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Technology in early childhood education

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Synthesis

How important is it?

Digital media in the form of text, graphics, video and audio, usually integrated and increasingly delivered over mobile devices, are ubiquitous in homes and schools. Even the youngest children have access to these media with 83% of children aged 6 months to 6 years using screens every day for recreation, school work or reading. Here we focus on e-books and apps that are intended to support language and literacy learning by children.

Reading books with children is recognized as one of the most important contexts for language and literacy learning in early childhood. Public health and education programs have long emphasized the importance of reading to children from a young age. There is concern that e-books will supplant the traditional book before we fully understand the impact of this medium on children's learning. One device can hold an entire library of stories. Children find digital stories to be highly engaging and many students report that they read more from screens than from paper. The digital format includes features that are entertaining but potentially distracting. Some features included in e-books are designed to make it possible for prereaders and early readers to enjoy books without adult guidance. Overall there is much concern that the time children spend with digital media replaces opportunities for high quality social interaction with adults. Understanding how children learn from digital media will support recommendations for the design, selection and use of e-books and educational apps for young children.

What do we know?

Most research on the impact of media on children's learning has involved television and video. More recent studies have investigated children's learning from CD-ROM, web-based, and tablet applications, including e-books, educational games, and formal instructional technology designed for school use. These studies yield some clear conclusions and directions for future research:

There is good reason to limit access to screens during the first two years of life. Infants and toddlers do not generally learn vocabulary from videos and clearly learn best from exploring their surroundings and interacting with others. Furthermore, there is some evidence that excessive "screen time" in early childhood is associated with poor attention and self-regulation.

Good quality e-books and apps will be designed to support rather than replace social interaction. Parents and teachers can support the child's learning by participating with the child in an interactive fashion, talking about the story, asking questions, directing attention when necessary and otherwise guiding and supporting the child's learning from the app.

Special features built into e-books are very engaging to children and have the potential to enhance the child's attention to print. However, these engaging features are not equally helpful for learning. Multimedia features such as sound and video that is congruent with the story can deepen the child's understanding of new words and the story. Interactive features that distract the child from the flow of the story interfere with learning.

Not all so-called "educational" apps are equally helpful for children's learning. The app should have clear learning goals but the content should be presented in a meaningful context that actively engages the child and allows for creative exploration rather than mere rote-learning.

Some e-book features, such as text and narration in multiple languages, recording functions, pop-up dictionaries, and apps to create personalized books may be especially helpful to prepare second-language learners for school entry by strengthening the child's knowledge of the majority language.

Teachers and parents require explicit instruction to select and use digital media effectively with young children. More research is required to identify best practices for home and classroom use of these technologies.

What can be done?

The policy response to the rapid increase in access to digital media by children has largely been directed at educating parents. Increasingly, professional associations and advisory groups are providing advice to parents (and to a lesser extent, teachers) on limits to access, the characteristics of good quality apps, and appropriate co-reading practices. Much of this advice rests on a thin research base however and draws heavily on prior research with print books or television. More research specifically designed to discover how children learn from digital media, with and without adult guidance, is required to ensure that this advice is well-founded.

Adoption of digital media in the classroom requires sufficient training and support of teachers for effective integration of technology and software into their instructional practices. Furthermore,

better partnerships between researchers, teachers and software designers are required to ensure that instructional software properly reflects best practice for the teaching of literacy. For example, it is known that reading acquisition requires a particular balance of attention to phonological awareness, phonics, reading comprehension and reading fluency; however, yet apps to teach reading do not typically cover all of these components – in fact, they often fall back on a discredited “sight reading” approach to reading that is seemingly encouraged by the technology itself. A closer fit between theory, practice and design might arise from partnerships between all the stakeholders.

Finally, multiple levels of government, concerned with the “digital divide,” have devised policies to ensure that all segments of society have equal access to technologies such as desktop computers or tablets. These policies have been quite successful in that access to hardware is relatively well distributed in western society. However research shows that socioeconomic gaps are currently greater in terms of the way that different families use digital technologies. Public health agencies, librarians and educators have a role to play in ensuring that children and parents in all families know how to access and use these technologies to their best advantage, ensuring greater equality in both literacy and digital literacy.

Infants, Toddlers and Learning from Screen Media

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Introduction

Infants and toddlers today have unprecedented access to screen media, including content viewed on television, computers, and gaming consoles, as well as on newer mobile devices (smartphones and tablets).[1,2] Although most of their direct viewing consists of 1 to 2 hours of television and video daily, younger children are also exposed to about 5.5 hours of “background” television, meaning television that is left on for the attention of older children or adults or as background noise without direct attention by any family member.[3] Their experience with mobile devices is more limited, though access is growing rapidly with increasing availability.[1] The popularity of screen media among the youngest viewers has inspired the production of thousands of video programs and apps designed to teach them about language, numbers, music and other abilities that ostensibly foster brain development.[4] Parent endorsement of these products has created a multimillion-dollar industry, although claims about their educational value remain largely unsubstantiated.[5]

Subject

Infants and toddlers attend to screen media and are responsive to its sensory and perceptual features (movement, pace, bright color, music, and sound effects).[6] Imitating their parents and older children, they will pick up a tablet or smartphone and tap and swipe to navigate the screen. However, this does not mean that they understand or learn from the content.[7] Although infants and toddlers are remarkably capable learners in direct social interaction,[8] their language and story comprehension skills are limited and they are unlikely to follow the narrative content, story line, or content to be learned from a video or app.[6] This contrasts with the potential of screen media to facilitate older children’s learning when the content is age appropriate, engaging, and educational.[9]

Problems

When infants and toddlers view screen media, their understanding of what they see is limited. They more easily learn actions, words, and problem solving directly from a person than from the same information on a screen.[10] This learning difference ("video deficit") occurs because very young children are inflexible learners: the features of the learning situation (video) and transfer context (real world) must match exactly for learning to be evident. Objects and characters on screens look and behave differently than their real-world counterparts. Two-dimensionality and size, the failure of TV characters to respond to viewers, and extraordinary visual and sound effects are sources of mismatch.[11,12] Video is a representational medium that differs from reality. Infants and toddlers simply do not understand the medium and do not see it as a "window on the world".[6] During the third year of life, improvements in language, cognition, social awareness and experience with screens make their learning more flexible, and transfer from video to the real world can occur.[10,12]

Research Context

Information currently available to parents and child development professionals on this topic provides mixed messages. As infants' and toddlers' exposure is fairly high, there is concern that time spent with screens might replace learning activities known to benefit development, such as reading, play, and social and language interactions with others. There is also worry that screen media might be harmful to children's developing attention and self-regulation and that this could diminish learning.[13,14] These issues, though unresolved, prompted pediatricians to recommend that children under 2 years be discouraged from viewing any screen media.[15] Those who develop and market baby videos and apps send a different message,[5] pointing to the positive role that well designed material can play in supporting older children's learning. They offer persuasive testimonials and cite "experts" who explicitly or implicitly affirm that age-appropriate screen media will advance infants' and toddlers' learning and brain development. These conflicting views, along with the sheer number of available videos and apps, make it very difficult for parents to evaluate the pros and cons of screen media for very young children.[4] Against this backdrop, as researchers have conducted many studies using different methods and measures, answers to some of these issues are becoming clear.

Key Research Questions

1. What can infants and toddlers learn from baby media? How does age matter?
2. How does the omnipresence of background television affect infant and toddler learning?

3. Are newer interactive screens more effective as learning tools than more passive television?
4. How much screen media is too much?

Recent Research Results

Many infant-directed videos target word learning, a milestone achievement at this age.[16] Researchers who have carefully evaluated vocabulary learning from video report that both child age and adult scaffolding matters – when parents co-view with their children, direct their attention to the video, talk about the story, ask questions, and otherwise support their children's learning, children between 2 and 4 years of age can learn new words from video.[17-21] However, even when children do learn new words, there can be a video deficit: reduced learning relative to learning from live and interactive instruction. For infants younger than 2 years, there is little evidence of word learning from baby video, even with parent co-viewing.[22-24] Notably, a recent study indicated that 15-month-olds learned American Sign Language baby signs from video, both with and without parent scaffolding.[25]

There is also evidence that background television distracts infants and toddlers from learning during play: they direct many quick looks to the screen and show less focused attention to their toys.[26,27] They also engage less with parents, who respond more slowly to their children's bids for attention and talk to them less often using simpler and briefer utterances.[27] The potential of these reduced interactions are significant, as these provide a major route to young children's learning about language and their world more generally.[28,29]

Some have suggested that the newer mobile devices may hold promise for infant learning, as they are interactive and can be programmed to meet the goals and skills of the individual child.[30,31] For example, there is evidence from older children that well designed e-books can facilitate word learning, emergent literacy, and reading through thoughtful use of multimedia (highlighting or animating relevant parts of picture or text) and possibly hotspots on the screen that when touched, activate interactive features (such as dictionaries, word readouts or learning games).[32-34] Early research on toddlers' learning from video chat and touchscreens has yielded promising results.[35-37] However, the effectiveness of interactive devices with infants and toddlers may still rely on parent scaffolding to help children understand how information on a screen relates to real life.[38,39]

Research Gaps

Several important questions about infant and toddler learning from screen media remain to be answered.[40] Among the most important concern the nature and consequences of their interaction with mobile devices, whether and how they operate them, whether these media are better suited to support learning than are passive media like television, and whether built-in features (hotspots, artificial intelligence) can replace parent scaffolding in facilitating learning. A second issue concerns the potential of mobile devices to target the needs of individual children, and whether they might provide a useful supplement to learning for young children at risk for developmental delays or whose parents may often be unavailable. Finally, there is the thorny question of how much screen media is too much. The answer likely will depend on a judicious consideration of the characteristics of the child, the effectiveness with which good design and an awareness of how infants learn are integrated into the content, and the quality of the supportive learning environment.

Conclusions

There is little evidence that children under 2 or 3 years learn much from viewing screen media, especially if they are viewing alone.[39] Most of their learning comes from interacting with others, listening to storybooks, exploring their surroundings, and playing with toys. Screen media, and especially background television are distracting and can interfere with these important learning opportunities. The expectation that newer interactive mobile devices might be more effective than passive media such as television is a question for future research. There is also some evidence that the amount of time young children spend viewing screen media is associated with poorer executive functions and self-regulation in the preschool years, even when potentially confounding child and family demographic factors were ruled out. Executive functions are those cognitive processes that control the regulation of attention, thought, emotion, and behaviours and they form a foundation for effective learning in very young children.[40-42]

Implications for Parents, Services and Policy

Although limited exposure to age-appropriate screen media is unlikely to be harmful, the best thing parents can do for very young children is to talk to, read to, and play with them. Parents should be aware that the marketing claims of educational benefits from infant directed media have not been substantiated. A number of websites dedicated to evaluating screen media content provide evidence-based options for viewing and are a valuable resource for parents and educators (see “Resources” tab for examples). If parents opt to provide screen media to their

infants and toddlers, co-viewing with them will optimize their learning potential. If very young children view alone, they may be entertained but may not be informed. Finally, it is important to turn screen media off if no one is watching. Background television is a distraction for infants and toddlers and can impede their learning during the serious business of play.

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Learning in the Digital Age: Putting Education Back in Educational Apps for Young Children

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Introduction

In its most recent guidance on screen time in childhood, the American Academy of Pediatrics suggested that interactive apps should not be lumped into the same category as television.[1] Most people agree that passive screen time is less than ideal for infants younger than age 2 because it replaces opportunities for social interaction and motor exploration. However, technological advances have created a hybrid of interactive screen time that forces a re-examination of the hardline "avoid screens in childhood" stance. The idea that a single device (e.g., the iPad) could provide not 10, not 100, not 1,000, but 170,000 educational apps into the homes of children is a revolutionary concept.[2] But inherent in the term "educational apps" comes the implication that someone has determined that these apps are indeed educationally beneficial. The fact is, however, that nobody regulates the use of "educational" to describe apps, not developers, users or an independent review committee. What makes an app educational? And for whom?

Subject

Given the ubiquitous nature of technology in children's lives, it is critical to determine the educational potential of apps for children of various ages. Existing knowledge about children's cognitive and social abilities can inform best practices for app development and use.

Problems

Currently, "educational" is a free-for-all label used by children's app developers. Scientific principles may serve to identify characteristics that increase the likelihood that an app is, in fact, educational.

Research Context

Hirsh-Pasek, Zosh, and colleagues[3] reviewed the literature from the Science of Learning – an amalgamated field from neuroscience, education, psychology, cognitive science, and linguistics - and used converging evidence to propose four pillars of learning to evaluate the educational potential of apps for children over the age of 2 years.

Key Research Questions

What can the Science of Learning tell us about the characteristics of apps that might increase or decrease their educational potential?

Recent Research Results

Below, we highlight the findings generated by the Science of Learning to identify the characteristics of apps with true educational potential. Subsequently we stress that the learning potential of even the best quality app is enhanced when the child uses it with adult-guidance.

Learning occurs when the learner is active rather than passive

Active learning occurs when the learner is "minds-on"[4] meaning that the app stimulates active learning by the child. Tablets encourage more active engagement than other forms of media, such as television or traditional books, given the interaction children have with the tablet screen. We caution, however, that it is easy to mistake the physical movements that children make when using electronic devices as active learning because of action. Learning does not occur through the finger – it occurs through active comprehension and mental manipulation whether or not the child taps or swipes.

Learning occurs when the learner has to mentally manipulate ideas, see similarities and differences between new concepts and existing knowledge, and incorporate this new information into a more comprehensive understanding. This is true in many contexts for varied learners.[5,6] When evaluating the educational potential of an app, it is important to consider the minds-on nature of the learning activity.

Learning occurs when the learner is engaged (not distracted)

Technology has transformed the creation of educational content for children. Children can watch a lion in an actual habitat rather than read about it or see a static picture. Children can interact with letters and words by dragging letters around the screen and hearing how sounds work. Concurrently, these technological enhancements have the potential to distract children from learning and developers from the educational goal. All too often, developers prescribe to the "more is better" framework and inundate the child with "bells and whistles" that, while entertaining, distract children from the learning goal.

Young children may be particularly susceptible to this distraction[7] and the negative impacts of distracting stimuli have been found with even low-tech pop-up books.[8,9] In a recent study investigating parent-child interaction with electronic books versus their traditional counterparts, researchers found that parents used more directives and asked fewer questions with electronic books; furthermore, 3-year-olds' story comprehension suffered.[10] Therefore, multimedia enhancements must be evaluated as a possible benefit or harm.

Learning occurs when the content is meaningful

Children can learn anything – from the names of animals to the characteristics that make mammals different from reptiles. However, this learning must occur in contexts that connect meaningfully to children's lives.[11] When selecting or creating apps, it is crucial that children do not just learn that the triangle on the screen is a triangle but that the piece of pizza in front of them resembles a triangle, too. The idea that meaningful learning has greater educational potential than rote learning is not limited to apps and implicates learners of all ages. By engaging deeper levels of processing, greater learning occurs. Apps should help children see lessons beyond the apps and even beyond the screen.

Learning is maximized with social interaction

While one of the attractive features of tablets is that children, from an early age, can use devices independently, research repeatedly shows that social interaction supports learning.[12] Apps should support, rather than replace, this interaction.[13] Increasingly, app developers are beginning to promote off-screen or hybrid experiences where children play an app together or parents are included in the app experience. In some apps the technology requires children to work together to play games or solve problems off-screen with the device playing moderator instead of partner.

Guided exploration towards a learning goal is best

Lastly, the educational potential of apps is maximized within a context of guided exploration toward a learning goal. For decades, the debate has raged about the best context for learning, with extremes ranging from direct instruction in which the adult 'deposits' information into the children to free play where children are given independence to explore the world. In guided play [14,15] the child is given an active and primary role but a more knowledgeable partner or adult guides and supports the child's learning. There is evidence that guided play may be even better than either of the extreme contexts in some domains (e.g., language,[16] space,[17]). This method may help children establish a particularly prepared, flexible and active mindset that promotes active, engaged, meaningful, and socially interactive learning.[18]

When evaluating or designing educational apps, it is crucial to go beyond the content itself. It is not enough to ask whether the content appears educational; it is important to examine how the app supports active learning by the child.

Research Gaps

While apps have educational potential, the field must continue to investigate under what circumstances and in which contexts material should be presented to children across development (e.g., formal vs. informal contexts, group versus solo-use, guided or independent learning). Further, it is an open question as to how child characteristics might impact the educational potential of apps. For example, are apps equally beneficial to children across age, ability levels, socioeconomic level, and learning styles? This is especially important when considering the youngest learners (under the age of 2).

Conclusions

As apps are added to the marketplace and we move beyond this first phase of app development, it is crucial that educators, parents, policy makers, and app developers use the science about how children actually learn to guide the creation and evaluation of apps. While 170,000 apps may not have equal educational benefit, apps that promote guided exploration with active, engaged, meaningful, and socially interactive methods will harness the power of the devices already in the homes of most children. In this way, apps with a learning goal could promote truly beneficial and educational experiences across all socio-economic levels. Although many empirical questions remain, the literature suggests that apps likely have educational potential but that their adoption should be met with a cautious outlook informed by the science of learning.

Implications for Parents, Services, and Policy

While technology use is often met with either widespread adoption or rejection in both homes and schools, evidence suggests that older children can indeed learn from technology and that this use may have inherent benefits. However, given the facts that no established board evaluates the educational potential of apps and that the number of so-called educational apps are in the hundreds of thousands, it is crucial for parents, service providers, and policy makers to be given evidence-based guidelines that can be used to evaluate the educational potential of apps. Data from the Science of Learning offers a roadmap to evaluate these apps to guide their decisions: specifically, ask whether apps inspire active, engaged, meaningful, and socially interactive experiences that provide guided exploration towards a learning goal.

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Literacy Technologies and the Early Years of School

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Introduction

Technology abounds in schools and homes. Literacy technologies such as CD-ROMs or DVDs have been available to educators and parents for at least the past 30 years. More recently web-based literacy technologies have emerged. Much of this material has been evaluated for impact on student learning outcomes. What have we learned from this work? What remains to be understood? These are the questions explored here.

Subject

Here we seek to review specific aspects of technology used in the early school years of education. Our focus is on web-based and traditional CD-ROM or similar ‘packages’ of literacy interventions. Other Encyclopedia entries consider the impact of specific technologies such as tablets or talking books, and the optimal methods for the inclusion of technologies within the classroom.[1,2]

Problems

The present article considers the following specific questions:

- Do children learn language and literacy skills from digital media? To do this we will summarize the whole literature.
- What are the characteristics of effective educational software-based teaching materials? We will analyze the features of the most effective tools.

Research Context

The focus of most evaluation research on technology has rightly been on implementation trials. Typically these trials are quantitative quasi-experiments or randomized control trials (RCTs) that

have as a bare minimum an intervention condition, a control condition and assess change in learning from pre to post-intervention on a respected language or literacy measure with known reliability and validity. Unfortunately, few really well-designed studies of this kind are published in education, and the work on literacy technology is no exception to this pattern. Nevertheless, such studies provide the only rigorous methods for knowing that the use of technology adds value in literacy development.[3] Only RCTs provide convincing evidence of causal links from the use of technology to raised reading attainments. Beyond this, the strongest evidence of the reliability and generalizability of such studies comes from carefully undertaken statistical meta-analyses of all such RCTs. Such studies are thus reviewed here.

Key Research Questions

So, do educational technologies 'work' to improve literacy? A tertiary analysis (that is, a review of a series of meta-analyses)[4] summarized all available individual meta-analyses and showed rather modest effects of intervention on literacy outcomes.[5-9] A more recent review of effective practices in elementary schools[10] also suggested that interventions using instructional technology generate only small effect sizes (d = +0.14) for reading outcomes.[a] More recently, a meta-analytic review[11] found similarly small positive effects (d = +.16). Finally, a meta-analysis of meta-analyses[12] also reported comparably modest effects.

Are such small positive effect sizes the best that technology can offer literacy? This is probably overly pessimistic on the basis of our own work and re-interpretation of the wider literature. We now have eleven published experimental (generally RCT) studies using our ABRACADABRA web-based intervention (http://abralite.concordia.ca). These have produced mostly small to medium effect sizes for impacts on a range of reading outcome measures in studies around the world.[13] In a recent meta-analysis[14] consistent medium effects were sometimes evident (e.g., g = +.38 for listening comprehension outcomes). Another recent meta-analytic review of the wider literature[15] also reported medium positive effect sizes for technology on outcomes such as children's concepts of print and phonological awareness.

Recent Research Results

One recent review[16] contrasted 'online' software with 'offline' closed systems (compact discs). Generally, online programs offered more comprehensive content, teaching more key literacy skills than offline software in Kindergarten and Grade 1 levels. Both the quality of instruction and the

scaffolding of learning was also quite variable across on and offline technologies. Perhaps surprisingly, few programs, either online or offline, provided automatic progression across levels of task difficulty from short blends to longer ones based on mastery at the lower level (e.g., for blending sounds, from: 'i'-'t' to 's'-'i'-'t' to 's'-'p'-'i'-t' to 's'-'p'-'l'-'i'-'t'). This review provides information to support the principled selection and use of digital instructional materials by parents and educators. These findings also suggest that better software is needed before we can evaluate whether it is efficacious or not.

Research Gaps

Arguably three methodological issues remain to be resolved in future research:[17]

1. Study implementation. A tertiary meta-analysis[18] found effect sizes for technology on reading can be as high as d = +.60, but where training and support of teachers are poor, effects are close to zero.
2. The quality of the technology. Consistent with recent work,[17] another study[19] used a taxonomy of reading skills applied to thirty popular literacy software programs. Results showed that only 15% of the programs taught the key skill of synthetic phonics. Startlingly, activities to develop text comprehension skills were entirely absent. Tellingly, there were limited examples given for training each skill, inconsistent progression from simpler to more demanding items, and few opportunities to practice taught skills.
3. The theoretical and pedagogical coherence of technologies. Most interventions do not test theories of reading, or of technology (e.g., its multiple modalities, simultaneity, immediacy, its impartiality, privacy).

Conclusions

This article has sought to evaluate the impact of technologies for literacy. What do we know as a result of all this work? We know that technologies can work. While early reviews all found small or near-zero effects of intervention, more recent high quality work has consistently shown small-to-medium effects of intervention on language and literacy outcomes. It is notable that some recent reviews have found largest effects on outcomes that have proved traditionally 'hard to remediate' such as listening comprehension. Arguably research on literacy technologies suffers from extremism: 'naïve' modernist enthusiasm for technology as 'the answer' to literacy difficulties is

countered by the backlash of cynicism against their use (‘Oversold and Underused’ as one critic has it[19]). The reality we argue is in the middle ground - technologies of high quality used by trained and well-supported expert staff in expert ways as one part of literacy instruction, connected to wider literacy goals appear to add consistent small to medium sized ‘value added’ for literacy in the early years.

Implications for Parents, Services and Policy

What are the implications for technology users? We think there are four:

Firstly, for parents and teachers the implication is caveat emptor (‘let the purchaser beware’). Some commercially available technologies teach valuable content in a manner that conforms to best practices and are quite likely to aid early literacy. It is however important to critically evaluate technologies before purchasing and using them. Secondly, there are also very few technologies that teach all of the skills that wider research and expert opinion agree are core to effective reading acquisition, so literacy technologies can be used as an additional tool to aid some aspects of literacy, never as a replacement for expert teaching. In this respect ‘on-line’ technologies are as good if not superior to ‘off-line’ technologies.

Thirdly in formal educational contexts, the careful training of- and support for- staff in using technologies is likely to be an important feature of their effective use (though parents may benefit too!). Given that none of the most popular technologies provide automatic graduated transition for simpler to more complex items, the programming of effective learning lies with a capable adult who understands curricular progressions in early literacy. Expert teachers will therefore likely get the best from the best technologies. It is also highly unlikely that children left unsupervised with such technologies will learn effectively.

Fourthly, for policy makers we counsel that they should not throw the ‘baby’ of literacy technologies out with the bathwater of poor results of earlier systematic reviews. Better technologies used in more sophisticated ways to test theory, implemented and supported well can, we think, add visible value to language and literacy learning. This goal awaits further better basic research testing contemporary theories of multimedia, literacy and technology.

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Note:

[a] 'Effect size' is an accepted way to measure the size or practical significance of improvements that follow any intervention. Mathematically this is based on the mean post-intervention score minus the mean pre-intervention score and usually divided by a measure of variability in scores at pre-intervention (e.g., pooled standard deviation), to give an effect size score, d. By common consent a 'small' effect size is d = + .2, a 'medium' effect size is d = +.5 and a 'large' effect size is d = + .8.

Electronic(E)-books as a Support for Young Children's Language and Early Literacy

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Introduction

Use of technology has become common and natural in our lives, including among children. Increasingly, young children are exposed not only to printed books, but also to e-books, which they read independently or together with adults. Market share for e-book sales is rising steadily. This is true even for products targeting preschool aged children in different languages.[1] Reading e-books which incorporate multimedia, such as animation, music, sound effects, illuminated text, and text read out loud by a narrator, provides synergy where there is a joint and integrated operation of two or more factors that might affect the reader.[2] The combined operation of these actions is perceived as more effective than the employment of each factor separately. According to this theory, young children, especially children at risk for language learning, may benefit more by studying in a way which incorporates the use of several types of media than by using only a single medium.[3,4]

Subject

Reading books to young children is one of the most important activities for developing language and early literacy skills.[5,6] Popular e-books go beyond written text and illustrations: they also integrate multimedia features. Hidden ‘hotspots’ on the screen can be touched by the user to animate or elaborate illustrations and text in a fashion that supports language development and story comprehension. Illuminated text, which is highlighted congruently with the narrator’s reading, may help the child track the written text, thus promoting print awareness. These features are engaging and motivating and may comprise a support for young children's language and early literacy learning. These e-book features also make it possible for children to "read" (or listen to the books) independently without adult support. Therefore, the abundance of e-books available on the market today present new possibilities for learning but also new challenges for shared reading between adults and children.

Problems

Although many hopes have been raised with reference to the potential of e-book reading by young children, their quality as language and early literacy support is controversial. There is a concern that many e-books found on the commercial market are targeted more towards amusement, and emphasize multimedia, colours, sounds, and graphics, but that they are not necessarily suitable for promoting young children’s learning.

Research Context

Reviews of e-book research vary in focus. Some researchers have examined the structure and components of e-books available on the market in relation to ideal parameters.[7,8,9] Others have reviewed the evidence regarding the effectiveness of e-books on children's story comprehension, language and early literacy learning.[10,11,12,13] Other researchers have developed e-books for research purposes.[14,15]

Key Research Questions

Several research questions have been addressed: (a) What is the quality of commercial e-books for children aged 3 to 8 years, with respect to structure and components? (b) What is the effect of e-book reading on children's language (mainly vocabulary and story comprehension) and early literacy development (including emergent word reading, word writing, phonological awareness and print knowledge), when considering the evidence on commercial e-books and those specifically created for research?

Recent Research Results

Research shows that many of the existing e-books are loaded with multimedia, colours, sounds, and graphics and also incorporate games in the story reading. In most e-books these features are not designed to promote young children’s language and literacy development.[7,8,9] For example, there may be too many animations or the hotspots may not be related to the story, thus distracting from the child’s story line understanding.

E-books specifically created for research have been used with children from different socioeconomic status (SES) groups,[14] children at risk for learning disabilities,[16] and children of different ages; furthermore, the children have experienced the books in different contexts such as independent child reading, joint reading of children in pairs, parent-child and researcher-child

reading.[17,18,19] In these studies, e-books were found to be effective for promoting a broad range of language and literacy skills during the preschool and early school years.[15,20]

One recent meta-analysis concluded that well-designed e-books can facilitate children's story comprehension and word learning better than print storybooks.[21,22] Two types of design elements were important to the impact of the e-book. Multimedia elements added nonverbal information (animations, sound) to enhance understanding of verbal content (text, narration) and benefitted children's cognitive development as much as support from an adult while reading print storybooks. Multimedia features were especially helpful for children from disadvantaged families. However, interactive features that drew the child’s attention away from the story were harmful to children’s learning. This differential pattern was explained by young children's limited cognitive control and inability to multitask which is required in the case of interactive features. When children must switch frequently between the story and the interactive elements such as games and hotspots, the design of the e-book interferes with story understanding and language learning.[21,22]

Research Gaps

There is a need for more research on the contribution of e-books to aspects of spoken language, including vocabulary and story comprehension, and also on the effect of written text tracking in the e-book on children's print awareness, including emergent reading and writing, especially among kindergarten children. We need to deepen our understanding on the nature of child-child and adult-child joint processes and interactions and their effects on children' knowledge. In addition, it is necessary to go a step further in suggesting an e-book system that assesses the child's language and story understanding level and suggests tutoring adjusted to the child's level. A digital tutor might make children more attentive to the story, similarly to the way they are when getting adults' support during shared book reading. Providing digital questions and feedback in an adaptive manner that focuses on language and story aspects might help young children's language and story comprehension.[23]

Conclusions

Listening to a story requires great cognitive effort by young children and additional activities in the e-book seem to distract them from the story line. Multimedia features such as animations, music and sound effects that closely illustrate the story content have been shown to facilitate children's understanding of the story, probably by depicting and concretizing the abstract

language and directing children's attention to key details in the illustrations.[23] Such nonverbal information has been found to be especially helpful for children who experience problems in understanding the story line and language due to language delay. In contradistinction, interactive features that interrupt the story such as games, pop-up dictionaries and hotspots have not been found to be beneficial for young children's story comprehension even though these elements commonly appear in e-books.22

Implications for Parents, Services and Policy

Well-designed e-books based on research principles are needed. The current literature may serve as a good basis for software developers who can design e-books for the next generation, which can be both amusing and directed to language and literacy learning. Parents and educators need to exert caution when choosing an e-book for young children, and should keep in mind that in terms of interactivity and multimedia additions, "more is often less." Quality e-books can be used to support language and literacy learning in children who have normal or delayed developmental trajectories in these domains.

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Teaching Early Literacy with E-books: Emerging Practices

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Introduction

For students of all ages, the e-book is a compelling alternative to the print book. E-book readership among children and youth has nearly doubled since 2010[1]; students report that they now read more on screen than on paper).[2] Parents, too, are increasingly interested in having their child read e-books.[1]

Likewise, e-book reading is fast becoming the grist of academics and publishers who seek to understand what screen reading does for the mind and heart (motivation). It is equally transformative for teachers who are increasingly expected to integrate e-books into instruction, engage students in digital reading, and enable them to actively participate in a multimedia world. This presents a new layer of complexities in an already challenging job.

Subject

The role of e-books in the teaching of reading is emerging. The e-book with its growing number of affordances introduces not only new possibilities into the reading experience (e.g., highlighted text), but also a new level of accessibility anytime, anywhere. An entire e-book collection can be archived on a small, mobile device that literally houses a pocket size library. Instructional guidance for effective teaching with e-books, however, is scant, leaving teachers to trial and error efforts at incorporating e-books into their routine practice. As a result, the e-book can easily become edutainment in an already packed instructional day.

Problems

E-books are an exciting technology, but they are also problematic. For the reader, they afford more verbal and non-verbal information for integration to aid print and meaning processing, but they also introduce distractions that can trivialize reading as a cognitive act.[3,4,5] Multimedia theory[6]

argues that when incongruent with the story line, enticing auditory and visual inputs can split attention from reading and focus it elsewhere—on motoric or exploratory play behaviours, for example, that lead to a cursory reading of text.

For the teacher, the e-book promises an exciting curriculum resource that can enliven literacy instruction. E-books are engaging and motivating for students to read. They can be stored on a single device, and made accessible at school and home. They can be an integral part of a comprehensive online reading program complete with learning activities and dashboards. But they can be risky in an age of accountability when teachers must demonstrate that their reading instruction helps all students to achieve rigorous literacy standards. Teachers need to learn to teach reading with new technologies, which can be a steep learning curve for some with time spent learning how to use technology at the expense of integrating it into instruction.

Research Context

Research that informs early literacy teaching with e-books is in its infancy, hence largely descriptive. Studies explore teacher knowledge and beliefs about technology, digital practices, implementation in classrooms, and how print vs. digital reading instruction influences early literacy skills. Overarching theories and models of the digital teaching of reading, however, are lacking. Leading scholars propose going beyond a technology-integration model, in which digital tools substitute or augment print-based tools, to redefining the language arts curriculum for a mobile age in which digital tools mediate learning across contexts, in and out of school.[7,8,9]

Key Research Questions

What do teachers need to know and be able to do to instruct with e-books?

What e-book practices are promising in teaching early literacy?

What are issues of implementation in early childhood classrooms?

Recent Research Results

The International Society for Technology in Education (ISTE) Standards for Teachers define the new knowledge and skills educators need to teach, work and learn in the digital age (http://www.iste.org/standards/iste-standards/standards-for-teachers). Teachers, for example, are expected to demonstrate fluency in technology systems and the transfer of current knowledge to

new technologies and situations (Standard 3.a). Studies show, however, that meeting these expectations is still beyond the reach of many teachers.[10,11] Researchers point to several obstacles: teacher understanding of how digital tools actually work; new instructional practices for technology integration; teacher confidence, vision and beliefs; and time to learn and plan for teaching with digital tools.[12] Harris & Hofer,[13] for example, identified instructional activity types that help teachers plan with technology in mind, but such studies are rare.

Scientific research on e-book instructional approaches and techniques is thin. Synthesizing current scholarly thought, experts recommend core strategies of modeling, choosing appropriate e-books, locating e-books in the learning environment to facilitate social interaction, and encouraging verbal interactions around screen content.[14] A few quasi-experimental studies describe routines with e-books found to be supportive of early literacy skills.[15,16] Descriptive accounts highlight techniques specific to teaching reading with digital books. Schugar, Smith & Schugar,[17] for example, identify several considerations, such as teaching students how to transfer print reading skills to e-reading tasks. Others describe frameworks and procedures to capitalize on digital features (e.g. teaching letter-name phonics) in teaching early literacy skills.[18]

Few studies have examined the real-time implementation of e-book teaching in classrooms. Field studies augmented by practitioner action research projects report persistent technical difficulties, i.e., sufficiently robust internet access, device access and management, functionality of the digital environment and logistics, such as classroom routines.[19,20,21]

Research Gaps

Considerable research is needed to design and test professional development that increases teachers' technological-pedagogical-content knowledge[22] to meet expectations for digital reading teaching. Increasingly personalized professional development approaches are recommended (e.g., blended learning in which digital delivery of content is combined with traditional instruction) to provide teachers what they need, when they need it, where they are able to access it.[23]

A solid foundation of 'proof of concept' studies that identify and test promising reading practices with e-books is critical. Controlled studies that examine the effects of instructional techniques (e.g., print-referencing techniques that draw children's attention to print) are urgently needed to build an evidentiary base for practice as applied in the e-book environment. Relatedly, rigorous qualitative studies can provide insights as to perceptions of efficient and effective instructional

techniques.

Implementation research is also needed to assess the adoption and adaptation of e-books into the language arts curriculum.[24] Pragmatic trials with comparison sites can shed light on the effectiveness of implementation strategies and lay the groundwork for guidance that improves implementation of effective e-book teaching practices across settings.

Conclusions

The pedagogy of the e-book is evolving, its signature features as yet undefined and untested for fit in real classrooms. The transition of best practice from print to screen is ripe for research. How does the shared book approach work, for example, in a digital environment with a 1:1 device deployment? What is trustworthy guidance? New, innovative techniques are also wide open to investigation that pushes e-book teaching forward in a digital world. Can e-books, for instance, blur the boundaries between home and school in ways that accelerate literacy learning? What are potential e-book interventions that prevent early reading difficulties?

Implications for Parents, Services and Policy

Since the body of research on e-book pedagogy is small, evidence-based recommendations for parents, service providers and policy makers are limited, aside from be cautious. In the absence of sufficient science, we turn to professional wisdom, which suggests applying best practices with print books to e-books.[25]

As with print books, teaching with e-books should be interactive where teacher and students have active roles in responding to text. Re-reading e-books is encouraged so that some become “old favorites” that students return to again and again to browse/read on their own. Relatedly, teachers should establish consistent routines for easy access to e-books on devices.

Instruction should focus children’s attention on printed words as well as relevant word meanings; word work should occur across several readings, especially during and after reading segments. To actively engage young readers, teachers/narrators should read fluently and model appropriate intonation and rhythm. E-book reading should be enjoyable and playful.

Teachers should carefully select e-books that meet quality design guidelines from empirical research.[26] They should plan for connecting core e-books for reading to related e-books and apps that extend teacher-led instruction to student-centered studios, hubs and play areas where

students have opportunities to dig into ideas--to explore, rethink, rehearse and revise their thinking and skills.[27] And they should be ever mindful of good teaching.

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Educational Media Supports for Preschool-aged English Language Learners

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Introduction

Educational media has the potential to foster early literacy skills in children well before they set foot in school, which may be particularly important for young English Language Learners (ELLs). Comprising ten percent of America's student population,[1] ELLs face challenges because the language they grow up speaking at home does not often reflect the language used in school. Research has investigated how young ELLs acquire a second language, and has deemed vocabulary knowledge to be critical in early childhood literacy development.[2] The purpose of this article is to synthesize recent research that has investigated how educational media may serve as a platform for vocabulary learning among young ELLs.[3]

Subject

Children today are immersed in educational media more than ever, with approximately 83% of children aged 6 months to 6 years old using some form of screen media every day[4] and therefore the reality of media usage among young children cannot be ignored. As such, it is imperative that we understand how media might support children's vocabulary learning and thus their school readiness.

Problems

Parents, educators and researchers share the challenge of understanding how young ELLs can enter school with a stronger literacy foundation in their second language. Educational media serves as a potential solution to this problem by facilitating second language acquisition and easing the home to school transition.

Research Context

Educational media is defined as videos and programs deliberately and systematically designed and marketed to enhance children's school readiness and academic development.[5,6] While vocabulary learning from media has been documented as early as 1990,7 studies did not hone in on younger ELL populations until about 2006,[8,9] investigating the effectiveness of educational media in both the home and school context. At home, parents and caretakers are often asked to document the viewing habits of children,[8] while at school, media has been integrated into classroom practice,[3,10] and used in isolation as a separate pedagogical activity.[9]

Key Research Question

The key research question to be considered here is how do ELL preschoolers learn vocabulary from educational media?

Recent Research Results

Intentional vocabulary instruction is missing from a lot of school curricula[11] despite the importance of supporting vocabulary growth in the early childhood period, especially for children with risk factors such as poverty, language delay or ELL status.[12] Educational media support with rich vocabulary exposure has been shown to be one of the most effective means for enhancing word learning in these children. In addition, as these children begin to learn the dominant language as sequential bilinguals acquiring a second language,[13] research primarily reinforces the use of the dominant language to promote vocabulary acquisition in educational media.[3,14,15] Although this assumption is pervasive in the recent literature, a number of empirical and theoretical non-media based studies have documented the importance of cultural relevance[16,17] and translanguaging[18,19] in second language classrooms to promote vocabulary acquisition. Translanguaging is the teaching practice of using both the minority (home) language and the majority (school) language alongside each other for instruction in the classroom. Multimedia technologies are particularly well suited to support these teaching practices because verbal content to accompany illustrations in dictionaries or digital stories are often available in multiple languages and may include a facility for recording personalized narration. Personalized books are especially adaptable for cultural relevance.

There are currently two salient theories of vocabulary learning in educational media. Paivio's[20] dual-coding theory proposes that verbal and nonverbal information are processed separately in the brain. According to his theory, when information is transmitted through verbal (e.g., speech) and nonverbal (e.g., visual image) signals, the two systems support each other and are

represented more fully, leading to stronger comprehension and greater information recall.[21] This serves as an appropriate scaffold for children's vocabulary learning.

Second, Neuman's[22,23] theory of synergy posits that multimedia presentations can create robust mental representations of content that facilitate recall and deepen understanding. In fact, multimedia characteristics such as sound effects, subtitles and zoom shots make actions more relevant and draw children's attention to details that cultivate a deeper understanding of content information.[24] Together, these theories purport that educational media may support ELL preschoolers' vocabulary acquisition by providing rich information exposure about a specific topic. Therefore, multimedia may help children develop multi-dimensional and extensive understandings of new words and their meanings, providing language learners with added word depth and richer comprehension.

A few key studies have explored the intersection of educational media and vocabulary development among young ELLs. Findings are as follows: First, educational media may affect the expressive and receptive vocabularies of ELLs differently, with programs that emphasize literacy skills being most beneficial in both domains.8 Second, studies show that when media is integrated into lessons, young ELL students acquire more vocabulary, while non-ELL students demonstrate no added benefit.[10] Third, when ELL and non-ELL children watch videos with multiple or single viewings, there is no significant difference in their receptive vocabulary. However, young ELLs who view the video multiple times do show improvement in their expressive vocabulary.[3]

Research Gaps

Two important issues remain unexplored. First, while research has documented the effects of multimedia on ELLs, many of these studies are situated in elementary or middle school contexts. Yet, preschool is a critical time period that requires further investigation considering the importance of laying an early literacy foundation in the language of school.[2] Second, after establishing whether educational media is beneficial for young learners, studies need to understand how these programs effectively teach early literacy: What are the specific pedagogical cues found on screen that promote vocabulary development? How might these cues affect ELL and non-ELL preschoolers differently? Furthermore, do cultural relevance and translanguaging pedagogy play a role in facilitating second language vocabulary development on screen?

Conclusions

Three findings regarding the use of multimedia to support vocabulary learning stand out:

1. Educational media has a high potential for teaching vocabulary words to ELL preschoolers, helping to prepare children from linguistically diverse backgrounds to enter school ready to learn in their second language.
2. Educational media can help cultivate early literacy in multiple settings: watching it at home, integrating it in lessons, and using it as an independent activity in school. However, understanding how best to use media in these settings requires further investigation.
3. Future research should explore the developmental and cognitive processes that facilitate word learning in multimedia, focusing on both expressive and receptive vocabulary skills.

Implications for Parents, Services and Policy

First, parents can choose educational content that is specifically designed to promote language and literacy learning, thus supporting their ELL child's readiness for school. Second, studies have shown that children learn more from educational videos when parents or guardians accompany them.[25] Having conversations with children that apply what was taught on screen maximizes the digital platform and better prepares children for school. Finally, for educators, consider how educational programs can be used to promote vocabulary acquisition in the early childhood classroom, either integrated into routines and lessons or as part of a literacy center.

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Technology in early childhood education: overall commentary

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Introduction

The six papers[1-6] presented in this section review the scientific literature on the potential harms and benefits of digital media for supporting language and literacy development in young children. The project itself presupposes the inevitable penetration of digital media into our homes and schools for entertainment and educational purposes. Although television and video remain the most commonly used forms of screen media by children, access to mobile devices is growing by children as young as two years of age.[7] Some people are afraid that increased exposure to digital media will harm the developing brain, but their warnings are based more on moral panic than evidence.[8] Most scientists are taking a cautious approach, working to understand the conditions under which digital media support learning and to identify factors that undermine the learning potential of these new technologies: for example, Courage and Troseth[1] conclude that toddlers may learn from ebooks with adult guidance but warn against excessive exposure to screen media at too young an age; Zosh, Hirsh-Pasek, Golinkoff, and Parish-Morris[2] report that good quality educational apps support guided exploration toward a learning goal; Korat and Segal-Drori[4] identify multimedia e-book features that facilitate learning as well as interactive features that distract from learning; Roskos and Brueck[5] consider the use of e-books in the school environment and focus on the need for more research on best practices by teachers; Savage and Wood[3] review computer based reading programs and note that their effectiveness depends upon the congruence of the program with literacy research and on the expertise of the teachers who implement them; finally, Wong and Neuman[6] discuss the potential of e-books to help prepare English Language Learners for school in the majority language.

Research and Conclusions

The research reviewed in these six papers[1-6] takes a cognitive approach, describing how individual learners respond to digital media given variations in the characteristics of specific applications.

Universal principles of learning are abstracted from this research, which in turn motivate certain guidelines that are offered to parents and teachers for the selection and use of educational media. In particular it is recommended that an adult guide the child's interactions with digital media: to direct the child's attention, help the child regulate their own behaviour and emotion, and relate the screen content to their own life experiences. E-books should also be designed to encourage guided exploration by the child toward a clear learning goal with multimedia elements used to focus attention on content that supports language and literacy learning.

The research reviewed is excellent and the general message abstracted is most assuredly sound: the potential of digital media to support children's learning is determined by the quality of the specific apps and the way in which they are implemented in the home and school environment. However, research with mobile devices is only just beginning and there are significant gaps in our knowledge, bringing much uncertainty regarding the policy implications of this research. A primary concern is the need for research targeting diverse groups of users. Korat and Segal-Drori[4] point out that multimedia features in e-books appear to be especially valuable for children from socially disadvantaged families; therefore, "one size fits all" guidelines for book design and use may not be ideal. Courage and Troseth[1] identify a research gap for children with language impairments – it is not known whether this population will uniquely benefit from the multimedia stimulation offered by e-books or be uniquely vulnerable to the distracting elements contained in these books. It is also not known whether the standard dialogic reading and language stimulation training program provided to parents of children with language impairments will generalize to the e-book reading context. Wong and Neumann[6] discuss the potential for multimedia e-books to support English language learning by minority language students, thus easing the transition to school. However, research with multilingual students in other contexts is lacking: for example, in some countries the state may support retention of the minority home language; in others, the schools are teaching multiple official languages; and increasingly, there is a need to preserve indigenous languages. More research is required to determine how best to design and implement digital technologies to support language and literacy learning in multiple languages in these varied contexts.

Implications for Policy and Service Development

The policy implications of the research presented in these papers is directed at individual consumers. Parents are encouraged to engage jointly with their children when they are playing with apps and to share ebooks just like paper books.[9,10] Teachers and librarians are exhorted to

select apps according to scientific principles and implement them according to best practice.[11,12] However, there is no research to indicate that these guidelines will be effective for the target individuals. Furthermore, we don't know that services designed to change individual behaviour will have broader impacts, especially for the groups already mentioned: children from lower income families, children with language impairments, and multilingual children.

It is well known that the uptake of new technologies lags in families with fewer financial resources, creating a "digital divide."[13] For example, in Canada, 7% of households do not have internet access and 11% do not have a cell phone; the gap between the poorest and the richest households is about 30% for both technologies.[14] Families that do not have these technologies cite a broad range of reasons but prohibitive cost and poor quality service in rural regions play a significant role. Access to technology is not the only issue however; the way in which these technologies are used differs across families. Even when internet access is universal, less advantaged young people use computers primarily to play games whereas more advantaged young people also use computers to search for information, read the news, and access important services.[15] Families from different social groups appear to have different attitudes about their young children's use of digital media. Upper middle class parents are somewhat less likely to consider tablet apps to be "educational" and do not like to read e-books to their children because they are actively limiting "screen time." Less advantaged parents report that they do not have time to share e-books and apps with their children; therefore, they might appreciate access to educational apps that effectively substitute for this time.[7,16,17] These differences across social groups in access to financial, skill, and time resources suggest that policies should be tailored to the needs of specific families. Public education campaigns that exhort all parents to share paper and e-books with their children may serve to widen rather than narrow the digital divide. In any case, research must directly assess the outcomes of policies and services across a range of social groups.

Some studies have found that digital books enhance language and literacy learning by socially disadvantaged children.[18] Subsequently, it has been suggested that children with biological risk factors, and in particular boys with language and reading disabilities, might benefit especially from digital media.[19,20,21] Text highlighting draws the child's attention to print, animations teach vocabulary and print-meaning connections, and text-to-speech functions facilitate story comprehension. The multimedia experience afforded by e-books is engaging and may be particularly motivating to children who are reputed to be uninterested in print book reading. This

hypothesis has not been fully investigated however and it seems equally likely that these technological features might be especially disruptive rather than adaptive for children with special needs. It is possible that children with weak language and literacy skills may become distracted by the interactive features or overly reliant on the nonprint aspects of the books for comprehension; subsequently, their experience with actual reading would be further reduced. The impact of digital media on the literacy skills of children with special needs requires urgent research attention.

The research gap with multilingual learners is also particularly acute. E-books have many features with potential to support the maintenance of the home language and acquisition of the school language by multilingual children.[22] In particular, options to add multilingual narration to commercial stories or to produce personalized stories are promising, as demonstrated in a project to use multimedia computer stories to revitalize endangered Indigenous languages.[23] Adapting policy and services for children across a broad spectrum of social, cultural, and linguistic communities requires close collaboration among researchers, families, communities, educators and app designers; these collaborations in turn require a solid foundation of public funding and support. Ultimately, the full potential of digital media cannot be realized by addressing the users of these tools simply as individual consumers.

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Digital Technology and Play in Early Childhood

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Introduction

Young children[1] engage with a broad array of technology including, but not limited to, television, film, internet accessed on any device, video games, tablet or smartphone apps and games and associated artefacts (e.g., books, toys or physical games relating to characters or brands). Play is complex to define[2] and is discussed in diverse ways in different contexts.[3] Many agree that play is distinguished by being fun, freely-chosen, serving its own purpose and being subject to (internal) rules.[4]

Subject

From birth, children have increasing access to a range of digital technologies. This inevitably impacts the landscapes of their play.[5] Since play is universally acknowledged as being important for children, it is necessary to understand the nature of children's play in relation to technology. Families need support for parenting in the digital age[6] and early childhood educators must know how to embed digital technologies in their own professional practice.[7]

Problems

There are numerous tensions and provocations in the study of young children's digital lives and play. Technology has sometimes been presented as antithetical to play.[2] More recently, the benefits of children's engagements with technology have been recognized, although not always their playful potential. Research has highlighted how specific characteristics of play contribute to children's development and learning[8] and how digital play may serve educative purposes if it is designed with specific learning outcomes in mind.[9] There is a risk that tying digital play's value too closely to a narrow definition of learning might risk ignoring the other crucial functions play fulfils.[2] However, highlighting specific formally educative impacts of digital play might be essential to reversing the trend towards reduced opportunities for play in many education systems.[10]

Research Context

Historically, much experimental, psychological research assumed that technology use by young children was primarily passive, in contrast to the active nature fundamental to children's play. A range of large-scale surveys and qualitative observational studies have summarized digital use in the Global North,[11,12] but play is rarely their primary focus. One recent exception[13] researched five topics related to play with technologies in the UK and South Africa. Recent approaches in smaller scale work have brought new insights into the nature of digital play. Ecological,[14] ecocultural[15] and sociocultural[16,17] studies have considered how social and cultural factors shape digital play. Digital literacies[18] researchers have considered the new and unique forms of play made possible by particular digital contexts.[19]

Key Research Questions

Three questions are considered: (1) which technologies do young children play with and how do they play with them? (2) Is play with technology similar or different to traditional (non-digital) play? (3) What are the implications of digital play for children's development?

Recent Research Results

Recent European,[11,20] Australian[21] and North American[12] data suggest that many young children are growing up in media-rich homes, frequently accessing moving image media[20] and using a range of digital technologies.[22] Use continues to diversify: young children spend increasing time using smartphones and tablets,[12] while smart speakers have recently emerged as important.[20] Diversification inevitably invites previously undocumented examples of play, such as children asking smart speakers to count to 10 while they play hide-and-seek.[13] Such examples show that digital contexts do not limit the types of play that are possible; rather, the precise nature of play changes.[23] Many studies have focused on 'screen time' as a displacement of time that might be better spent on 'real world' activities including non-digital play.[24,25] However, play is one of the primary ways that children use their digital devices.[5]

The precise nature of that play is complex and contested, having sometimes been criticized as 'less than' traditional play, constraining creativity[26] or limiting social interaction.[27,28] Certain digital contexts are viewed as less playful, such as television watching, when compared to applications on tablets,[5] smartphones and consoles.[29] Scholarly observations counter these commonly held perceptions. For example, children carry the narrative themes of television into their imaginative play.[30] Empirical work has highlighted children's highly creative play with computer games, apps,

digital cameras, coding toys and more.[5,31,32] Meanwhile, numerous sources[13,33] document the social nature of young children's play with technologies. The social contexts of children's digital engagement also play an important role.[29,34] Parents and carers have been shown to support the development of particular skills by engaging with their children's digital play,[35,36] although children's free-play with technology also holds important benefits.[13] Analyses of children's play with technologies suggest that all of the play types[37] typical in non-digital play can also be found in their digital play.[23]

Implications for young children are complex. Children develop a wide range of skills through their digital play,[13] including: subject knowledge and understanding; digital skills; and holistic skills (social, emotional, cognitive, physical and creative). Research has called attention to a range of social, cultural, political and economic issues associated with digital play. A recent study highlighted disparities in relation to digital play in the Global North and South.[13] For example, South African children spent less time playing titles such as Minecraft, Roblox and Fortnite than their UK counterparts. Studies suggest that girls and boys sometimes make different digital play choices.[38,39] Certain types of play with digital technologies, such as play based on adult television[40] or playing 'shooter' video games,[41] have been constructed as deficit or even dangerous, as in the case of the digital play of African American boys.[42] While there is a need to support children in using technology safely, a wide range of play practices hold value in diverse ways, not least in relation to identity formation.[43] There are, then, risks associated with the narrow value judgements sometimes implicit in formal education, if some young children's play practices are embraced and expanded upon in the classroom, while other types of play are discouraged.[29] The commercialization of children's play with digital technologies has been subject to long-standing critical review,[44] with recent work highlighting issues related to features of video game play, such as 'loot boxes'.[45]

Research Gaps

Much research concerns older children (9-16 years).[11] There is a lack of empirical work focused on the youngest children (0-2 years), although exceptions exist.[46] There is a need for device and platform specific research focused on the play afforded by emerging technologies, for example Augmented[32] and Virtual[47] Reality. Much has focused on the skills and knowledge acquired through digital play and specifically in relation to self-styled educational technologies.[25] However, there is also a need to research children's play holistically across a broad range of digital and non-digital contexts,[48] particularly as the presence of the digital in everyday life is such that it is no longer

feasible to distinguish between the oft intertwined digital and non-digital.[49] Research should consider broad benefits of play beyond the formally educative. Given the diverse daily life-worlds of children, there is a need for more research across geographical contexts beyond the Global North,[5,50] particularly the Global South.

Conclusions

Children's play in relation to digital technologies is at once similar to non-digital play and distinct from it. Scholars have mapped traditional play types against digital play and found that all are represented. However, digital contexts afford previously undocumented examples of play worthy of study in their own right. The digital and non-digital are intertwined in young children's lives and it is thus useful to consider play more holistically. Ongoing research is needed to deepen knowledge and understanding of the precise nature of young children's play in relation to the digital - both generally and more specifically in relation to the identified gaps in knowledge.

Implications for Parents, Services and Policy

Much information for parents and carers warns of potential harms and provides guidance on how to mitigate the risks of children's technology use. The research reviewed here suggests that a greater emphasis on the possible benefits is warranted. Families need information about how best to support and mediate their children's play with digital devices. The benefits of children's solo free-play with technologies can also be highlighted. The value of digital play for developing specific knowledge as well as physical, social, emotional and creative skills should be communicated to families and early childhood professionals.

Digital play is often ignored in early years policy, yet it holds value for learning and contributes meaningfully to young children's lives in broader ways. Policy-makers must attend to digital play, and in a way that is representative of a broad range of play practices. Training programs for early years educators would benefit from some consideration of how educators can build productively on children's home digital play practices.

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