Literature Review – NewSchools Ignite Early Learning Challenge

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Overview

There has a been a recent shift in the role technology and interactive media play in young children's lives. Given the current emphasis on incorporating technology into everyday practices both at home and in school, educational technology (edtech) developers have an unparalleled opportunity to support young learners across different content areas and learning environments. In order to effectively support children (ages 3-8) in utilizing technology and interactive media, a review of best practices and research-backed findings must be conducted.

Educational technology developers can turn to research in child development and technology in early learning to provide a framework to guide their future work. Specifically, what we know about how the use of technology and interactive media impacts learning outcomes may be used to inform future directions in edtech development. This includes the recognition of global best-practices as well as technology- and content-area focused findings centered around the role of educational technology on learning outcomes.

Three best-practice themes are echoed throughout the literature. Technology and interactive media should be: 1) child focused, 2) conscious of enhancing present learning activities, and 3) mindful of support needed for adults who are guiding use of technology. In addition to best practices, research supported methods specific to content areas (e.g., STEM, social-emotional learning, literacy, special education) and identified areas for development opportunities should also be utilized. Thus, edtech and interactive media developers can directly support learning outcomes through a focus on research-based methods for technology use, child-focused developmentally appropriate practices, development of products that add to educational experiences instead of replacing current practices, and support needed to facilitate tech and media use.

Need

The National Association for the Education of Young Children (NAEYC) and Fred Rogers Center for Early Learning and Children's Media define interactive media and technology to include computers, tablets, mobile devices, cameras, electronic toys, e-readers, software, applications (apps), broadcast and streaming media, TV programming, and Internet, as well as "other forms of content designed to facilitate active and creative use by young children and to encourage social engagement with other children and adults." On average, children spend about two hours per day with screen media, and approximately 98% of homes with children ages 0- to 8-years-old have a mobile device. Of the parents whose children use screen media, a majority believe that it helps support their child's learning and creativity. Early childhood educators report an increase in technology use in the classroom to help support student learning, and the National Education Technology Plan (NETP) recommends the integration of "multimedia communication into the teaching of traditional academic subjects."

Technology also plays an integral role in connecting home and school, as educators now use apps and email to keep parents aware and involved in child- and school-related information and to facilitate more direct lines of communication between the home and school environments. As our

culture becomes progressively dependent on these technologies for everyday activities, it becomes increasingly important for educators and caregivers to support meaningful experiences with technology and interactive media.

While educational technologies are viewed as a tool that can "provide children with additional ways to explore, create, communicate, problem-solve, investigate, and learn,", a "digital divide" is still present despite the increase in accessibility to tech-based devices. There are clear differences in technology use between low- and middle-income households, driven by socio-economic status (SES). Approximately one quarter of low-income families lack home computer access and Internet, compared to their middle-SES counterparts, with only about 4% lacking Internet access. Furthermore, families who have lower-levels of education, who are from rural areas, and who are black and Hispanic are less likely to have access to the newer forms of technology and Internet. While there is a general need for effective technology for young learners, these SES differences must be overcome both at home and in school to ensure equitable access to education for all children. Embedding technology into the school setting while utilizing best practices creates opportunities for children from families without resources or access to such tools. As per the NETP guidelines, "[t]echnology access when equitable can help close the digital divide and make transformative learning opportunities available to all learners." Government-supported programs such as ConnectHome, Lifeline, and E-rates aim to provide homes, schools, and libraries with Internet access at a discounted rate, making efforts to close the digital divide.

Best Practices for Technology Use in Early Childhood Settings

There is a wealth of research on child development and early learning. Several recent publications draw on this body of literature for advising early learning in the context of technology and interactive media. NAEYC and FRC, California Preschool Program Guidelines, and the U.S. Department of Education also provide their own frameworks and guidelines for young children's use of media and tech. Three clear guiding themes are present in each of these frameworks: 1) Technology should be child-focused; 2) Technology should enhance current educational practices; and 3) Adults should support learners when using technology. The following section outlines best practices for technology use in early childhood settings, as compiled from the policy and position statements that have been derived from the research in the field.

Child-Focused. It is critical to incorporate principals of child development with the use of technology and digital media. Children's developmental levels, interests, abilities, and cultural and linguistic backgrounds must be considered in development. Tech and media-related activities should be used within the framework of "developmentally appropriate practice." Broadly, DAP "is an approach to teaching [that is] grounded in the research on how young children develop and learn, and in what is known about effective early education." DAP also considers three points: 1) what is known about child development, 2) what is known about the child as an individual, and 3) what is known about the culture. Educators and caregivers should be conscious of children's developmental levels, what kind of age-appropriate material can support their learning goals, and

what is culturally appropriate and valued. Content must be evaluated for negative messages or stereotypes that "may be biased and fail to promote social and emotional understanding in the early years," thereby ensuring that materials are culturally and linguistically appropriate. In other words, selection of technology should be intentional and focused on the "3 C's": Content, Context, and Child. The content should be appropriate for viewing by the child, the context should complement the child's learning activities, and the child's individual needs must be considered. Finally, edtech should support children's social interactions and relationship building.

Enhancement of Current Educational Practices. Technology and interactive media should enhance – and not replace – existing activities or experiences for young children. In action, this can work by integrating technology and media into the learning environment, including curriculum and daily routines. Technology and interactive media should be used as tools for learning or as a curricular support, as opposed to being the central learning goal of an activity. There should also be an emphasis on active experiences as opposed to passive use interactions. Active tech and media experiences involve interactive use (e.g., playing an educational computer game with age-appropriate scaffolding while co-viewing with an adult caregiver) versus passive use (e.g., independently watching a TV program for entertainment purposes). The goal should be for students to have deep, cognitively-engaging experiences with the content that is developmentally appropriate and that supports learning.

Finally, time spent with technology should be monitored and limited. The American Academy of Pediatrics recommends up to 1 hour of screen time per day for children between the ages of 2 and 5, as "infants and toddlers cannot learn from traditional digital media as they do from interactions with caregivers, and they have difficulty transferring that knowledge to their 3-dimensional experience." For children between the ages of 6 and 8 in school settings, it is recommended that "technology should be used as a tool for children to explore and become active creators of content." Further, teachers and parents should be aware of how much time per day children are spending with technologies across different settings. Research supports this recommendation: even the benefits of viewing educational TV programming tends to peak at 1-2 hours a day, and then declines after that timeframe. The individual needs of each child should also be considered. Instead of applying "one-size-fits-all" limits, teachers and families should consider the needs of the individual child. For example, some children may need access to assistive technologies for more than one hour a day. In order to determine how technologies and interactive media should be used, as well as when, educators and caregivers need to keep each child's needs as well as the classroom's needs in mind.

Adult Support for Learners. Administrators, educators, and parents alike need to be able to provide support for their students or children. When it comes to using media and technology, educators and caregivers should understand the underlying objectives of the technology and evaluate the quality of the content. Teachers and families should identify the purpose of technologies prior to child introduction to ensure educational components are aligned with individual learning goals. The quality of content also matters. High-quality educational curriculum is associated with academic outcomes, whereas technologies focused purely on entertainment,

including those with violent material, are linked to poorer academic outcomes. Above all, the content should not hurt young children's development or well-being.

Educators and families should select technology and interactive media that support children's creativity, exploration, and problem solving, and use the best available evidence in the selection process. Interactive media and technology should be previewed to ensure it encourages children to engage deeply and meaningfully with the product. There should be room to explore, create, and grapple with concepts. Feedback and scaffolding allow children to grow as they experiment with more challenging educational activities. Furthermore, teachers and families should use available research to guide product selection and support use of best practices.

Finally, teachers and caregivers should provide support while children use technology and interactive media. Parents and educators are children's primary role models for technology use. Child led-interactions should be observed and monitored in order to take advantage of learning opportunities. Co-viewing is the practice of an adult viewing programming, such as television, along with a child. Adults enhance the effectiveness of educational programming by drawing attention to the most important aspects of the program and by extending lessons presented in the program. Some studies suggest that co-viewing with a parent or other adult may increase a child's learning from educational television, particularly when the co-viewer actively participates in viewing by interacting with children about the program content. This extends to computer-based interactive media as well. For example, children's math learning increases when children and parents work together on computer-based transmedia games and activities. Collaborative work with adults is recommended, as well as joint work with peers.

Content-Specific Findings Around Educational Technology and Early Childhood Learning

In addition to guiding themes and best practices for technology use in early childhood settings, there is a need to be aware of content-specific findings. While research indicates that children can learn from educational media, use should be centered around effective use of technology, and it is important the content and procedures for using such tools follow best-practice guidelines. The following sections break down a sampling of findings in different conceptual areas relevant to early childhood that can inform the development of tech and interactive media products and devices. Edtech developers may use research findings to guide their own development and application of devices, programs, and tools.

Language and Literacy: Computer software and mobile apps have supported various literacy skills, such as speaking, writing, vocabulary, and reading. Electronic books (e-books) are widely available via mobile devices, tablets, apps, and computer software. However, even with the increase in accessibility to e-books, children under 8-years-old are, on average, read to for about 30 minutes a day. Most of this is done with printed versions of books as opposed to e-books. For preschool-age children, some research suggests that reading traditional print books produces better learning outcomes than reading e-books. Specifically, when reading e-books to children, parents

were more likely to talk about the digital book *format* (distracted talk) than about the story content, which differed from how they read the traditional print version. As a result, children who read from a print version demonstrated better reading comprehension than their counterparts.

However, other studies have found literacy gains from digitized books. For example, one study revealed gains in vocabulary from educational software with an interactive vocabulary book, and a second found no differences in reading comprehension when comparing a traditional storybook and an interactive computer storybook. Another study investigated a comparison of two types of e-books (enhanced with interactive features vs. standard non-interactive e-book) and a print book. Findings revealed that children in the standard e-book and print book condition demonstrated higher levels of reading comprehension than the children in the enhanced e-book condition.

Authors advise developers to use caution when adding enhancements to e-books, particularly for non-topic related enhancements, and advised parents and educators to elect to use standard e-books or print books for use when reading with young children when the desire is to promote comprehension. Interestingly, authors acknowledge that enhanced e-books may help inspire less-motivated readers to engage in reading when they may opt out otherwise. Additional research is needed to determine a clear pattern of outcomes from digital literacy tools.

***English Learner (ELs) Students*:** English learners have utilized computers to support both English learning and their home language. For example, older students learning English have used dictionaries available on a tablet device to help look-up words at home and at school, as well as using a text-to-speech function to hear the proper pronunciation of the word. Technology has also been used to record EL students reading aloud in English. This allowed teachers to observe their students' language development without forcing English learners to speak in class. Educators should provide opportunities for all students to experience technologies while being mindful of linguistic background. For example, teachers with EL students could utilize e-books in students' home languages as well as English. This could extend to working with colleagues and children's families who speak their home language in order to support the use of media in children's home language.

STEM (Science, Technology, Engineering, and Mathematics): STEM teaching tends to foster interactive learning, so educational technology lends itself favorably to this academic domain. When topics are presented in multiple modalities, children have an easier time understanding topics such as math and science.

Tablet games are one way to incorporate STEM learning in the classroom. One study investigated different levels of tablet-based interactivity on the transfer of learning skills related to measurement. Children who played a tablet-based interactive game and children who simply viewed the video game demonstrated greater transfer of knowledge than children in the control group. However, further investigation revealed a more nuanced story. Children in the interactive group performed better on near-transfer tasks, while children in the non-interactive group

performed better on far-transfer tasks. Videos with high levels of interactivity may be most "helpful in contexts that are highly similar to the original learning context, but may not have a lasting effect once the transfer task becomes too far removed from the original learning context." The authors conclude that interactive elements may best support learning within certain contexts.

The National Council of Teachers of Mathematics (NCTM) supports the use of technology for mathematics learning stating, "it is essential that teachers and students have regular access to technologies that support and advance mathematical sense making, reasoning, problem solving, and communication." NCTM recommends subject-specific technologies including interactive programs that can assist in the exploration of math concepts, and more general technologies in the classroom that support students' access to "communication and collaboration tools."

Problem solving is considered a foundational tool for the development of STEM knowledge. Educational TV programming such as *Blue's Clues*, which promotes audience participation, have demonstrated effects on problem solving skills. Problem solving skills have also been investigated with touch screen devices. Preschool-age children demonstrated the ability to transfer knowledge of a problem solving task completed on a touchscreen device to a 3D physical context.

Special Education and Assistive Technologies: Interactive media and assistive technology can be useful for children with disabilities and special needs. IDEA defines assistive technology as, "any item, piece of equipment, or product system, whether acquired commercially off the shelf, modified, or customized, that is used to increase, maintain, or improve functional capabilities of a child with a disability." NETP recommends that learning software and hardware should have built-in supports to make learning more accessible to more children—also known as "universal design." For example, enlarged font, text-to-speech, and speech-to-text are tools that make accessing learning more easily available.

Assistive technologies in particular can help children with special needs to become more independent and communicate with peers and adults. For example, devices may help children communicate with teachers, families, and peers in ways that were previously unavailable. Using edtech tools, children may be enabled to access learning in different ways and participate in classroom activities.

The use of videos, for example, has been commonly used to help children with autism and developmental delays learn social and communication skills. A case study of a multimedia intervention showed the intervention was successfully used to improve the social interactions of two students with autism, resulting in participants having increased engagement with peers during free-play periods at school. Tablet devices such as iPads have been utilized to assist students with language-based disabilities. Language arts lessons delivered on the tablets were found to help increase academic engagement and were well liked by students and teachers. A recent meta-analysis of different assistive technology devices used with young children (pre-K and younger) with a disability found that the use of technology such as switch interfaces, powered mobility, computers, and augmentative communication improved student outcomes.

Social-Emotional Learning: Prosocial behavior, or behavior with the intention of benefitting others, is in important element of social-emotional learning. This can include behaviors such as

caring, showing emotional support, sharing, helping others, and thinking in prosocial ways. A recent meta-analysis with a broad age range of participants found a link between exposure to media demonstrating prosocial behavior and increased levels of such behavior and sympathy, as well as lower levels of aggressive behaviors. This finding remained stable across different age groups, suggesting that this is also the case for early childhood. Computer play is another way to encourage social interactions, relationship skills, and social awareness. Young children observe each other play, share and help each other with computer-related problems, and practice turn-taking skills.

One study examined a "media diet" intervention in which parents introduced high quality educational and prosocial programming, as opposed to aggressive programming, to children without minimizing total screen time. While the intervention focused on TV and videos, it also addressed all screen interactions (computers, video games, handheld devices) and encouraged co-viewing. Results indicate that an intervention to reduce exposure to screen aggression and increase exposure to prosocial programming can positively impact child behavior.

Applying Educational Technology to Early Childhood Learning

Technology has the power to enhance and enrich learning experiences for children from all backgrounds, inclusive of home and school environments. The US Department of Education developed a series of guiding principles for media and technology use for young children, highlighting how technology provides a unique opportunity to enhance both learning and relationships. These recommendations build on the research presented in earlier sections of this literature review, and present principles and applications of the research in the field of early childhood learning. The guiding principles are:

1. *Guiding Principle #1*: Technology—when used appropriately—can be a tool for learning.
2. *Guiding Principle #2*: Technology should be used to increase access to learning opportunities for all children.
3. *Guiding Principle #3*: Technology may be used to strengthen relationships among parents, families, early educators, and young children.
4. *Guiding Principle #4*: Technology is more effective for learning when adults and peers interact or co-view with young children.

Additionally, the US Office of Educational Technology published a primer designed specifically for edtech developers to help the field gain knowledge about education needs. Developers may utilize this tool to identify the educational areas with the potential to make the most impact on intended users. OET provides a list of 10 actionable "opportunities" (listed below) that edtech developers may address, most of which apply directly to practice in early childhood:

1. Improving Mastery of Academic Skills: OET specifies that edtech developers should "innovate, not digitize." Developers can focus efforts on creating apps and programs that "teach academic skills in more meaningful ways than traditional textbooks and lectures" (e.g., simulations). There is an emphasis on enabling students to learn, explore, and create using technology and interactive

media in ways not available without such advances. For example, OET recommends developers and educators to "consider merging teaching and assessing to pinpoint knowledge gaps along the way to mastery through probes of understanding, or by identifying competencies through formative assessments that are seamlessly embedded in the learning materials." Finally, technology should be used to incorporate research-based methods into the classroom to impact learning outcomes.

2. Developing Skills to Promote Lifelong Learning: OET suggests that future development should be mindful of ways that may help students develop skills to promote lifelong learning. Non-cognitive and emotional skills should be addressed, in addition to the traditional academic domains. Promoting the ideas of persistence, self-regulation, behavior management, classroom management, and concepts such as growth mindset helps to support broad non-academic skills and abilities. Examples include products or apps that present mistakes as learning opportunities, involve self-directed goal setting and activity selection, help students reflect on their performance and difficulty of material, and support demonstrating persistence on a task.

3. Increasing Family Engagement: Edtech developers should apply principles of family engagement to their products. Engagement from all areas—home, school, and child—are integral to ensuring child success. Apps that can be accessed by families at home may be particularly useful in keeping parents and educators engaged in the learning process. Programs that help parents and teachers communicate in the language spoken at home, provide frequent updates, and provide online learning resources may help connect these learning communities. Features such as off-line access are useful to families without access to reliable Internet, thus assisting with issues caused by the digital divide.

4. Planning for Future Education Opportunities: OET recommends products that allow families to be knowledgeable about their future education. For example, families may use technology to help know what educational opportunities are available in the future—from school options to financial aid. While this is particularly useful for older students, there are opportunities for early learners as well. For example, apps or tools designed for school counselors could help to support each students' individual needs when transitioning to a new school, as well as build connections between families and students.

5. Designing Effective Assessments: Assessments aligned with learning goals can effectively provide a snapshot of student performance, thereby enabling educators to better identify the skills and knowledge children have mastered, as well as those in need of further development. Education technology developers can help schools enhance current educational assessment practices by providing real-time feedback on student performance that is aligned with learning goals. In addition to assessments on traditional academic topics, assessments for non-academic topics are also needed (e.g., self-regulation, persistence, creativity), thereby ensuring that educators are measuring "what is important, not simply what is easy to measure." Teachers could also benefit

from enhanced grading tools, such as those that provide feedback to students, and those that provide different types of assessment formats (e.g., multiple choice, fill in the blank).

6. Improving Educator Professional Development: Educator professional development and support is an integral part of promoting the effective use of technology and interactive media in the classroom. Technology allows for on-the-spot professional development, and allows teaching resources to be quickly and easily accessible. OET recommends that edtech developers develop tools that help connect educators to research-supported best practices, that help educators reflect on their own practices, and that help educators grow in their professional practice. Further, when developing these types of tools, edtech developers should be mindful of adult learning needs.

7. Improving Educator Productivity: Technology can provide educators support for their administrative duties such as grading, monitoring student progress, lesson plans, and parent/family communication. By simplifying these tasks with innovative technology design, educators can focus on more important tasks such as teaching or professional development. OET recommends developing tools that "organize data visually for easier interpretation," help teachers differentiate instruction, streamline feedback to students and families, and help educators create, edit, and share classroom resources.

8. Making Learning Accessible to All Students: Technology has the distinct ability to make learning more accessible to all students through its ability to deliver material in more than one format, such as text, pictures, or audio. Since many schools are unable to use apps or tools that are not accessible for students with disabilities, OET provides three recommendations for edtech developers: 1) all apps should include accessibility functions for students with special needs (e.g., text-to-speech features), 2) specific apps can be designed for particular learning needs (e.g., screen readers for individuals who cannot see; digital wordboards for children who cannot speak), and 3) apps and tools should allow for a variety of individual needs, such as providing visualizations (e.g., apps that allow for English learners to access the content in their home language).

9. Closing Opportunity Gaps: Many children still lack access to quality technology and interactive media tools. Though we have made progress towards closing the opportunity gap, an obvious digital divide still exists. Edtech developers have the opportunity to create tools for teachers to quickly and easily access quality teaching products and best practice guidelines at low-cost. OET recommends that developers "be mindful of equity of technical accessibility when designing products. Users on slower systems should be able to access and experience an application or service with the same ease as those using more cutting-edge technology."

10. Closing Achievement Gaps: Achievement gaps are present as early as when children enter school and must be addressed to ensure equitable education experiences for all students. Tools designed to help teachers, parents, and children alike are key to helping close these gaps. Both non-academic and academic skills must be supported, and students should be provided accessible

technologies to meet their own learning needs. OET recommends "illustrating how your product helps to achieve these goals while working to close gaps in achievement makes it more compelling to educators and more likely to succeed in schools."

Conclusion

Educational technology developers, educators, and families need to work together to develop and implement effective edtech and interactive media products. There is clear evidence that these technologies can enhance student learning and promote inclusion. The focus of our efforts should center around the individual child, enhancement of current educational activities, support of learners, and research-supported practices. With additional research and advocacy we can continue to better understand impacts of technology in learning environments, make progress in closing the digital divide, and ensure equitable access to education for all children.

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