbull, 2019). Teepe et al.'s (2017) research suggests that teachers need to be aware of differences among parent-child relationships and how they engage with technology. Flewitt et al.'s (2015) research reminds teachers to intentionally create playful experiences that use technology as a facilitating or contributory tool. Technology alone cannot meet all the developmental needs of every student, but research is showing that it can be an influential piece of the puzzle for educators to make instruction and learning complete.

Family Involvement

The appropriateness of digital tools in young children's lives has been intensely debated (AAP, 2016; NAEYC & Fred Rogers Center, 2012). These debates often forget that parents are engaged in digital practices themselves and will introduce their children to digital media, even if only by proxy (AAP, 2016). Preschool technology tools may promote an early foundation for digital literacy, in which children learn appropriate ways of using technology for constructive

learning activities, rather than for mindless passive entertainment. According to the AAP (2016), families model technology uses daily, and McPake et al.'s (2013) research found that most children will come to school with prior exposure and experiences with technology.

Research by McPake et al. (2013) found families have a lot of influence with the types of technology used in the home and the functionality of those technologies in the family routine and experiences. Bedford et al.'s (2016) research showed that despite recommendations against independent touchscreen use by infants and toddlers, a majority of parents report letting their child use a device regularly. According to Ho et al. (2018) parents and caregivers should be cognizant of the fact that interacting with technology does not remove the importance of parental engagement to provide scaffolding to support children's learning throughout early childhood. The study by Carson & Kuzik (2021) found that there were approximately 12-16 parent-child technology interruptions per day, 60% of interruptions were smartphones, and 95% of the sample reported some type of parent-child interference. Sharkins et al.'s (2016) research findings add that parents and teachers from varied backgrounds agree on many issues pertaining to young children's media, technology, and screen time experiences; however, there appears to be a large range of in-home adult and child technology usage. Questions still exist for those that embrace early technology use, and how early it is required to start teaching digital citizenship and safety to young children.

Consequently, we cannot simply provide these tools and expect children to use them for creative expression on their own, without adult intervention (Ackermann, 2017). The AAP (2016) confirms that the evidence is sufficient to recommend time limitations on digital media use for children 2 to 5 years to no more than 1 hour per day to allow children ample time to engage in other activities important to their health and development and to establish media

viewing habits associated with lower risk of obesity later in life. Teepe et al. (2017) adds that promoting parent-child interaction quantity and quality is challenging, and technology enhanced storytelling is one way to stimulate positive parent-child interaction. According to Ho et al. (2018) there are few reliable resources for parents and caregivers to seek out educational applications based on formal evaluation of their educational content, so it is important for teachers to provide guidance. Research found that some children asked parents to download apps they use at school, and this provided links and opportunities for teachers to encourage quality use at home (Dunn & Sweeney, 2018). The DoEd (2021) advises that adults should strive to provide balance and moderation when using technology with children and when introducing technology to children, adults should model behaviors such as using technology to promote positive interaction instead of allowing it to interfere with interactions, designating and enforcing face-to-face time that is free of interruptions, and using technology together before allowing children to use it independently.

In a short time, access to mobile devices has dramatically increased and traditional TV watching, though still prevalent has declined (Teichert, 2017). Research has been done in many areas of technology use, including when young children (age 8 and under) are using devices, and some parents value new media and children's engagement with digital devices (Teichert, 2017). Teichert's (2017) study noted many parents felt that their children that use such devices were learning far more than skills such as dexterity or fine motor skills. The parents were proud of their child's digital literacy skills necessary to perform in society. Some mothers were concerned about the amount of screen time their children experience; however, they also expressed that they felt there were positive learning experiences tied to digital tool use (Teichert, 2017). According to Teichert (2017), parents report using technology devices for learning opportunities,

entertainment, and documenting life. The DoEd (2016) reminds us that technology use should unite families of young children to engage, communicate, learn, and create together.

Future Implications

With the increased adoption and dependence on technology use, the research seems to show that we need to utilize this potentially transformative learning opportunity. There is still not enough empirical data to support claims that digital technology does or does not improve children's learning (Disney et al., 2019; Dunn & Sweeney, 2018). Research also cautions that learning with digital technology may not be appropriate for all children (Dunn & Sweeney, 2018). Disney et al. (2019) noted that further studies are needed to determine if gestural interface screens were the determining factor as to why the children achieved higher outcomes. The results showed *that* children learned, not *how* they learned. There is agreement that further research should address fears that early exposure to touchscreen devices may negatively impact development, and that there is also a need for longitudinal studies about screen exposure time and content, and how interactive screens affect executive functioning skills (Bedford et al., 2016; Jusienė et al., 2020; NAEYC & The Fred Rogers Center, 2012). There is also agreement among researchers that there should be more research on the ability to focus and disengage attention as well as memory capabilities that influence how young children learn in play contexts (Ho et al., 2018; Maureen et al., 2020; McPake et al., 2013).

One researcher noted that longitudinal studies would better fulfill the students' need for learning and if used with a delayed post-test, such studies would also show whether the knowledge was retained into future grades (Papadakis et al., 2018). A wide body of literature supports further longitudinal studies, and many researchers agreed that to confirm and build on study findings, more research is needed in a variety of settings and for more extended periods of

time (Ackermann, 2017; Carson & Kuzik, 2021; Crompton et al., 2018; Jusienė et al., 2020; NAEYC & The Fred Rogers Center, 2012). Longer studies would allow the teachers more opportunities for planning and implementing the technology (Crompton et al., 2018). O'Brien et al.'s research also concluded that future studies should consider planning time based upon characteristics of individual students and providing more time for intervention (O'Brien et al., 2018).

Current studies show that research is also needed concerning reciprocity between reading and writing, in the context of both digital multimodal and more traditional literacy practices (Maureen et al., 2020; Oakley et al., 2020). The findings need to be replicated with an extended series of storytelling activities that involve larger groups of participants (Maureen et al., 2018). Kervin & Mantei (2016) agree that digital stories from a range of contexts could provide insight into the different experiences offered in preschool and the ways children interact with them. It is important to continue the research and use various modes for teaching and work to rebalance the instruction in the classroom to include multimodal opportunities (Dunn & Sweeney, 2018). McPake et al. (2013) adds that teachers need to develop imaginative ways to incorporate what children already know about technology into instruction.

In summary, the evidence shows that more research is needed on the integration of digital technologies in preschool (Ralph, 2018), including further research into the equity of access (Sharkins et al., 2016), verbal stimulation using technology enhanced storytelling, and varying differences in adult-child relationships (Teepe et al., 2017). With the fast-paced and changing nature of technology, it is critical to continue development of apps and devices and make them better accessible to young children (Flewitt et al., 2015). Future research should examine the role of collaborative and cooperative learning while using technology, and the importance of risk-

taking in sharing work, building learner resiliency, and engagement (O'Byrne et al., 2018). Fox-Turnbull (2019) adds that it is necessary to conduct further research into not only the teachers' attitudes and practices, but also the children's learning when teachers are familiar with and trained to use technology. Kervin & Mantei (2016) concur that the insights from the children about their environment can also be used for future teacher training and planning. Fleer's (2018) research concludes that teachers' digital pedagogy and practices in free play settings need to be further researched to better understand the use and place of digital devices in the naturalistic preschool setting.

Conclusion

The DoEd (2021) provides these guiding principles regarding technology and early childhood: (1) Technology, when used appropriately, can be a tool for learning; (2) Technology should be used to increase access to learning opportunities for all children; (3) Technology may be used to strengthen relationships among parents, families, early educators, and young children; and (4) Technology is more effective for learning when adults and peers interact or co-view with young children. Developmentally appropriate use of technology can help young children grow and learn, especially when families and early educators play an active role. By the time children reach kindergarten, they are likely to have countless encounters with various forms of digital communication (Maureen et al., 2018).

Research shows technology use in the classroom provides an authentic opportunity to develop the different types of literacy that students will need in the 21st century (O’Byrne et al., 2018). The DoEd (2016) stresses that whether in early learning settings or at home, appropriate use of technology should support deep cognitive processing and intentional, purposeful learning that promotes the healthy development of children. The DoEd (2021) also suggests that technology should never be used for technology’s sake. Instead, it should only be used for learning and meeting developmental objectives, which can include being used as a tool during play. The NAEYC & The Fred Rogers Center (2012) similarly believe when used appropriately, technology and media are effective and emphasized technology should be educational and developmentally appropriate.

With vast amounts of new technologies and the active ways they can be used, families and early educators should take a more comprehensive approach, rather than simply thinking about screen time limits, and evaluate the content, context, and their child’s development to

determine what is appropriate in each circumstance (DoEd, 2016). The AAP (2016) agreed that an emphasis on previewing apps and choosing high quality content for children is an important aspect of the updated AAP guidelines. Research findings show that intentionally chosen apps can support and transform learning, but ones that are too difficult are not as effective. Scaffolding apps are the most effective (Vatalaro et al., 2018). The DoEd (2016) asserts that when evaluating and recommending technology for use with early learners, consideration should be given to how the child is using the technology, including the quality of the content, the context for its use, and the involvement of adults and peers.

Technology can be empowering for children, with tools that help them learn in fun and engaging ways, express their creativity, create art, make marks, perform early reading, writing, and math skills, and stay connected to others. There is agreement among researchers that technology is a positive force in child development (Ackermann, 2017; Fantozzi et al., 2018; Flewitt et al., 2015; Maureen et al., 2020; Ralph, 2018). Children can learn about technology and technology tools and use them to play, solve problems, and role play (DoEd, 2021). Children are being born into a society that does not know a world without technology, and those children who are tech-savvy will be better prepared for a workforce that will be predominantly digital (Fantozzi et al., 2018). Maureen et al. (2020) agrees that young children are growing up in an environment where digital devices are common daily experiences, and they need to become skilled in handling these digital forms of communication. The comfortable use of many forms of technology is a new global requirement and an essential 21st century literacy skill (Fantozzi et al., 2018).

The research supports the proposition that using an iPad motivates and actively involves children. Their eyes were often focused on the iPad and not each other or distractors in the room

and they verbally expressed interest in using the iPads (Ralph, 2018). This medium and the associated tools incorporated higher order thinking skills, while also strengthening social connections in and out of the classroom (O'Byrne et al., 2018). Sharkins et al. (2016) claims that young children can grow as successful digital consumers and creators in the 21st century. There is a plethora of research available for parents and educators to inform their decision-making about technology use in early childhood, but ultimately more time and concentrated effort is needed to experience and research the long-term effects of the early use of technology.

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