Literacy Studies: Perspectives from Cognitive Neurosciences, Linguistics, Psychology and Education

Ji Eun Kim
Brenna Hassinger-Das *Editors*

Reading in the Digital Age: Young Children's Experiences with E-books

International Studies with E-books in Diverse Contexts

Springer

Literacy Studies

Perspectives from Cognitive Neurosciences, Linguistics, Psychology and Education

Volume 18

While language defines humanity, literacy defines civilization. Understandably, illiteracy or difficulties in acquiring literacy skills have become a major concern of our technological society. A conservative estimate of the prevalence of literacy problems would put the figure at more than a billion people in the world. Because of the seriousness of the problem, research in literacy acquisition and its breakdown is pursued with enormous vigor and persistence by experts from diverse backgrounds such as cognitive psychology, neuroscience, linguistics and education. This, of course, has resulted in a plethora of data, and consequently it has become difficult to integrate this abundance of information into a coherent body because of the artificial barriers that exist among different professional specialties.

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ISSN 2214-000X ISSN 2214-0018 (electronic)
Literacy Studies
ISBN 978-3-030-20076-3 ISBN 978-3-030-20077-0 (eBook)
https://doi.org/10.1007/978-3-030-20077-0

This Springer imprint is published by the registered company Springer Nature Switzerland AG.
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

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Introduction to the Edited Volume

Ji Eun Kim and Brenna Hassinger-Das

Born into a digital world, today's children spend more and more time with new media starting at an ever-younger age. While data show that games, YouTube videos, and television shows are children's favorites and digital books are generally underutilized (Merga and Mat Roni 2017), the number of studies targeting digital books is growing. Books are seen as the bedrock of reading comprehension and language development and as such digital books attract researchers' attention. The narration—a main source of information in (digital) books—includes sophisticated words and complex grammar, both of which are rare in films and television shows (e.g., Montag et al. 2015). This may explain why books are much more stimulating for language and literacy than alternatives such as YouTube videos and television shows.

An abundance of evidence shows that time spent with television and film is much less productive than book reading; television and film may even have a negative effect on language and literacy development of very young children. For instance, a recent study by Ma et al. (2017) demonstrates that the more handheld screen time a child's parent reports, the more likely the child is to have delays in expressive speech

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J. E. Kim, B. Hassinger-Das (eds.), *Reading in the Digital Age: Young Children's Experiences with E-books*, Literacy Studies 18,
https://doi.org/10.1007/978-3-030-20077-0_1

at 18 months of age. The time children share books with an adult is, by contrast, a strong predictor for both language comprehension and production skills (e.g., Bus et al. 1995; Mol and Bus 2011). Given the positive influence of adult-child book reading, how digital books impact the young child's early reading experiences is of major concern among researchers, educators, and parents.

1 The Prevalence of e-Books

Research shows that ever-increasing numbers of children use digital devices with storybook apps as part of their daily routine (Rideout 2013). Yet, despite children's increasing use of book apps from an early age, there is a limited understanding of how these "new age" books influence children's literacy development. e-Books go beyond paper books to offer new and expanded opportunities for practicing early literacy skills. And, compared to paper books, e-books with particular additions may be more compelling not only for engaging children in storybook reading (Richter and Courage 2017), but also for developing cognitive skills foundational in early literacy learning, such as vocabulary (Korat 2010; Smeets and Bus 2012; Verhallen and Bus 2010).

2 The Conflicting Evidence

As access to e-books widens, it is important to examine the educational benefits and limitations of these types of books. To date studies on the topic have presented inconsistent findings regarding the potential benefits and limitations of e-books in helping children learn literacy skills at home and in school (Bus et al. 2015; Roskos et al. 2017). In particular, researchers have examined the software features of e-books and their possible influences on both independent and adult-child shared reading. For example, children's independent reading of motion-enhanced e-books is particularly beneficial for children who are at risk of attention-related problems (Takacs and Bus 2016). However, low quality e-books, such as those containing animations and sound effects irrelevant to the story, do not provide children many learning opportunities (Reich et al. 2016). In addition, findings from studies that have compared paper and digital books in adult-child shared reading are also mixed in relation to levels of child story comprehension (Krcmar and Cingel 2014; Lauricella et al. 2017) and amount and styles of adult-child speech (e.g., Parish-Morris et al. 2013).

3 How This Book Captures These Issues

At present, researchers, educators, and caregivers are faced with a pressing question: How can e-books in early literacy experience shape healthy literacy development and promote better learning? We are beginning to understand what constitutes a quality e-book in children's literature (Yokota and Teale 2014; Yokota 2015) and as a learning resource (Bus et al. 2015; Reints 2015). We are also discovering how e-books support narrative comprehension skills and vocabulary that are the foundation of future reading comprehension (Kendeou et al. 2009; Potocki et al. 2013). But we need to know much more.

This book seeks to answer this question by summarizing what we know about current e-book design and usage practices, thus providing a "working" knowledge base. Its primary aim is to describe new mechanisms that digital books afford and to what extent these mechanisms support literacy development and learning for all children or specific groups.

4 Book Overview

The book contains 13 chapters on a range of topics related to e-books and young children's language and literacy development and learning. The chapters review the qualities of digital books as children's literature; describe adult-child interactions in shared digital book reading; explore children's independent digital book reading; and examine the use of digital books with children at risk for literacy problems. They also point the way ahead for future research that can expand what we know about the role of e-books in children's literacy experience and inform their use in early literacy teaching to achieve the best results. The book is divided into four broad parts: (1) e-book features and literacy development, (2) e-books and literacy practices at home, (3) e-book and literacy practices in schools, and (4) e-books and special populations.

4.1 e-Book Features and Literacy Development

The four chapters in this part examine how various e-book features and platforms affect young children's literacy development. First, Hassinger-Das, Dore, and Zosh examine four pillars from the science of learning regarding how people learn best—active, engaged, meaningful, and socially interactive—in relation to the design and effectiveness of e-books for shared book-reading. This review chapter explores how we can use the science of learning to harness the potential—and mitigate the drawbacks—of e-books for adult-child book reading.

In the following chapter, Courage reviews the current literature about (1) the potential of e-books interactive features to distract children from story information and possibly diminish learning, and (2) the change in the adult-child interaction that occurs during e-book reading compared to traditional paper book reading. Courage situates her review around three experimental studies with 2- to 5-year-olds from her own research group.

Next, Bus, Sari, and Takacs's review focuses specifically on the multimedia and interactive elements of e-books and how they impact children's story comprehension. They review evidence about effective and ineffective multimedia enhancements, while also discussing how e-book designers can employ such effective enhancements in meaningful ways to boost children's story comprehension.

Relatedly, in the following chapter, Evans reports about a study examining differences in young children's behaviors during independent reading of different e-book formats. She discusses which types of book features, including multimedia enhancements and voice-overs, are most effective in helping children learn from alphabet books. The chapters in this part review the literature as well as report new empirical findings to provide a roadmap for understanding how science can help us understand the benefits and drawbacks of e-book formats and features for literacy development.

4.2 e-Books and Literacy Practices at Home

Two chapters comprise this part, providing insights regarding parents' perceptions of both e-books and their children's literacy practices with e-books at home. The authors also highlight the positive influences well-designed e-books can have on dialogic reading at home. Etta's chapter presents parents' reports on reading behavior and perception on children's print and e-books. The findings show different ways of using print and e-books and various purposes for both the print and e-book uses. In particular, although the primary purpose of print and e-book use is children's learning at home, another common purpose of print books is related to social-related aspects (e.g., bedtime routine), while e-books are commonly used for babysitting-related aspects (e.g., entertaining children).

In their review of five studies, Revelle, Strouse, Troseth, Rvachew, and Forrester investigate adult-child shared reading of specially designed e-books for dialogic reading and print referencing behaviors. Their review demonstrates that an agent's modeling of dialogic reading on an e-book positively influences adult-child's dialogic reading of e-books regardless of the provision of adults' training sessions. Also, e-books containing animated target words encourage print referencing during shared reading. The chapters in this part report and review the authors' own studies that show what literacy practices occur at home and how well-designed e-books can enhance home literacy practices, such as making shared reading more productive.

4.3 e-Books and Literacy Practices in Schools

The chapters in this part discuss broad topics related to e-books in schools: the examination of different types of e-books for independent reading; comparisons of shared reading of print and e-books; potentials of informational e-books in students' reading comprehension; and pedagogical uses of e-books shared reading practices and early literacy teaching.

Brueck, Lenhart, and Roskos review popular digital reading platforms and their implementation in elementary school students' independent reading at school. They assert that new learning technologies in digital books personalize reading in new ways to address students' strengths and needs, as well incentivize their motivation to read.

At the preschool level, Wong and Neuman discuss their study on 36 preschoolers' literacy achievements—word learning and comprehension—in two different contexts: after a teacher read aloud of two print books and after independent reading of two e-books. Their results demonstrate that book contents, but not book formats, influence children's comprehension.

Relatedly, Hoel and Tønnessen point out three major aspects that teachers should consider for digital book shared reading in kindergarten classes, including texts, media and situations. In terms of texts, they assert that the relevance between meanings presented by words and images, and children's life experiences is important to increase children's interest in and engagement with the story. According to them, the success of multimedia features lies in the good integration with the narration of the story and the opportunities they offer for extra-textual discussion.

At the primary grade level, Herman and Ciampa examine 14 first grade students' independent reading of informational e-books by utilizing mixed methods. Results show a significant positive relationship between the students' comprehension scores and their use of literacy support tools (e.g., annotating). The examination of the students' reading behaviors also reveals that students are capable and prefer to use the support tools embedded in the e-books.

Finally, Moody and Swafford discuss their analysis of a survey and in-depth interviews with K-5 teachers. They report some of the benefits—such as increased engagement and motivation— and challenges—such as lack of tech skills— and provide practical guidance on how to use e-books for school literacy practices, such as how to select appropriate e-books. Chapters in this part provide a critical examination of e-book features that may influence children's learning with in-class e-book reading and discuss essential aspects that should be considered when e-books are selected for and are used in class reading practices, such as independent and shared reading for better literacy learning at school.

4.4 e-Books and Special Populations

The part two chapters provide invaluable insights into the positive effects of e-books on literacy learning for young children with learning challenges. First, Shamir, and Doshinsky review two empirical studies that examine vocabulary learning and reading comprehension in first grade children at risk for learning disabilities. One study focuses on children's story comprehension with two different types of educational e-books and the other examines children's vocabulary learning and story comprehension after an intervention program. The findings suggest some optimal ways to use e-books in the classroom for young children at risk.

The final chapter by Van Daal, Sandvik, and Adèr is a meta-analysis of 37 empirical studies carried out over 10 years examining the effects of interventions with e-books on literacy learning for young children aged between 0 and 8 (at risk and not at risk). Their review shows that children's age and time spent on the task seem to be the two variables that have the biggest influence on learning from e-book reading. The two chapters in this part highlight the positive influences e-books have on young children with learning challenges when learning to read and write.

5 Summary and Future Directions

As a whole, this book demonstrates the potential of e-books to enhance home and school literacy practices. In particular, the use of e-books is beneficial for young children's literacy learning when well-designed e-books are used in home and school contexts for both independent and shared reading practices. The benefits of the e-books are also present reading practices of children at risk. Other aspects discussed in the chapters are variables (e.g., age, disability status, etc.) that may influence the effects of e-books on young children's literacy learning, young children's engagement with e-books (e.g., behaviours and preferences) and positive ways of using e-books at home and school.

However, as indicated in the chapters, children's attention to story may be distracted by certain e-book designs (e.g., animated illustrations and hotspot activities that are not relevant to the story in the e-books). This will negatively impact children's reading comprehension and result in less dialogic parent-child interactions. Moreover, some authors indicate that despite the increasing use of e-books and evidence showing the benefits of e-books, e-books should not replace traditional print books, as both formats provide different learning opportunities. It should also be noted that, for children from minority socio-cultural groups, e-books reflecting their life experiences (e.g., values and practices) may be more meaningful.

Regarding future research directions, several authors in this book call for further studies involving larger samples with diverse groups of participants, including children at risk. Also, some authors suggest developing longitudinal studies that involve repeated reading of e-books that increase the participants' familiarity with

the stories and digital tools, and that examine the long term effects of e-books—including both story books and informational books—on young children's language and literacy learning. Other areas that deserve a closer examination are the effects of each particular multimedia feature (e.g., mixing of sound effects and music) and more productive design of interactive features, as well as further investigation of the effects of different interventions for parents and children at risk.

In sum, this volume provides a wealth of fresh information on major topics in early childhood e-books and digital book reading, including chapters on qualities of e-books for young children and emerging e-books literacy practices at home and school, making it a timely and informative read.

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Part I
e-Book Features and Literacy Development

The Four Pillars of Learning: e-Books Past, Present, and Future

Brenna Hassinger-Das, Rebecca Dore, and Jennifer M. Zosh

Abstract In this chapter, we will explore explanations for this conflicting evidence, and importantly, demonstrate the power of evidence-based recommendations for e-book use. In an effort to compare traditional books and e-books, this chapter will apply four pillars of learning generated from the Science of Learning (Hirsh-Pasek K, Zosh JM, Golinkoff RM, Gray JH, Robb MB, Kaufman J. Psychol Sci Public Interest 16(1):3–34. https://doi.org/10.1177/1529100615569721, 2015)—active, engaged, meaningful, and socially interactive. By harnessing the science of learning and relying upon the lesson generated by decades of research in psychology, education, and cognitive science, this chapter will explore how we can harness the potential—and mitigate the drawbacks—of e-books. Technology can be a marvelous tool—but only if we know how to use it.

Keywords Science of learning · e-Books · Early childhood · Literacy

In 2016, the American Academy of Pediatrics (AAP) released new guidelines on media use, and again, parents and educators were challenged to consider a readjustment of how they facilitate children's access to smartphones and tablets. How much—and likely more importantly—what kind of digital media consumption is acceptable for young children?

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J. E. Kim, B. Hassinger-Das (eds.), *Reading in the Digital Age: Young Children's Experiences with E-books*, Literacy Studies 18,
https://doi.org/10.1007/978-3-030-20077-0_2

In these new AAP recommendations (2016), "no screens under two" became "no screens for 18 months and younger" with the proviso that video chatting is acceptable for all ages. Recommendations for older children include less than 1 hour per day of screen time, using only "high-quality programming," and co-viewing with an adult. However, the notion of "high-quality" remains abstract. The revisions by the AAP along with the current state of research seem to be converging on the following idea: digital media itself is not necessarily a problem—the problem lies with how that technology is used.

One specific type of digital media that has the potential to be high quality is the e-book. The benefits of traditional storybook reading for young children's language and literacy development is well-established in the literature (e.g., Hargrave and Sénéchal 2000; Whitehurst et al. 1988; Zevenbergen and Whitehurst 2003), and one primary advantage of e-books is that families now have easy access to a variety of different e-books on devices that are constantly within reach. By 2014, 62% of 2- to 10-year-olds had access to either a tablet or a dedicated e-reader for electronic reading at home, and parents reported that about half of those children regularly engaged in electronic reading (Rideout 2014). Even children with emergent literacy skills are using this new technology for reading. Younger children (2- to 4-year-olds) use e-reading devices at similar rates as older children (Rideout 2014), with children beginning to use e-books at an average of 5 years of age (Gilmore 2015). When we use the term "e-book" in this chapter, we include several different formats of digital books, including those formatted for computers, consoles like LeapFrog, as well as their more modern equivalents on tablets. Although these formats may have some differences, the research literature has investigated all of these formats under the broad umbrella of "e-books" as technology has developed over the years. Also, it is worth noting that not all e-books have multimedia features, such as animation, narration, or interactive, touch-screen components, so here we include both interactive and non-interactive formats.

To date, there have been conflicting findings with some studies finding that e-books hinder learning while others demonstrate that they help. Some researchers have argued that e-books can support literacy development while some argue that they do not. Meanwhile, some studies have demonstrated that e-books can hurt parent-child interaction and some show similar interactions in the two mediums. Here, we explore these seemingly contradictory results through the lens of a particular set of book reading behaviors that have consistently demonstrated success in children's literacy development across book platforms: dialogic reading. Whitehurst et al. (1988) coined the term *dialogic reading* for a now widely recognized shared book-reading technique featuring adult scaffolding and child participation. Dialogic reading consists of adults: (1) using strategies to encourage a child to actively participate reading a story; (2) offering praise, explanations, and corrections for children's comments about the story; and (3) scaffolding children's independent level of understanding by incrementally increasing the complexity of adult – child reading interaction (Whitehurst et al. 1988).

We examine evidence about how children learn generated from the Science of Learning (Hirsh-Pasek et al. 2015) to make sense of how traditional and electronic books compare and explore how we can harness the potential—and mitigate the drawbacks—of e-books.

1 The Four Pillars and Book Reading

In their paper about "putting the education back in educational apps", Hirsh-Pasek, Zosh, and colleagues (2015) suggest that children learn best when they are active (minds-on) and engaged (not distracted) in meaningful learning via high-quality social interaction. Here, we suggest that dialogic reading is a perfect example of an activity that leverages all 4 pillars simultaneously. Further, we argue that lessons learned from traditional books should inform how electronic books are designed and used and that these insights could potentially provide explanations for seemingly contradictory research results about the benefits and costs of electronic books.

1.1 Dialogic Reading

Many studies with children from a variety of ages and diverse backgrounds using traditional paper books have found that dialogic reading is effective for supporting children's language and literacy development (e.g., Fielding-Barnsley and Purdie 2003; Mol et al. 2008; Wasik and Bond 2001; Zevenbergen and Whitehurst 2003) and those lagging behind in vocabulary (Hargrave and Sénéchal 2000). For instance, Wasik and Bond (2001) tested the efficacy of dialogic reading in a school setting. The authors assigned two classrooms to the intervention condition and two classrooms to a control condition. In the intervention, teachers were trained in the CROWD-style of dialogic reading (Whitehurst et al. 1994). The CROWD acronym represents: sentence **C**ompletion prompts, information **R**ecall prompts, **O**pen-ended (recalling information in students' own words) prompts, **W**h-word prompts (who, what, when, where), and **D**istancing (applying book content to other contexts) prompts (Whitehurst et al. 1994). Control group teachers received no specific training. The study examined the effect of interactive shared book reading plus extension activities reinforcing the use of target vocabulary in the book on children's language development (Wasik and Bond 2001). Teachers read two storybooks to their students every week for 15 weeks, either using dialogic reading strategies or using their typical reading styles. Afterwards, children who received the intervention performed significantly better on a measure of receptive vocabulary than their control group peers.

Below, we suggest that dialogic reading may be so beneficial because it harnesses the four pillars of learning. We briefly review how dialogic reading relates to each pillar and then explore what is known about how traditional and electronic books support (or detract from) each pillar.

Active Contexts Research from the Science of Learning suggests that children learn best when they are active, meaning that they remain "minds on" instead of passive (Hirsh-Pasek et al. 2015). Learning requires the active mental manipulation of ideas. It requires that children think about possibilities, comprehend not just the

words but also the story, hypothesize about what comes next based on the story and their own experiences and knowledge, and hold information in mind as the story unfolds. This is precisely the work of dialogic reading. The CROWD model (Whitehurst et al. 1994) described above is a perfect example of engaging children in minds-on thinking.

Even when children use e-books independently, outside of a dialogic reading context with an adult, features that encourage children to use minds on thinking can promote learning, as long as the features help focus children's attention on the educational content. In fact, Courage (this volume) argues that active e-book features can be highly effective if they steer the child to focus on key story information, define and use new words, and increase children's attention to the story. Indeed, Smeets and Bus (2014) found that children learned more vocabulary from an e-book featuring hotspots that defined target words when children touched them compared to an e-book without a touch feature. Similarly, research has found that some multimedia features like animated pictures, music, and sound effects seem to be beneficial for word learning, likely because these features can point to a word's meaning or support definitional information in the text (Bus et al. 2015; Takacs et al. 2015). For example, an animation of someone fanning a fire would likely lead to a more complete understanding of the meaning of the word "fanning" than a still image would because the back-and-forth motion would be visible in the animation, whereas motion is more difficult to depict in a still image. Although e-book features may still lag behind the type of active learning that can occur during one-on-one interaction with an adult, they might promote more comprehension and learning than completely non-interactive versions.

Engaged Contexts Hirsh-Pasek et al. (2015) proposed that a second pillar of learning is that the context must be engaging and this is accomplished through keeping children's minds "on task" and not distracted. Anyone who has sat through a fire alarm while in school, gotten a text message mid-conversation, or even struggled to focus due to an emotional experience can identify how distraction takes away from the matter at hand. Indeed, research suggests that the ability to focus on the right information and exclude extraneous information (Mayer 2014) is critical for learning. This is a challenge, not just for children (e.g., Kannass and Colombo 2007), but also adults, with a miniscule 2% of adults classified as effective multitaskers (Watson and Strayer 2010).

Research with traditional books suggests that this is a particularly important pillar for children. Even something like pop-up features in paper books have been shown to incur a cost to comprehension (Tare et al. 2010) with simplified books leading to increased learning (Chiong and DeLoache 2012). Even limiting children's viewing to one illustrated page at a time rather than two has been linked to increased story comprehension (Flack and Horst 2017). But notably, a gesture that helped children to find the referent when presented within two illustrations eliminated this deficit, suggesting that contextual factors are critically important to helping children stay on task.

Although e-books have many potential advantages for learning, one danger is that the format itself can distract children from engaging with the educational content. For example, in one study, Parish-Morris et al. (2013) found that when reading an electronic console book with embedded activities, parents and children each made more behavioral comments, such as "Can I turn the page?" or "Touch the puppy and it will play a song," during e-book reading than when reading a paper book. When reading a paper book, parents and children made a greater number of dialogic, story-related comments, such as, "What's Caillou doing?" than during e-book reading. When book reading time is taken up by procedural comments about how to work the tablet or by reminders to touch the screen to activate an activity, less time and mental capacity is available for meaningful engagement with the story. For example, when reading *Little Snowflake* (Metzger 2003) in a version of Scholastic's Storia app, the story is interrupted so that children can complete the following hotspot activity: "Match the words with the pictures below. (Word "fly" (match with picture of a bird), carry (match with dog carrying a stick), hop (match with rabbit)" (Hassinger-Das et al. 2016). When many of these flashy and exciting activities are presented in e-books, it can alter the shared book reading experience and result in children comprehending less about the story (Parish-Morris et al. 2013). Indeed, Krcmar and Cingel (2014) suggested that the reason why children in their study comprehended significantly more when reading a traditional book compared to an e-book was related to the increase in distraction-related talk by parents in the e-book condition.

Conversely, some research suggests that e-books elicit greater engagement on the part of children than traditional books, perhaps because children are drawn to digital and mobile technology in general. Studies have demonstrated that children may pay more visual attention to an e-book than a traditional book (Lauricella et al. 2014) and also shown that children were more engaged with an e-book than a traditional book overall (Richter and Courage 2017; Strouse and Ganea 2017). Van Daal and colleagues (this volume) argue that a particular focus of future research needs to be on determining when and what factors influence children's readiness to use e-books, apps, and games. At what age and attention level are children prepared to look past the distractors present in various forms of digital media and engage with the content beyond?

Meaningful Contexts In order to increase the likelihood of learning new material, it is important to make that information personally relevant or connected to prior knowledge (Chi 2009; Hirsh-Pasek et al. 2015). Research has shown that people who make connections between new information and their own lives or previous knowledge are more likely to retain that information (Brown et al. 2014). Indeed, a cornerstone of dialogic reading is drawing attention to the meaning of what is happening in the current story and making connections between these topics and the child's life, experiences, and expectations.

In the realm of e-books, findings from a pilot study testing the features of e-books and traditional books (Hassinger-Das et al. 2016) suggested that although there were not significant differences in children's story comprehension based on book

format, the children of parents who used more distancing prompts—or talk that related the story to the children's own lives—while reading had better story comprehension. This type of parent comment may be especially valuable because distancing prompts have been shown to help children relate the story to their own lives and make inferences (Van 2008). When parents connect something in the story to their children's lives – for example, noting that the train in the book is like the one they saw on vacation last week – they encourage children to link the book's content to experiences they have had.

Other types of parent behavior may also help make e-book content meaningful for children. Because parents know a great deal about their children's development and prior knowledge and experiences, they are in a better position than a standard e-book to adjust in many ways to their child's reading level. They can adjust their reading speed, connect the story to their child's interests and experiences, and adapt to their child's background knowledge or lack thereof. Past research has shown that personalizing a storybook can promote children's learning (Kucirkova et al. 2014). Similarly, first to third grade children seem to profit from individualized literacy instruction (Connor et al. 2013). Despite much excitement about the potential of computers and tablets to offer individualized education (e.g., de Jong and Bus 2003; Moody 2010), for activities such as storybook reading, a caring and observant adult who is knowledgeable about the child's abilities and interests, may be best positioned to offer a child a beneficial individualized reading experience—regardless of book type.

In this publication, Revelle et al. (this volume), Strouse, Troseth, Rvachew, and Forrester review studies examining the *Read with Me, Talk with Me* program. These studies provide a great example of how dialogic reading practices can make meaningful connections for children between storybooks and their own lives. The studies featured versions of a Peg + Cat book with the Ramone character providing dialogic reading assistance. During feedback sessions after the book reading, parents mentioned that Ramone helped them see new ways that they could connect the story to their children's own lives--and make it more meaningful.

Socially-Interactive Contexts The importance of social interaction for learning begins at birth. Children's first teachers are the adults around them (Csibra and Gergely 2009), and learning from and with others continues to remain important throughout the lifespan. Research has investigated parent-child interactions around traditional book reading, and research suggests that the socially interactive nature of shared book reading may be the ingredient that promotes the best kind of learning environment for children (Hirsh-Pasek et al. 2015).

In the context of e-books, recent research has demonstrated that there is likely something unique about parents and children reading together—above and beyond the benefits of reading an e-book without a contingent partner (Dore et al. 2018). In a study of 4- and 5-year-olds, parent-child dyads participated in one of three condi-

tions: parent reading to child; child engaging independently with audio narration; or child engaging independently without audio narration. When parents read with children, children remembered more story details compared to children in both independent book conditions. Children in the parent reading condition remembered an average of 20% more story elements than children who heard the e-book audio narration independently. They also answered 13% more comprehension questions correctly than children who independently listened to the audio narration. These results suggest that e-book audio narration is not the same as a parent-child shared reading, perhaps due to the important back-and-forth contingent interactions that can occur when book reading is a social activity (see also Korat and Or 2010).

For the most part, current e-books do not offer built-in opportunities for dialogic reading, meaning that children who listen to the audio narration do not partake in this critical social component of shared book reading. It is these kinds of sensitive and responsive interactions that are seemingly the most difficult for e-books to recreate. Further, during dialogic reading, these contingent responses are individualized. We know that children benefit when adults apply their knowledge about the children's cognitive and emotional development to their question asking and commenting practices during book reading (Blewitt et al. 2009). Researchers are currently exploring how to employ technology—such as artificial intelligence—to more support the parent-child dialogic reading experience. But for now, contingent social interaction with an adult appears to be the best way to support children's learning from e-books. Yet, Bus, Sari, and Takacs in (this volume) highlight the idea that adults are not necessarily taking the opportunity to use dialogic reading practices, regardless of book type, when reading with their children. They suggest that adding engaging elements, such as camera movements, to e-books may complement the ways that adults are naturally inclined to interact with their children while reading and perhaps encourage greater adult-child interaction.

It is important to note that shared reading experiences also seem to serve multiple purposes for parents and children. For instance, parents report that they view time for shared book reading to also be important for the purposes of bonding with their child (Audet et al. 2008). Some research has begun investigating the impact of print versus electronic versions of books on parental warmth and child engagement (with children aged 7–9 years) and finds that despite no differences in story recall, reading the digital version appeared to serve as a detriment to warmth (Yuill and Martin 2016).

In fact, Etta (this volume) conducted a parent survey, in which parents stated that traditional print books were more commonly used for *social* purposes, including during the bedtime routine and for parent-child bonding, while e-books were used more frequently for *babysitting* purposes, including occupying children when a parent was unavailable. Not only do researchers and parents have to ask themselves about the format of the book they are reading (electronic or traditional), but also what they are hoping to accomplish during their shared reading experience.

1.2 Research with e-Books: A Moving Target?

It is important to note that the evidence on e-books is mixed, with some research finding costs to comprehension and the quality of the parent-child book reading interactions (e.g., Krcmar and Cingel 2014; Parish-Morris et al. 2013), but other research suggesting that there are not necessarily large differences in children's story comprehension after shared reading of paper books versus e-books (e.g., de Jong and Bus 2003; Lauricella et al. 2014). There are likely a variety of explanations that factor into these differences. For instance, (1) the **design** of electronic books vary (e.g., some features are more distracting during reading than others), (2) it is likely that **individual differences** (e.g., some children are more susceptible to distraction than others) play a role, (3) **age** (e.g., younger children may be more likely to be distracted than older children, older children are able to read books independently while younger children cannot) and, (4) **experience** (e.g., the first few times one reads an e-book, the focus might be about novelty of the technology but over time, this novelty may wear off).

Thus, it is crucial to note that not only are the devices (e.g., design) and children moving targets (e.g., age, individual differences), but also is the context in which children and parents are using these devices. For example, e-books may detract from children's learning when families have little to no experience with them at home, but not when families are comfortable with the e-book format. This kind of effect could explain why some early studies found differences between e-books and traditional books in parent-child interaction and learning (Krcmar and Cingel 2014; Parish-Morris et al. 2013), whereas more recent studies have not—and some have even shown advantages for e-books in language and literacy (Courage et al. 2017; Etta et al. 2017; Strouse and Ganea 2017). As the technology becomes more familiar, parents may be better able to effectively scaffold the interaction in order to effectively capitalize on the four pillars and support children's learning.

2 Conclusion

Evidence from the science of learning demonstrates that one reason dialogic reading may be so beneficial is because children are *active* in their own learning, *engaged* in and not distracted by extraneous information (from pop-up paper flaps to interactive electronic hotspots), participate when adults connect the story to the child's own *meaningful* life experiences, and experience reading in a *socially interactive* context that supports these kinds of interactions. By infusing reading with experiences based in the four pillars of learning, adults can ensure that children are deriving the greatest benefit from e-books. Technology can be a marvelous tool—but only if we know how to use it.

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From Print to Digital: The Medium Is Only Part of the Message

Mary L. Courage

Abstract Over the past decade, preschool children have had increasing experience with storybooks in an electronic format. These reading sessions are usually guided by an adult who keeps the child's attention focused as the story unfolds. Occasionally, children are given a tablet or smartphone to operate on their own when the adult is not available to scaffold (e.g., in a car, at a restaurant). Although traditional paper storybooks still dominate the preschooler's reading experience, the growing availability of e-books has opened a debate on the relative effectiveness of these two book formats for children's attention and learning. While it is clear that preschoolers are very attentive to, and engaged in e-books, questions remain about (a) the potential of their interactive features to distract children and diminish learning, (b) the change in the adult-child interaction that occurs during e-book reading compared to traditional book reading, and (c) whether the built-in interactive and multimedia features can replace the traditional role of the adult that occurs in joint reading. The answers to these questions are discussed in relation to three critical variables: the characteristics of the individual child, the content of the e-book material, and the context in which the joint or independent reading occurs.

Keywords Attention · e-Books · Engagement · Executive functioning · Language · Parent-child interaction · Preschoolers · Story comprehension

The market for electronic storybooks for preschoolers is growing steadily as children become increasingly immersed in digital media. A report from *Common Sense Media* (2013) indicated that 72% of children under 8-years of age in a national, United States sample have used a mobile device, up from 38% in 2011. Usage includes playing games, watching videos, communicating, taking pictures, reading

This research was supported by a grant from the Natural Sciences and Engineering Research Council of Canada to Mary L. Courage.

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J. E. Kim, B. Hassinger-Das (eds.), *Reading in the Digital Age: Young Children's Experiences with E-books*, Literacy Studies 18,
https://doi.org/10.1007/978-3-030-20077-0_3

books and accessing apps and content delivery sites (e.g., YouTube, Netflix). Among children 2 years or younger, 33% had used a touchscreen device. More recently, Kabali et al. (2015) reported even higher rates of ownership (75%) and use (96%) in a large sample of low-income minority children between birth and 4 years of age. Rates in two European samples of very young children were also high; 58% of 5- to 24-month-olds in France (Cristia and Seidl 2015), 52% of 6- to 12-month-olds and 92% of 19- to 36-month-olds in the UK TABLET (Toddler Attentional Behaviors and Learning with Touchscreens) project. However, exactly how effectively these toddlers and young preschoolers used the touchscreen devices is still unclear. It is likely that random touching and tapping the screen to produce any type of effect would developmentally precede deliberate, purposeful activation of a feature or an app to achieve a particular goal (Guernsey and Levine 2015).

Research on the cognitive, motor and social implications of this ubiquitous media exposure for very young children is ongoing. Most of the studies to date have examined the potential impact of e-books compared to traditional paper storybooks on language and literacy outcomes, adult-child communication during reading, and on children's engagement (attentiveness, interest) in the story. Indeed, Rideout (2014) reported that 27% of 2- to 4-year-olds and 39% of 5- to 8-year-olds have read, or been read to from an electronic book (e-book) accessed on a tablet, reader, or smartphone. However, most of the roughly 40 min a day spent reading to preschoolers is still done with traditional paper books (27 min) with less time spent reading on a computer, tablet, or e-reader (13 min). This is consistent with the mixed views that parents report about using e-books with preschoolers, even though e-reading devices are often available in the household (Etta this volume; Kucirkova and Littleton 2016; Richter and Courage 2017; Strouse and Ganea 2017a; Vaala and Takeuchi 2012; Zickuhr 2013). In contrast, there are relatively few studies of preschool children's learning from problem solving, reasoning, or number knowledge apps downloaded onto mobile devices (but see Zimmerman et al. 2016). Given this, the term "e-book" as used here refers to electronic storybook content but also covers the various learning apps for children that are available but that do not have a narrative structure per se. The distinction between "e-books" and "apps" is not always obvious and likely rests more on the intended outcome or goal than on any difference in format or structure.

The growing availability and uptake of e-books for preschool children has raised concerns that in addition to providing more screen time, they will also distract them from the story content and interfere with pre-reading skills and story comprehension (Rideout 2014). There is also evidence that e-books change the nature of the very important parent-child interaction that occurs during reading with traditional print books (Chiong et al. 2012; Krcmar and Cingel 2014; Parish-Morris et al. 2013; Mol and Bus 2011). On the other hand, because e-books are delivered on popular mobile devices, they might engage and motivate children to read more, provide benefit from built-in reading aids, and direct children's attention to important story details that support comprehension (Brueck et al. this volume; Moody et al. 2010). Children who are engaged during reading explore the book more extensively, create conversation, show an interest in the illustrations, and can sustain their attention

throughout the reading. Reading engagement is associated with important positive short- and long-term literacy outcomes (Justice et al. 2003; Whitehurst and Lonigan 1998). The case has also been made that electronic devices are here to stay and that reading from e-books will enhance children's capability with the digital technology that is part of their present and future lives (Bedford et al. 2016; Flynn and Richert 2015; Lauricella et al. 2009; Mol et al. 2014; Roskos et al. 2014).

Research findings in which preschoolers' language and literacy outcomes have been compared across electronic and paper formats have been inconclusive. Some have indicated that e-books facilitate learning (Herman and Ciampa this volume; Ihmeideh 2014; Korat 2010; Smeets and Bus 2012), produce outcomes similar to that from paper books (de Jong and Bus 2004; Lauricella et al. 2014; Neuman et al. 2017; Willoughby et al. 2015), or diminish comprehension and learning (de Jong and Bus 2002; Krcmar and Cingel 2014; Parish-Morris et al. 2013). Factors that underlie the lack of agreement include: (1) the diversity of methods, procedures, materials, and dependent measures that have been used to study the outcome measures of interest, (2) the wide range in the number, type, and quality of the interactive features embedded in the e-books makes them difficult to compare with each other or with paper books, and (3) that individual differences in the maturity of preschoolers' executive functioning and language proficiency have not been considered in relation to literacy outcomes. Although these variables are strongly correlated with age, there are also individual differences that potentially relate to learning outcomes (Carlson et al. 2016).

1 The Cognitive Theory of Multimedia Learning: An Integrative Perspective

Some of the uncertainty about learning from e-books versus paper books can be resolved by considering well-established principles of human cognition. For example, Mayer (2005) proposed a cognitive theory of multimedia learning (CTML) in which he argued that effective instructional materials in any medium must be consistent with the way that the human information processing system works. Three principles guide the theory. The first, based on dual-coding theory (Paivio 1986), is that when incoming information can be processed in both visual and auditory channels at the same time it is learned and retained more effectively than if it is processed in a single channel. Second, there is a limit to the amount of information that can be processed in working memory at any one time (Baddeley and Hitch 1974; Kahneman 1973). Third, learning is most effective when individuals are actively engaged in its processing (e.g., paying attention, integrating new information into existing knowledge) (Gopnik and Meltzoff 1997).

Although the CTML was developed to enhance multimedia learning for older students, much of it can be adapted to the design and evaluation of paper and electronic storybooks for younger children. Both formats support dual processing

(visual image, narration), though the multimedia features added to e-books might enhance or perhaps diminish the effect compared to the same paper book. Likewise, either format might tax working memory; e-books with too many features, or paper books with too few features that require more interaction with long term memory. Both formats permit active learning; e-books through story compatible interactive features and paper books through conversation with the adult during joint reading. Ultimately, the effectiveness of any application of these principles will depend on the cognitive load that the medium and the story content jointly impose on young children, whose executive functions are immature (Diamond 2013; Garon et al. 2008). Indeed, Fisch (2000) proposed a capacity model of children's comprehension of educational television content that is relevant. The basic idea was that young children have limited cognitive resources available to process and comprehend both the narrative and instructional contents that require them to follow the story (e.g., understanding goals, making inferences) and at the same time retain and use the elements targeted for learning (e.g., new words, facts, numbers) to support comprehension. All of these requirements consume resources. When capacity is exceeded, comprehension and learning are reduced. Cognitive load could be further increased if extra resources are needed to control and process the interactive features and to carry out the operation (e.g., swipe, drag and drop) of the electronic device itself. Alternatively, if the sources of narrative and instructional information are cohesive, load could be reduced, and resources enhanced.

2 Predicting the Learning Potential of e-Books and Learning Apps

Like many complex questions about early child development, the truth lies in considering a multitude of factors as well as the interactions among them. It is important to note that many of the current questions and concerns about interactive mobile devices (including e-books) were asked and answered about the effects of television viewing on cognitive and social development in young children over the past several decades (Guernsey 2012; Pecora et al. 2007). However, there is a critical difference between television and e-books and other mobile devices. Television is a passive medium as children simply sit and watch and do not take an active role in the learning process. In contrast, e-books and other apps are interactive and engage the child directly and often require verbal responses or actions as the story unfolds. Consistent with the CTML, it is this interactivity that makes the e-book and apps potentially more effective platforms for learning than is television. This possibility was recognized by the American Academy of Pediatrics (AAP) in their revised, more flexible recommendations on screen time for children (Chassiakos et al. 2016). These recommendations have also been endorsed by the Canadian Pediatric Society (2017). That being said, a consensus from the literature on the efficacy of e-books compared to paper books indicates that, as is also the case for television viewing, the answer

depends on (a) factors within the *child* (e.g., age, executive functioning, language proficiency), (b) the *content* of the e-book or app itself (e.g., age appropriateness, comprehensibility, the quantity and quality of the interactive and multimedia features it includes), and (c) the *context* in which the reading activity takes place (e.g., alone or with a supportive adult; with or without dialogic prompts; presentation format such as electronic, paper, face-to-face) (Barr and Linebarger 2017; Guernsey and Levine 2015; Lerner and Barr 2015).

Although these three sets of factors provide a convenient organizational framework in which to review the literature on the effectiveness of digital media, it is important to note that it is the nature of the interactions among them that will primarily affect learning and literacy outcomes from all formats. In particular, it can be difficult to separate the effects of the content of any medium on outcomes from the effects of the affordances (e.g., amount of interactivity) provided by the medium itself (e.g. e-book, paper book). In any case, individually and collectively, the three sets of factors are a good fit with the guiding principles of the CTML. The literature on the roles of the child, content, and context in relation to screen media will be considered next. Where relevant, comparative data from research on the effects of television on attention and learning will be also described.

2.1 The Individual Child

Perhaps the most obvious individual child characteristic is age. Older preschoolers and school aged children can learn from television or e-books more effectively than can younger preschoolers, toddlers, or infants. However, age itself is only a proxy for the many domain general and domain specific developments that co-occur with it. As children age, the prefrontal cortical regions of their brains become better articulated and more specialized, they acquire conventional language proficiency, and they master the narrative skills with which to interpret and comprehend a story. They also have a richer knowledge base about the world, better learning strategies, have come to understand the symbolic nature of screen media, and have more mature executive functions (Garon et al. 2008).

Executive functions are of particular importance in understanding digital technologies as they enable self-regulation or cognitive control of one's thoughts, feelings, and behavior in a wide range of daily activities. Broadly speaking, there are three core (but interrelated) executive functions (a) inhibition; the ability to resist making a dominant but incorrect response in favor of a subdominant but correct response, (b) working memory; the limited capacity mental workspace essential for thinking and reasoning (e.g., reading, mental arithmetic, conversation), and (c) attention control; the mental flexibility that enables one to maintain focus or shift attention from one task to another appropriately. Executive functions are poorly developed in infants and toddlers but mature rapidly across the preschool years and continue to fine-tune into adolescence (Diamond 2013; Garon et al. 2008).

There is a growing research interest in the development of executive functions as their importance to a range of cognitive and social outcomes that require self-regulation is recognized (Lawson and Farah 2015). Consistent with the limited capacity principle of the CTML, for both e-books and paper books, more mature executive functions will enable children to keep more information in mind, sustain their attention to the story, and to resist distraction (Diamond 2013; Johansson et al. 2015). However, the additional distractions from the animations and interactive e-book features and the operation of the touchscreens themselves might further tax the young child's executive functions and diminish learning. In contrast, older children have sufficient resources to adapt to the additional cognitive load and still benefit from the interactive and multimedia features. Although advances in executive functioning are typically related to age across the preschool years, there are also marked individual differences within age that result from neurobiological, genetic, and social factors (e.g., prefrontal cortex, child temperament, parenting) (Bell and Cuevas 2016; Benson et al. 2013; Bernier et al. 2010). Indeed, Richter and Courage (2017) found that executive functioning was a better predictor of preschool children's attention and story comprehension of both an e-book and a matched paper book than was age or language comprehension alone. Finally, there is evidence that viewing certain types of screen media content seem to diminish executive functioning, at least in the short term (Huber et al. 2018).

The maturity of children's language development is another factor that will affect what and how they learn from storybooks. Specifically, more mature language facilitates story comprehension and recall. Strong receptive language provides the child with a richer knowledge base with which to interpret, comprehend, and retain the story content. Likewise, having strong productive language enables effective story retelling that not only serves as a rehearsal mechanism that supports retention of story information, but also reflects good story comprehension regardless of book format (Dunst et al. 2012). e-Books for preschool children often have additional features that support language development, including word pronunciations, explanations, repetitions, and highlighted text. Older children and those with more mature executive functions and language may not need those supports and will therefore have additional resources to devote to processing the story for comprehension. For example, Strouse and Ganea (2016) found that 4-year-olds who had stronger language skills were better able to learn a new concept provided in an e-book format than those with weaker language skill. Although the familiar language milestones unfold in a predictable order that is strongly related to age, there are also well documented individual differences in all aspects of language development, from first words to grammar, that originate from a host of biogenic and environmental influences (Bates et al. 1995; Richter and Courage 2017).

2.2 The Content of e-Books and Digital Screen Media

There is little doubt that reading to children from traditional paper storybooks is the "gold standard" activity that provides educational advantages and predicts a range of positive developmental outcomes for children of all ages. Among the most important advantages for preschool children are improvements in language (expressive, receptive) and in emergent literacy (e.g., print awareness, vocabulary acquisition, letter knowledge, phonological awareness) that are fundamental to learning to read, engagement in reading, and achievement in school (Fletcher and Reese 2005; Mol and Bus 2011; Mol et al. 2009; Whitehurst and Lonigan 1998). Storybook reading also supports the development of attention, memory, narrative, and learning more generally (Greenhoot et al. 2014; Lever and Senechal 2011; Whitehurst and Lonigan 1998). These important gains from early exposure to books are robust and persist beyond early childhood and continue into adolescence and young adulthood (Mol and Bus 2011). It is also clear that the content of the storybook, or indeed any learning medium, must be developmentally appropriate in order to optimize learning. The content must be matched to the child's level of cognitive development, including their language proficiency, their knowledge of the world, and the narrative understanding that will make the story comprehensible. Presumably, these basic requirements also apply to learning from stories and other types of content presented on electronic media. Whether these have been considered and included in the roughly 80,000 commercially available, "educational" e-books and apps for children is unclear, in part because the claims of educational content remain largely untested and unregulated (Hirsh-Pasek et al. 2015).

Television Many of the early studies of television related the amount of viewing to the outcome measure of interest. Subsequently, researchers discovered that while the amount of television viewing is not unimportant (e.g., Pagani et al. 2013), "watching television" is not a single activity that in and of itself can support or interfere with learning and child development. Rather, the content of the television material being viewed is far more important. Indeed, several studies that showed negative associations between the amount of television viewing and a particular developmental outcome (e.g., poor language, aggression) disappeared when the content of the television program was considered (Christakis et al. 2004).

Perhaps one of the most thoroughly documented examples of the benefits that educational content can provide is *Sesame Street* (e.g., Anderson and Hanson 2010; Mares and Han 2013). A meta-analysis of 24 studies done on *Sesame Street* in 15 countries that included 10,000 children from all social classes and income levels,

showed strong positive effects of regular viewing on cognitive outcomes (literacy, numeracy); knowledge about the world, social reasoning and attitudes to minority groups (Mares and Han 2013). Other research groups have also shown the positive effects that certain well-designed television programs can have on language (e.g., Linebarger and Piotrowski 2010; Linebarger and Vaala 2010) and social (e.g., Anderson and Hanson 2010) development. That being said, educational content is not sufficient on its own to support learning. Linebarger and Walker (2005) examined the relationship between television exposure, and vocabulary knowledge and expressive language in toddlers' who regularly viewed several popular children's educational programs. The results varied by the program and in particular, the language strategies that were incorporated into the content of each one (see Linebarger and Piotrowski 2010). It should also be noted that just as children can learn from good positive content, they can also learn from negative content. The relation between viewing violent content and aggressive behavior and attitudes in some children is well known (Anderson and Hanson 2010; Pecora et al. 2007).

The Transfer Deficit A significant limitation to what young children can learn from video content is the fact that until about 3 years of age they have a "transfer" deficit. This refers to the fact that infants and toddlers do not readily imitate action sequences viewed on video, although they will imitate the same actions when viewed by a "live" model (Anderson and Pempek 2005; Barr 2010, 2013). This transfer deficit is not limited to action sequences but also occurs with object-retrieval, word-learning, and language-recognition tasks (Kirkorian et al. 2016; Krcmar et al. 2007; Kuhl et al. 2003; Troseth 2010). Research has shown that this deficit originates from the specificity of infant and toddler learning whereby the characteristics of the encoding (e.g., video) and retrieval (e.g., real world) contexts must match exactly for learning to occur and be transferable (Hayne 2009; Rovee-Collier 1999). Over their second year, infants develop greater "representational flexibility" and only then are they able to tolerate mismatches between encoding and retrieval contexts and to transfer learned information to new objects and situations. However, the transfer deficit is usually not fully resolved until late in the second year (Barr 2013; Hayne 2009). Notably, it has also been observed in toddlers' learning from picture book content (Barr 2013).

Research on the transfer deficit showed that mismatches can arise from immaturities in several perceptual, cognitive, and social processes. These include (1) the difficulties in equating information obtained from the 2-D video with the corresponding 3-D live source, and vice versa (Barr 2010, 2013), (2) understanding the symbolic nature of the medium; that the video is something in its own right and also represents the same information in the real world (DeLoache et al. 2010; Troseth 2010), and (3) the fact that their usual experience with responsive, contingent others tells them that the non-contingent video source is not real or directed to them personally and therefore not useful (Troseth 2010; Stouse and Troseth 2014). Mitigation of these factors (e.g., by repetition of the material, experience with closed-circuit

video, embedded verbal prompting cues) improved performance (e.g., Barr et al. 2007, 2008) but did not eliminate the advantage of live learning. Finally, very young children have limited understanding of the medium and the conventions of television itself; the form and function of its formal features, the size, movement and trajectory of the objects and characters, the format (narrative or expository) of the content delivery, or its interactional quality (non-contingency). Following experience with television and with coincident advances in language, cognition, and social awareness, these limitations become resolved, and learning and transfer from video begin to occur (Anderson and Hanson 2010; Barr 2010).

e-Books and e-Learning Apps Notwithstanding the transfer deficit, the content of e-book stories is critical to their effectiveness as a learning platform. However, unlike television, the content of the current genre of e-books are interactive and engage the child directly as a participant as the story unfolds. Importantly, well-designed e-books incorporate some of the features that mitigate the transfer deficit (e.g., repetition, contingency) that occurs when passively viewing television. However, as with television, the e-book content must be both engaging and age appropriate for learning to occur. The results of several recent studies have shown that children were generally more engaged during the reading of an age appropriate e-book than a matched paper book (Parish-Morris et al. 2013; Richter and Courage 2017; Strouse and Ganea 2017a). It is also important to note that e-book technology has evolved dramatically over the past decade. The early versions were standard storybooks available on CD-ROM for presentation on a computer and operated by a mouse. Others were available on game-like reading consoles. Currently, many e-books are downloaded on hand-held devices with touchscreen operation. Moreover, e-book software has become highly sophisticated in the features that they can provide to illustrate and enhance the stories. In addition to storybook content, e-learning apps now include a range of other types of material (e.g., word learning, concept acquisition, number knowledge).

How Engaging Features Enhance Content The number and type of built-in features that are contained in an e-book can have a powerful effect on learning. Consistent with principles of the CTML, these must also be carefully placed and integrated into the story if they are to focus the child's attention and support learning rather than being a distraction. e-Book features can be highly effective if they direct the child's focus to important story information, provide explanation of new words, and motivate them to sustain their attention until the story is finished (Bus et al. this volume). In a recent meta-analysis, Takacs et al. (2015) distinguished between two general types of e-book features, multimedia and interactive. Multimedia features are those that include story congruent animations, sounds, voices, or music that are presented simultaneously with the text as the child hears or reads the e-book (e.g., the sound of a splash as a baby bird falls into the water). In contrast, interactive features, often called "hot spots", include built-in games or activities that require

children to shift their attention away from the story content and toward the particular feature (e.g., tapping a hot spot to change the color of Cinderella's dress). The results revealed a significant benefit from e-book reading for story comprehension for those that included multimedia features, while no additional benefit was found for stories with interactive features. Likewise, Strouse and Ganea (2017b) reported that 17- to 26-month-olds who were read an electronic or paper book were more attentive and engaged during e-book reading, produced more content related comments, and showed more recognition of newly labeled object. The authors noted that the e-book was quite simple and contained multimedia but no distracting interactive features.

These findings are consistent with a large literature showing that attention or task switching in both older children and adults almost always results in a response cost in terms of increased errors or a response delay (Courage et al. 2015; Kiesel et al. 2010). Given this, there may be a trade off in the effectiveness of story congruent hotspots whereby they might provide additional relevant information but also divide children's attention and produce a response cost. In fact, the results of recent studies with preschool children who were read to from an e-book on a touchscreen device and a matched paper book showed that in spite of greater engagement in the e-book, there was no difference in the recall of story comprehension by format (Richter and Courage 2017; Willoughby et al. 2015).

In contrast, older preschoolers and school-aged children can learn readily from well designed, age appropriate content, regardless of the book format (Jones and Brown 2011; Moody 2010; Takacs et al. 2015; Zucker et al. 2009). They can (or are beginning to) read independently, making the transition from "learning to read" to "reading to learn" (Miller and Warschauer 2014). They no longer need as much parent or teacher oversight, and the interactive and multimedia features (e.g., built in dictionaries, word pronunciations, highlight text, drag and drop options, tapping for special effects, feedback, repetition) can serve to engage and motivate them to read more often. However, as with younger children, too many or incongruent hot spots (e.g., games, puzzles, activities), can also distract them and reduce the learning potential (Bus et al. 2015.)

e-Books in School Building on this evidence from older children, several large-scale studies of e-reading programs confirm the effectiveness of well-designed e-books in the classroom (e.g., Korat 2010). A particular strength of including e-books in school curricula is that they can support individual differences in children's ability, including those who are at risk for language delay, who are socially disadvantaged, whose learning processes are atypical, or who are learning English as a second language (Bus et al. 2015; Korat and Shamir 2007; Verhallen et al. 2006). The most effective e-book features for these special populations are self-pacing (e.g., pausing the story, turning the page at will) repetition (e.g., going back to read a page or activate a feature again), immediate feedback (e.g., the narrator will respond to the child's actions), and the incorporation of dialogic questioning and prompts to which the child can respond (e.g., What color was Cinderella's ball gown?). It is clear that good, well-designed content presented on interactive digital

media devices can enhance reading, language, science and social skills, and teach factual information about the world for all school aged children (Blumberg and Brooks 2017). However, incorporating technologies into classroom pedagogy has been a challenge (Roskos et al. 2009). To be optimally effective, they should be systematically integrated into the curriculum such that the content of the application and the teaching and learning goals are clear and consistent. That balance can be difficult, as diverse expertise in curriculum and software development are required. As with any new technology, teachers must adapt the way they teach in order to successfully accommodate e-books into the classroom.

2.3 The Viewing and Reading Contexts

The importance of the context in which learning occurs should not be underestimated. When new information is presented for learning it is encoded, but so too are the proximal and distal characteristics of the context (e.g., place, persons, time of day, season) in which the learning occurs (Tulving and Thomson 1973). These contextual cues structure the learning situation and can serve to facilitate retrieval of the information at a later time. The bond between content and context is extremely strong in human infants such that if they learn an operant response (e.g., that a foot kick moves an overhead mobile) while lying in a crib with a patterned surround, they will not emit the kick if the surround is changed to a different pattern at retention. Over the first few years of life, the bond gradually becomes more flexible (Hayne 2009; Rovee-Collier 1999) and the young child can transfer the learning in a different context. This inflexible learning is at the core of the transfer deficit whereby young children only gradually come to understand the symbolic nature of screen media. Although context dependency is reduced across early childhood, it remains an integral support to learning and retention across the lifespan.

There are two key aspects of the context in which children's learning occurs that should be considered: (a) the learning medium itself (i.e., television, e-books and apps, traditional paper book), and (b) the presence of an adult who scaffolds children's attention and learning. Concerning (a), as has been noted, it is difficult to disentangle the content of a learning medium from the affordances that it provides. For example, a paper storybook and an e-book with identical content will provide different contexts (e.g., with or without enhanced features) in which the content is experienced. The research on those contextual factors has been considered in the previous section on the content of screen media.

Concerning (b), a critical question for screen media research in general is whether parent-child interactions during video viewing might become part of the context that structures and facilitates learning just as they do for learning from traditional storybooks. Many of the positive outcomes from storybook reading are mediated by verbal exchanges that occur during the reading experience (Fletcher and Reese 2005). Adults talk to children in more complex ways during reading than they do in other contexts. They typically use a "dialogic" strategy (Whitehurst and Lonigan 1998)

in which they direct children's attention to key elements of the story, engage them in conversation, ask distancing questions, and provide repetitions, recasts, expansions, and explanations of the story content. These shared reading experiences underlie the literacy outcomes, school readiness, and interest in independent reading that have been observed (Mol et al. 2009; Whitehurst and Lonigan 1998). They not only serve to focus the child's attention, but also promote active involvement in the learning process, an important guiding principle of the CTML.

The Parent as Context: Attention and Word Learning from Video Barr et al. (2008) showed that toddlers who viewed baby videos with their parents looked longer at the videos, and were more responsive (e.g., vocalizing, pointing) to them when the parents provided scaffolding (e.g., descriptions, labelling, pointing) during viewing. Even when parents' verbal scaffolding was controlled, infants between 18 and 21 months of age were more likely to look towards a baby video (and to look longer at it) during free-play immediately following a parent's look toward the video than to do so spontaneously (Demers et al. 2012). Such interactions that direct the child's attention to important content could potentially increase comprehension and learning (Barr et al. 2007).

The results of several other studies showed that parent-child verbal interactions can have a positive impact on word learning from video. In one study, adult scaffolding and contingent responsiveness facilitated 3-year-olds' learning of novel object names from video, and it was especially effective if the intervention included dialogic questioning (Strouse et al. 2013). Similarly, when 30- to 42-month-olds were taught action verbs either by video alone or through a combination of video and a live interaction with an adult about the video content, only the children older than 36 months learned verbs in the video alone condition (Roseberry et al. 2009). In another study, 2- to 3-year-olds viewed a picture of an object several times on a screen while hearing a voice-over label the object. Children were then able to point to the target object from among several distractors and to transfer their learning to a real 3D version of the target (Allen and Scofield 2010). Stouse and Troseth (2014) reported that 2-year-olds showed reliable transfer of a novel word learned from video to the real object, but only when the parent pointed out that the real object and the video image were "the same". Similarly, Roseberry et al. (2014) showed that 24–30-month-olds who took part of a simulated video "chat" in which they were taught novel verbs, were successful only when the video partner interacted contingently with them. O'Doherty et al. (2011) showed that 2.5-year-old onlookers could learn a novel word from viewing a shared interaction between two adults on video though they did not learn words from the adults in a passive labelling condition without engagement.

Collectively, these studies show that beginning at about 24–30 months, children are able to learn some new words from video and that this is most likely to occur in the presence of an engaging, contingent, supportive adult who provides verbal and nonverbal structure as well as social cues (e.g., using the child's name). However, this early learning did not come easily, nor was it robust. In any case, it seems that only when parents co-view, talk to children about the story, scaffold their attention,

and use a dialogic approach will young toddlers learn some language from video. It is important to note that these optimal conditions are unlikely to occur when a child views "real" video content at home as parents report co-viewing with their children only about 50% of the time.

In contrast, there is little evidence that children younger than 2 years learn much language from video, even with parent-child interaction (e.g., Krcmar 2014; Krcmar et al. 2007; Richert et al. 2010). Video viewing in these very young children is still dominated by the transfer deficit, and the minimal learning they can show is often more readily learned from a live source (Barr 2010; DeLoache et al. 2010; Richert et al. 2010; Roseberry et al. 2014). On the other hand, older children, from about 4 or 5 years of age can learn language from well-designed educational video without difficulty (e.g., Sesame Street; Blue's Clues; Dora the Explorer). With their more mature executive functions and the onset of conventional reading, adult scaffolding is not as essential, though it still plays an important role.

Parents as Context for e-Book Learning Contextual support and scaffolding are equally important for e-book reading. Preschool and kindergarten children learned more language from an e-book supported by an adult's scaffolding than from one read without scaffolding (Segal-Drori et al. 2010; Strouse et al. 2013). In addition, a sample of toddlers aged 17–23 months learned novel labels for unfamiliar objects from either an adult-led e-book or print book. However, only those who read the traditional format book generalized and transferred the label to another context. An older group of toddlers aged 24–30 months were able to learn and transfer the label from the electronic book (Strouse and Ganea 2017b). In a study on the quality of parent interactional style, Zack and Barr (2016) found that 15-month-old toddlers could learn and transfer a button press from a 3D object to a 2D touchscreen and vise versa when parents provided a high quality (i.e., diverse) compared to a lower quality (i.e., repetitive) interactional style.

It is clear that language exchanges are the heart of the valuable parent-child interactions during storybook reading. However, recent reports of spontaneous communications between parent-child dyads during e-book and paper book reading showed that both parties talked less during the e-book than the paper book session (Chiong et al. 2012; Krcmar and Cingel 2014; Lauricella et al. 2014; Parish-Morris et al. 2013; Richter and Courage 2017). Moreover, the utterances that even the most verbal children produced were primarily about the device and its operation during the e-book and mostly included labeling and comments about the story content during the paper book session. One implication of the prominence of technology talk during e-book reading is the corresponding reduction in the dialogic exchanges that have been so important to preschoolers' language and literacy outcomes more generally (Fletcher and Reese 2005).

Can e-Books and Learning App Software Provide Effective Scaffolding? A fundamental question in that regard is whether the interactive e-book features that are intended to support learning in well-designed books can replace the scaffolding provided by a parent or teacher. Typically, e-book stories include an oral narration

or Read-to-Me option making it possible for children to "read" storybooks by themselves. Based on the research to date, a logical expectation might be that the effect of adult support during storybook reading would be greater than the benefits provided by multimedia features in the story content. However, well-designed e-books now include many built-in features that simulate parent scaffolding with the expectation that these will facilitate literacy outcomes in the same way that parents do. In addition to story consistent multimedia features, these include dialogic questioning, definitions and prompts provided by the story narrator or one of the characters, or suggested activities that enhance the memorability of the story information (e.g., use drag and drop to help Red Riding Hood pack the basket of food for Grandma). In addition, other features, such as motion and zooming-in, are commonly used techniques in e-books that direct children's attention to a particular detail of the illustration just as an adult might do when pointing out a detail and providing comments or explanations in a traditional book (Bus et al. 2015). With the inclusion of these design features that provide active involvement in the material, e-books may be just as effective in supporting story and language comprehension as an interaction with an adult who explains the meanings of the story and novel or complex words in the narration. This might be especially likely for older kindergarten and first grade children who are beginning to become independent readers. Younger children, whose executive functions are still fragile, might still have difficulty in sustaining their attention and become distracted before the story is complete (Richter and Courage 2017). Recently, Strouse and Ganea (2016) reported that 4-year-olds learned a biological concept (camouflage) from an e-book with electronic prompts as effectively as from an adult prompting from a paper book or face-to-face. Similarly, Kwok et al. (2016) reported that 4- to 8-year-olds learned information about animals equally well from interactive media or from face to face instruction.

There is also a trend for schools to adopt electronic formats to tutor and instruct young children (Kucirkova 2014; Rideout 2014; Takacs et al. 2014). The implications of these new reading contexts are unclear, but given the importance of parent-child communication for development, should be a focus of future research. In a recent evaluation of this question, Takacs et al. (2014) conducted a meta-analysis that included 29 studies and 1272 preschool, kindergarten, and elementary school children. The results showed that stories with multimedia features were more beneficial for story comprehension and vocabulary than reading sessions with traditional paper books that did not include the adult's scaffolding. However, no significant differences were found between the learning outcomes of multimedia stories and reading with traditional paper book stories with scaffolding from an adult. These analyses suggest that multimedia features like animations, background music and sound effects, and parent scaffolding simulations can provide similar support and facilitation for children's story comprehension and word learning as can a "live" adult, at least for older children who are becoming independent readers.

3 Conclusion

Although these three sets of variables concerning the child, the content of the media and the reading or viewing context have been considered separately, it would be misleading not to consider their conjoint effects. That being said, it is generally the case that older children who typically have more advanced cognitive skills and executive functions, will be better able to comprehend and retain story information that they read or hear from any medium – electronic or paper. Conversely, younger preschool children who typically have more limited information processing capacity and more fragile executive functions will comprehend and retain less story information from either medium. However, a child's age cannot meaningfully be considered in isolation from the content of the material in question and the context in which it is presented. What this means is that, consistent with the guiding principles of the cognitive theory of multimedia learning (CTML), children of all ages (and perhaps some adolescents) could benefit from the skillful inclusion of certain multimedia enhancements that engage their attention, get them actively involved in the learning process, and highlight novel words and concepts and reinforce the most important story information. Beyond this, as older children have larger working memory capacity and better attention control they will have sufficient cognitive resources to avail of multimedia and story consistent interactive features while continuing to operate the device and follow the sequence of events and the information in the story. Although interactive hot spots will divide their attention and likely result in some response cost (e.g., longer completion times), they will be less distracted by them and be better to resume the basic story reading than will younger children (Courage et al. 2015). Most older preschoolers (as well as those with advanced executive functioning or language) and school aged children who have begun to read independently do not need constant parental scaffolding to structure their learning. In addition, the built-in multimedia supports that are included in well-designed e-books and apps will serve a comparable "parent-like" role in supporting children's retention and comprehension for those who do still need some scaffolding. It is also the case however, that the excessive or story incongruent though engaging features that are common in many commercially available e-books, will lead even the mature reader to become involved in significant task switching that could distract them and diminish learning (Hirsh-Pasek et al. 2015; Miller and Warschauer 2014).

In contrast, younger children who have less working memory capacity and more difficulties with directing and maintaining their attention on task will likely be distracted from the story content by the touch-activated interactive features or "hotspots" that many e-books typically provide (Chiong et al. 2012). As their general knowledge base and language competency are more limited, their story comprehension will be compromised, especially when the content of the story is unfamiliar.

Younger preschoolers also depend strongly on parental scaffolding to direct their attention during traditional reading. However, when the e-book software scaffolding techniques are embedded in the story, it is possible for comparable learning to occur (Takacs et al. 2014). Finally, when younger children have to use a mouse or finger to activate hotspots and turn pages, they have to allocate some of their limited cognitive resources to point, click, and swipe while still following the narrative (Guernsey and Levine 2015; Lauricella et al. 2009). This also places them at risk for cognitive overload and poorer learning outcomes (Fisch 2000). There is little evidence that children under 2 years of age can benefit from e-books without traditional scaffolding from a parent. Their very limited cognitive resources, language, and executive functions will make it unlikely that e-books will be as effective as paper books for these very young children. However, Strouse and Ganea (2016) did show that toddlers between 17 and 24 months were able to learn new word labels from an e-book read by a "live" adult. Without that structure, their limited attention control and working memory would have made learning less likely. However, this remains an empirical question. Older toddlers from 24 to 28 months were able to learn and transfer the new words.

In sum, children of all ages can learn new information from well-designed e-books with story consistent multimedia features if the content is age appropriate and comprehensible for them and if parental or electronic supports are in place to scaffold learning as needed. Effective e-books and other digital apps for any age child should be designed based on the "science of learning" in which the principles of multimedia learning are integral to the material to be learned; it is active, engaging, meaningful and social and that cognitive load is appropriate to the available resources (Hirsh-Pasek et al. 2015). It appears that print-based resources and e-books are not mutually exclusive, nor is technology a substitute for print. Rather, traditional print books and e-books seem to play different roles in the literacy process, and eliminating this false dichotomy offers children more opportunity for diverse types of literacy experiences.

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The Promise of Multimedia Enhancement in Children's Digital Storybooks

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Abstract Apart from being vibrant, many children's digital books offer a rich source for learning as is confirmed by meta-analytic findings. The present chapter pinpoints ways in which children's books have been affected by digitization and which multimedia enhancements explain the boost these books provide particularly in groups of easily distractible children. There is increasing evidence for a positive impact of multimedia enhancements in digital books on children's story comprehension, especially of building in camera movements and motion into static pictures to guide children's visual attention. In contrast, common playful, interactive features reveal negative results although they might enhance children's engagement. This article discusses new ways in which designers can use interactive features in a meaningful manner.

Keywords Digital storybooks · Multimedia enhancement · Camera movements · Interactivity · Story comprehension · Adult-child interaction

Illustrations play a major role in children's story comprehension (Martinez and Harmon 2012). In fact, picture storybooks for children are multimedia presentations: that is, they include not only words but illustrations and text work together in diverse ways to support story comprehension (Mayer 2009). Most digital

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J. E. Kim, B. Hassinger-Das (eds.), *Reading in the Digital Age: Young Children's Experiences with E-books*, Literacy Studies 18,
https://doi.org/10.1007/978-3-030-20077-0_4

storybooks are enhanced multimedia presentations: that is, in addition to illustrations, digital storybooks may include a variety of digital storytelling techniques that, just as illustrations in paper books, aim at supporting comprehension of the narrative. Storytelling techniques typical for digital books may include camera movements, details in motion, background music, environmental sounds, and playful interactivity. Do these features enhance engagement in the story and story comprehension along with side effects such as vocabulary acquisition, compared to pictures alone (Revelle et al. this volume; Van Daal et al. this volume)? And do these enhanced digital storybooks change the crucial role of the adult during book reading?

These enhanced digital books became even more interesting when research revealed that they are particularly beneficial for specific groups of children (Plak et al. 2015). An intervention study in Dutch kindergarten classrooms revealed that a large subsample, children with a genetic disposition for distractibility – 30–40% of all kindergarten children – benefited more from digital books than from regular book reading at home and in kindergarten. This large-scale experiment showed that independent digital book reading narrowed the gap in language and literacy skills for distractible children. A replication of this large-scale experiment with similar results (Plak et al. 2016) reinforced our interest in the relevance of digital books and their benefits. As a rational justification we speculated that in a regular classroom environment, distractible children are easily flooded with irrelevant visual and auditory stimuli and often distracted during regular group reading activities. They may become less susceptible to irrelevant environmental stimuli, due to sources of sensory information in digital books. It is even conceivable that the high attentional load of these books may result in a state of hyperfocus: the books put a load on these children's visual and auditory perception, which might help them focus resulting in better performance as compared to their peers who are not at elevated risk for attention problems.

1 How Multimedia Support Learning

Around 1900, there started a discussion among educators in the Netherlands about illustrated, multimedia books for young children. Van Kol (1903), the initiator of the discussion, doubted that illustrations are useful additions. She expressed a strong preference for books with pictures or books with a narration but not both combined in the same book. When books include illustrations, she speculated, there is no incentive to create visualizations and this may have a negative impact on the development of young children's imagination. In addition, when a book is generously illustrated the narration may be marginalized and attract less attention than the illustrations. Half a century later these naïve notions were experimentally tested. The Canadian psychologist, Alan Paivio, developed a theory about the role of visualizations in understanding language (1986). His experiments revealed that the human

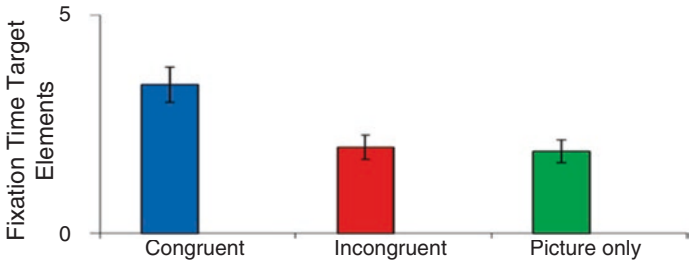

Fig. 1 Longer eye fixations at details in the pictures if those are highlighted in the oral narration. (Based on Takacs and Bus 2018)

brain is able to process visual and verbal information simultaneously and that information from both sources can be synchronized in working memory and support each other. Visualizations can thus help understand a narration especially when the language is complex due to unknown words and grammar.

With the help of children's eye fixations on illustrations while they listen to a narration, we tested whether children indeed synchronize pictures with the narration as Paivio's theory of dual-coding predicts, thus promoting that visual and verbal information are integrated. In a recent experiment (Takacs and Bus 2018) we therefore observed whether children fixate the parts of the pictures that are highlighted in the oral narration and whether they do so in the order in which those elements appear in the narration. All participants were exposed to the same pictures but under different conditions: with a narration that fitted the picture (*congruent condition*), without any narration (*picture only*) or with a narration that did not fit the picture and, accordingly, elements of the illustration were not highlighted in the narration (*incongruent condition*). In line with previous results (Evans and Saint-Aubin 2005; Verhallen and Bus 2011), children paid most visual attention to details in pictures when those were simultaneously highlighted in the story text. Target elements were fixated much longer in the congruent condition than in the incongruent or picture only conditions. See duration of fixations on details that are highlighted in the narration in Fig. 1.

These findings thus support that children use visual information sources and if the corresponding pictures concretize the narration, and both, narration and picture, are simultaneously available in working memory, the two can be integrated as a result of dual-channel information processing. Apparently, this is how children learn: they try to dispose of pictorial information in addition to the oral narration and create a situation that enables the synthesis of both sources of information. The order in which children fixate the details in the illustration highlighted in the narration was similar to the order in which they were mentioned in the narration, thus confirming that the integration of verbal and visual information happens on a moment-to-moment basis (Tanenhaus 2007).

2 How Digital Storytelling May Help Synchronize Picture and Narration

Digital storytelling techniques may help young children to synchronize picture and narration and support dual coding thus stimulating children's story comprehension. In Fig. 2, it is demonstrated how camera movements including zooming and panning – digital storytelling techniques – can guide children's visual attention through the illustration and thus help to synchronize narration and illustration in a digital storybook, *Lightning* by Coenraads and de Wijs (2017). The first screen shot presents an overview of the scene; we see a dad running after his son who is very eager to go to the school visible in the background. When the narration says, "Today I will learn how to make lightning", the camera zooms in on the boy as is shown in the next screen shot in Fig. 2. In the last screen shot when the text mentions that he is going to "the weather school", the camera pans to a depiction of the school.

Likewise, putting details of illustrations into motion is an effective way to attract a longer and steadier focus and thus facilitate dual coding of verbal and non-verbal information (Takacs and Bus 2016). In many digital books, motion is added with a purely 'decorative' or incidental goal. Motion might make children's television programs and cartoons more realistic but it is not added with the intention to guide children's attention to details that are highlighted in the narration as in digital storybooks and may therefore not benefit narrative comprehension. For instance, in the picture in Fig. 2 many details could be set in motion, which would contribute to a film-like effect: the safety glasses, the screwdriver, the pencil and the tapeline. However, attracting children's attention to those elements would not support the integration of narration and pictures. In fact drawing attention to details that are not relevant for the story is likely to distract attention from the main message.

The guidance that young children may receive by adding camera movements and motion to digital books mindfully may be comparable with guidance offered by adults while they read books to their young children (Bus et al. 2015). It is a myth that adults typically initiate dialogic reading including story-related utterances and distancing prompts. For instance, parents for the most part are not capitalizing on shared book reading as a context in which they explicitly coach vocabulary

Fig. 2 Three screen shots demonstrating how pan and zoom work as a digital storytelling technique. (Permission granted by *Het Woeste Woud*, the Netherlands)

development; see a study by Evans et al. (2011). On the whole, adults and children mainly point and comment at details in pictures while they listen to the narration (Sorsby and Martlew 1991). Their utterances most often involve mapping language onto immediate perception, similar to what camera movements and motion do, thus attracting visual attention to details in the pictures and stimulating a synthesis of narration and pictures.

3 Efficacy of Enhanced Multimedia

About 10 years ago we started experimenting with digital books that included an enhanced multimedia presentation to test the efficacy of these new additions (Verhallen et al. 2006). *Winnie the Witch* by Thomas and Gorky (1996), a story with memorable characters and an impressive storyline, includes all components of a well-formed story: a description of characters, setting, time and activity; events that advance the storyline, including the problem; a resolution; and an ending. In addition to a version with static illustrations, we used an enhanced digital version. This version was supplemented with camera movements and motion that may help focus attention on significant visual details. The additions drew attention selectively to congruent content in the illustrations, thereby helping the child to select helpful visualisations while processing the narration. For the rest the two versions were identical: the narration is told in the same voice and both are presented on a computer screen.

Five-year-old children from immigrant families with low language proficiency, due to the fact that they learn Dutch as a second language, profited from repeated encounters with the storybook with static pictures but much more from repeated encounters with the animated version of the story. Multimedia additions in the digital book were most pronounced for understanding the goals, intentions, motivations, and feelings of story characters. For instance, children in the static condition understood that *Winnie the Witch* kept stumbling over the cat (*action*) and that she changed the cat into a green cat (*action*). Retellings of the story after being exposed to the digital book enhanced with animation and sound/music, on the contrary, did not just contain actions but implied elements as well. Children in the digital condition mentioned the fact that Winnie the Witch got angry when she had fallen once again and decided to do something about it (*implied event*) and they emphasized states of minds of main characters ("sees," "is furious," or "decides"). After listening four times to an enhanced digital presentation children's scores regarding implied events were significantly higher than in all other conditions including the version with static pictures after four readings; see Fig. 3.

In addition to animated pictures, digital books often include music and environmental sounds. Winnie the Witch, for instance, presents immersive background music non-stop throughout the book. There are also environmental sounds that match the events of the story: we hear the noise of Winnie stumbling down the

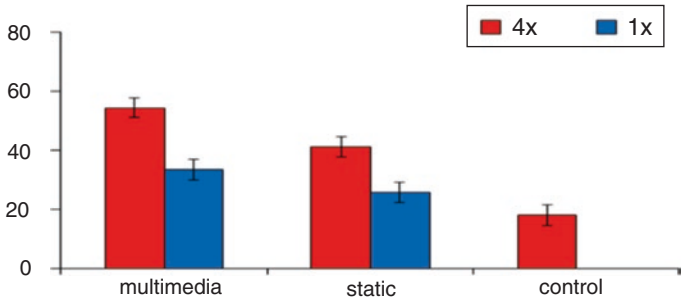

Fig. 3 Percentage of implied events mentioned in the story retelling after one or four readings of digital books with static pictures or enhanced with animation and sound/music. (Based on Verhallen et al. 2006)

stairs; we hear the cat snoring when she climbs down the tree. Is such a mix of environmental sounds and music a beneficial component of the enhanced multimedia presentation in digital storybooks? Whether music and sound are beneficial for or hindering learning may depend on qualities of the auditory stimuli. For instance, music during homework may block off the rest of the world and may therefore be helpful especially when children are easily distractible (Anderson et al. 2000). Likewise, elevator music while listening to a story might work as a barrier against distractions (Ben-Shabat 2017). On the other hand, negative findings may be expected especially for low-profile babble noise like a playground or a bear mumbling continuously. The listener may zoom in on particular components, which may make those distracting and cause a negative effect on story comprehension.

4 Effects of Music and Sound

There are several experiments running testing whether music and background sounds further enrich animated pictures or interfere with learning from digital books. The first results come from an experiment carried out in Turkey targeting typically developing children (41 boys and 58 girls) aged 4–6 years of age ($M = 61.32$ months, $SD = 9.67$) from middle socio-economic status families visiting two public kindergartens (Sarı et al. 2019). The design of the study was a randomized control trial with a control group (children only participated in general language assessment and post-test sessions) and four experimental conditions in order to test the effects of both animated illustrations and sound tracks separately.

The animated versions of the target books – including well-chosen camera movements and motion – were especially effective for gaining knowledge of implied elements of the stories that referred to goals or motives of main characters; note the higher scores of animated digital books in Fig. 4. Animated pictures had a moderately strong effect size of half a standard deviation ($d = 0.49$). Music and sounds, on the other hand, did not have an effect on knowledge of implied elements. The effect of

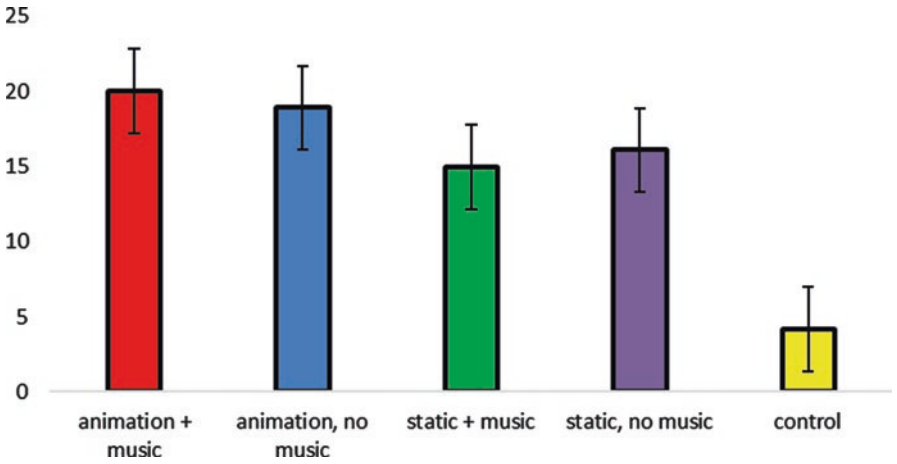

Fig. 4 Mean number of implied elements (and 95% confidence intervals) mentioned in the story retelling in the five different conditions. (Based on Sarı et al. 2019)

music and sounds ($d = -0.14$) was negative but statistically insignificant. In line with a prior study targeting children with serious language impairments (Smeets et al. 2014), music and sound effects had a moderately strong negative effect on children's receptive vocabulary ($d = 0.56$). Even though music and sounds were present only in the background and provided to supplement images, they may have attracted attention (Barr et al. 2010) and might have caused cognitive overload for these children because they had to process verbal and other auditory information simultaneously. Whatever the exact nature of the interference of music and sounds may be, an important message of these findings is that adding sounds and music to stories might diminish rather than enhance the learning potential of enhanced digital storybooks especially for children who have problems with verbal processing. In the research so far, target books included a mix of music and sounds. Further experiments are necessary to specify which kind of auditory stimuli in particular may cause negative effects.

5 Efficacy of Playful Enhancements

Since the first generation, digital storybooks include playful elements that are incentives for interaction with the illustration (Korat and Shamir 2004). Exemplary are the digital storybooks based on the stories by German author-illustrator Janosch (1998a, b, 1999). These were among the first digital books that came out in the Netherlands in the late '90s and are exemplary for many other digital books. A scene from one of the stories shows Dr. Cornelis Frog examining Tiger because he did not feel well. After the events were dramatized, it was possible to play: children could click within the frozen screen on about five details in each illustration such as

the light bulb, the little duck on the floor, or Tiger, whereupon visual and/or sound effects were activated, often not related to the story content. Similar interactivity is still used in commercially available digital books. This aligns Apple's policy: Apple's App Review Board commonly rejects book apps that have limited interactivity and a lack of media features: *if your App doesn't provide some sort of lasting entertainment value, it may not be accepted* (Apple 2017).

The question, however, is whether there is support for the designers' underlying conception that those techniques increase children's motivation to listen to stories and interactivity thereby promotes story comprehension (Tønnessen and Hoel this volume). Quite a few studies show positive effects of these features on child behavior during book reading: Children are more attentive to and engaged in digital books as compared to print books (e.g. Richter and Courage 2017). From the Richter and Courage study, however, it does not appear that there is any difference in story comprehension despite that children are more attentive in the condition with digital books as compared to print books. Unfortunately, the children in this study were read to from the target books only once which is known to be insufficient to demonstrate (differential) effects of book reading with young children (Verhallen et al. 2006).

In an early experiment, de Jong and Bus (2004) tested effects of playful elements by contrasting a book with such additions embedded in illustrations with a story without playful additions and a control condition (no readings between pre- and post-testing). In a publication about this study, the authors presented a non-significant effect on a variable based on how many *words* and *phrases in children's retellings of the story* were derived from the original text. Conclusions differ when we focus on story comprehension – the number of pages where the story that the child told was similar to the original story (*story structure*). Targeting this comprehension measure, children's score reduced with more than 25% when the story was enhanced with playful elements; compare in Fig. 5 the results in the condition with

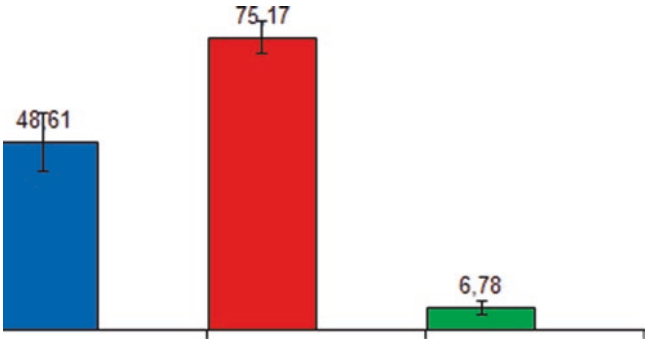

Fig. 5 The average percentage of pages where the story told during the retelling was similar to the original story, for three conditions: digital book enhanced with playful elements (blue pile), print book without playful elements (red pile), and control condition (green pile). (Based on data by de Jong and Bus 2004)

playful elements (blue pile) with the results without playful elements (red pile). There were many interruptions of the story in the digital book condition; on average children activated 35 playful elements (*SD* = 26) per reading.

In the same vein, Parish-Morris et al. (2013) and others showed that important aspects of dialogic reading like story-related utterances and distancing prompts were diminished when parents and children read digital books with playful elements as in the Janosch stories, while less productive behavior-related interaction ("Stop pressing the buttons and listen to the story") increased. An implication of this is that adult guidance cannot compensate for distractors in interactive digital books but might strengthen the negative effects.

Although these playful enhancements are designed to be interactive, motivating, and self-paced (e.g., Ricci and Beal 2002), adding 'bells-and-whistles' to a multimedia presentation seems to distract children from the story content and diminish comprehension (Mayer 2001). We wonder whether additions that include story-related content (e.g. a dictionary, questions about the story content) may have the same negative effect as playful enhancements. The human information processing system has a limited capacity; sharing resources among various tasks (e.g., memorizing and integrating story events in between playing) may come at a cost for performance (Kahneman 1973). Preschool children's learning may suffer from task switching between game-like and other interactive features and story understanding. According to Kahneman's (1973) *capacity theory* a person's ability to process several information sources simultaneously depends on how much "capacity" separate sources require. When demands exceed capabilities, part of the material will not be attended to and may result in distortions of the narrative content or less detailed retellings.

6 Towards Literary Interactivity

There are currently experiments running with digital books that stimulate new ways of interactivity. Children can carry out small actions that are in line with the narration, thus providing users opportunities to engage more deeply with the thematic content while maintaining "the integrity of the story" (Yokota and Teale 2014, p. 581). Instead of features that cause young readers to lose sight of the main storyline these apps successfully integrate playful interactivity with the narrative line. A well-known example is the *There's a Monster at the End of this Book* story (Callaway Digital Arts 2010). In this book, playful interactivity and the narration are intertwined in a very natural way. The interactive features tie directly into Grover's attempts to keep the child reader from turning the page because of the monster at the end of the book. Grover ties knots, nails up boards, builds a brick wall; the child is able to break through each of these by touching hot spots and thus moving the story forward.

Sargeant (2015) developed an app, *How Far is Up?*, that allows users to move a toy rocket around a scene by tilting the hardware device or by dragging a finger

across the screen. This simple play activity may provide users with the experience of moving an object around the space as happens in the story. "This activity", argues Sargeant (2015), "was designed to provide thematically linked, experiential play, allowing users to maintain a connection with narrative content whilst they engage in this simple activity" (Sargeant 2015, p. 461).

The Dutch app developer Christiaan Coenraads experiments with forms of interactivity that promotes children's reflection on story events and deepen story comprehension. He makes users carry out the same actions as the story characters that aim at solving core problems. For instance, when the main character is looking for the correct button on the dashboard of a machine we first see him sitting, puzzled, in front of the dashboard. Then the camera zooms in on the dashboard and one of the buttons lights up while the boy says: "Mmmm, which is the correct button? Maybe this one?" The story only continues after the user has clicked on or touched this button, even though it is evident that it is the wrong button.

The user thus becomes complicit in the actions of the main character, which may stimulate reflection on the action and the possible consequences that it may have. In order to test the efficacy of this approach, the researcher (Bus) observed four- and five-year old children while exploring this new app. She noticed that many children are hesitant to touch the button and make spontaneous comments ("this is the wrong button"; "what will happen?") suggesting that the action promotes reflection on the story content in children. She also observed that children are very eager to find out what will happen in the next scene after they pushed the (wrong) button. Other junctures in the story reveal similar observations. When the boy "borrows" his father's weather machine he has to crack the lock attached to the machine. The user has to click on or touch a hot spot, otherwise the story does not continue, thus creating a moment of reflection. Many children make spontaneous comments demonstrating that this action makes them think about the events. They start hypothesizing about what will happen ("the dad may wake up") and whether the action is allowed or not ("his dad will be angry"). A randomized control trial comparing an animated book without interaction with a book with such interactive moments is carried out currently to test whether this kind of built-in interactivity deepens children's story understanding as may be expected.

In addition, new experiments are needed to test whether this interactivity may facilitate adult-child interaction while they share the story. The built-in stops may be incentives for story-related utterances for both adult and child, thus stimulating adult-child interactivity about the story content in a very natural way. The stops take place at crucial moments in the storyline and are therefore very suggestive towards themes for discussion. So far, the researcher noticed that children often start talking to the adult sitting next to them when the story discontinues at these junctures and look for confirmation of their responses and feelings about the story events (disbelief, uncertainty, involvement). In line with this, Kim and Anderson (2008) showed that giving the parents and the children control over the pace of the story resulted in more interaction compared with a closed format in which pages were turned automatically.

7 Conclusion

The ability to process a narration is central in becoming literate and it is therefore vital that children have a chance to interact with books. For this purpose, it is important that books are read to young children from an early age thereby creating sufficient opportunity for developing foundational literacy skills. We discussed different features built in digital books that may support but also ones that might hinder story comprehension. We made a small selection of well-designed studies to test how children benefit from mindfully enhanced multimedia books.

Well-designed digital picture storybooks integrate illustration and narration so that each complements the other and, together, they provide an enhanced multimedia text experience that may help story comprehension. There is convincing evidence for the benefits of well-designed visual enhancements like zoom and pan and motion added to illustrations in digital storybooks. Concerning background sounds/music as is often built in the books, the findings so far are not very promising. The effect of the mix of sound effects and background music tends to be negative with some exceptions. More experiments are needed to distinguish between interfering and supportive auditory information.

A new, promising approach is adopted by adding interactive features to engage children in the story and to facilitate adult-child interaction. We cannot deny that interactive books have high appeal to young children according to children's attention and engagement while reading these books. Children may be distracted from the story content by the touch-activated interactive features that digital books typically provide. However, some interactivity may support learning. We sketched the contours of apps that include promising interactive literary digital storytelling techniques. We described examples of interactions with the story that seem to have the potential to engage children in the story, facilitate adult-child interaction and thereby deepen children's story understanding. Many questions remain. It is for instance not yet clarified whether these techniques demand special stories or can be added to any digitized print book. Further research is needed to reveal which criteria interactive elements should meet to be effective.

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e-Book Design and Young Children's Behaviour: The Case of Alphabet Books

Mary Ann Evans

Abstract In the last few years, alphabet e-books have appeared, ranging from simple static displays with a narrated voiceover to books with animated displays, music and sound effects, and hotspots. This chapter addresses the association between the design characteristics of alphabet e-books and how children use them. Eleven commercially available e-books, ranging from a static one with narration to those with increasingly elaborate media and interactivity, were read, demonstrated, and provided to 35 4-year-olds in groups of three to four children. In each of 16 weeks, children accessed four of the books for independent reading and their behaviour was coded by an observer. An average of 660 observations per book across children showed positive associations of book use with tapping object hotspots and book interactivity. Tapping letter hotspots was less common across books with the exception of one e-book which also proved to be of intermediate popularity. Imitating letter names or letter sounds narrated was infrequent. The observations provide clues as to why alphabet e-books may not be much of a boost to emergent literacy, and to what parents, critics, and designers should attend in the purchase, review, and creation of interactive alphabet e-books.

Keywords Alphabet books · e-Book design · Behaviour with e-books · Emergent literacy

Many parents in North America highly value literacy and are active in reading to their preschoolers and teaching them emergent literacy concepts including letter

The data in this study was collected through a grant to the author from the Social Sciences and Humanities Research Council of Canada (Grant #:410-2009-0055). Appreciation is also extended to the participating children, their parents and their schools, and to David Willoughby, Sarah Nowak, Lara Genik, Sarah Newcombe-Anjo, and Emma Louth for their assistance with data collection.

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J. E. Kim, B. Hassinger-Das (eds.), *Reading in the Digital Age: Young Children's Experiences with E-books*, Literacy Studies 18,
https://doi.org/10.1007/978-3-030-20077-0_5

names and sounds. These efforts are well placed given research showing the positive contribution of shared book reading and alphabet knowledge to beginning reading comprehension and word recognition. There is a large and consistent research literature showing that mastery of the names and sounds of letters of the alphabet is a good predictor of achievement in reading and spelling (see for example reviews by Adams 1990; Foulin 2005). Accordingly, directives from the Head Start Outcomes Framework (Administration for Children and Families 2015) and guidelines from NAEYC (1998) have specified that preschoolers should be able to name at least half of the letters of the alphabet and provide the sounds made by many of the letters that they recognize.

Alphabet books are often read by parents to their children (Levy et al. 2001; McCormick and Mason 1986) and are among the first books purchased for them (Sawyer and Sawyer 1993; Zeece 1996). They have a long history of use, beginning with horn books and primers in the fifteenth and seventeenth centuries respectively, and progressing to the colourful highly illustrated paper books of today. Like their predecessors, each letter of the alphabet appears in sequence on its own page, paired with an illustration, the name of which exemplifies the phoneme associated with that letter via its initial sound. Reading alphabet books to young children is commonly regarded as a helpful approach to exposing young children to alphabet shapes and to teaching the names and sounds associated with these shapes (e.g., Bus and Van IJzendoorn 1999; NAEYC 1998; Nodelman 2001). When asked what their goals are for reading alphabet books with children, present day parents report that their highest goal for this activity is that of helping their child to learn to read (Nowak and Evans 2013). In accordance with this goal, they engage in more talk about letters, letter sounds, and print concepts during shared reading of alphabet books than storybooks (Stadler and McEvoy 2003), especially when the child begins to take on part of the reader role (Davis et al. 2010).

1 Alphabet e-Books

Like other genres of print books, in the last 9 years or so, alphabet e-books have been created in digital form to be easily and inexpensively downloaded on tablets. These devices are easy for young children to use and provide an attractive alternative to print books. A recent study in the United Kingdom (Marsh et al. 2015) found that half of 2-year-olds and two thirds of 3- and 4-year-olds were able to open apps, and swipe and turn the pages of e-books on tablets without assistance. Adults' keenness for their preschoolers' tablet use is evidenced in a report by Shuler (2009) in her analysis of the sales of iTunes apps. Among educational apps, those for toddlers and preschoolers were far more frequently downloaded than those for children in elementary through high school (60 vs 16%).

e-Books, by their digital nature, are virtually limitless in not only the texts and images that can be programmed and accessed through hyperlinks and hot spots, but also in the sounds, animated graphics, and interactive features such as games and

drawing that may be included. As such, the distinction between e-books and book apps is a blurry one. For Sargeant (2015), the distinction is that "people read e-books whereas they use apps" (p. 461) but both may contain written text, and imagery, and albeit to a lesser degree in e-books than apps, interactive elements. In contrast, paper books, by their material nature, have natural restrictions on the text and illustrations that can be presented within them. Their interactive enhancements are limited, for example, to pop-ups, open-the-flap and peep-through-the-hole pages, and textures to feel. The contrast between the two has prompted an increasing body of literature on the potential advantages of interactive multimedia storybooks over their print counterparts for vocabulary acquisition, reading skill, and comprehension.

For alphabet e-books the presumed and promised advantages focus on the assistance they offer for learning the alphabet. For example, Jenny Bristol (n.d.) for Common Sense Media.com, (a website that posts independent reviews of media including apps, websites, and books), reviewed the e-book app *Interactive Alphabet* as "an educational experience for toddlers and preschoolers that will help them learn the alphabet and the sounds letters make…Playing with *Interactive Alphabet* is an entertaining and clever way to learn the alphabet and the sounds letters make." This same interactive e-book is described (July 14, 2017) at the iTunes App store as "Positively, the BEST Alphabet experience from crib to kindergarten!" Similarly, as distributor of *ABC Magic 2*, this website described (July 26, 2017) *ABC Magic 2* as follows: "This app will help your child learn the sounds of the letters … Most young learners will enjoy repeating the sounds they hear on this this app…It has been tested and used with preschool children. The children loved it and it helped them learn the letter sound." As a final example, regarding *Z is for Zebra,* News in Education (n.d.) posted the following, "This app makes it easy and fun for the children to learn the sounds of the letters. Just tap on the letter or the object to hear the audio."

Whether e-books realize such claims is a natural and important question to address. Karemaker et al. (2017) noted that "One major drawback in a rapidly changing technological world is that many e-books are untested and potentially not of educational benefit" (p. 31). In their 2015 paper, Bus, Takacs, and Kegel called for well-controlled studies to determine the effect that e-books and apps have on children's emergent literacy skills. Reviews of the few studies comparing the effects of e-storybooks versus print storybooks present mixed finding (see reviews by Bus et al. 2015; Reich et al. 2016), lending caution to a blanket endorsement of the effectiveness of e-books over their print counterparts. Recent studies contribute further to the debate. For example, Karemaker et al. (2017) compared the effectiveness of two versions of enhanced e-books (one with definitions, the other with comprehension questions) versus a flat e-book counterpart containing simply the illustrations and narration of the text. While these six-year-old children indicated that they preferred reading e-books to paper books and made many positive comments about the enhanced e-books, the word recognition, story comprehension, and vocabulary proved no better among children using the enhanced e-books than those using the flat e-book. By contrast Zipke (2017) found that the word recognition but not story

comprehension was higher when four- and five- year-olds independently used e-storybooks with a read-aloud audio than when listening to group read-alouds of a print book with their teacher, and a Jordanian study by Ihmeideh (2014) found advantages in several emergent literacy skills among children whose teacher read e-books and gave them an opportunity to use them in their kindergarten.

Peer-reviewed research publications to address claims for alphabetic learning through alphabet e-books are sparser still. Willoughby et al. (2015) examined whether 4-and 5-year-olds' alphabet learning would be enhanced after hearing, and then interacting with alphabet e-books (including the three lauded above) twice a week over a 16-week period. Comparison groups, equated for pre-exposure letter name knowledge and for sex, were a group who heard and read a variety of illustrated print alphabet books, and a group who heard and read a variety of illustrated storybooks. All groups gained in letter name knowledge with the e-book group showing no advantage. The null results mirror those of Cubelic (2013) whose dissertation research found that preschool classes using iPad apps throughout the year that were selected by teachers to foster phonemic awareness and alphabet knowledge fared no better than those not provided these apps. Similarly, Brown and Harmon (2013), who studied 4-and 5-year-old children in Head Start, found no difference in letter knowledge between those instructed with versus without apps across their 10 weeks of intervention.

Such null results are surprising given the promotional claims associated with alphabet e-books and the many opportunities these e-books present for children to repeatedly hear the letter names and sounds by activating letter hotspots and to potentially imitate them. To investigate what the children actually did with the books as a possible explanation for the null effects noted above, Evans et al. (2017) analyzed the behaviours of the children in the study by Willoughby et al. (2015) that had been coded by observers during each of the 16 sessions. The counts for these behaviour codes, within each group, were collapsed across books read and across four-week periods of eight sessions each to examine whether and how behaviour changed across time. The data showed significant linear declines across these four time periods in the extent to which children activated letter hotspots, said letter sounds, and named objects illustrating the letter sounds. Overall, behaviours that might aid or reflect alphabetic knowledge declined from roughly 20% of coded behaviour in the first four sessions to just 5% in the last four.

2 The Present Study

These findings suggest that alphabet e-books as sampled by Willoughby et al. (2015) were not particularly effective in eliciting behaviour that might help young children to explore, learn, and consolidate alphabet knowledge, and fared no better in boosting alphabet knowledge that print alphabet books or storybooks. However, it may be that e-books within those sampled differentially elicited certain behaviours. For example, were the children more likely to say letter names (naming or

imitation) when using certain e-books? Did children say letter sounds more if only sounds and not names were narrated by an e-book? Answers to such questions could provide clues to design characteristics that might better realize the claim that alphabet e-books are effective learning tools and prompted the research reported here. The approach taken was to revisit the behavioural data analysed by Evans et al. (2017). Rather than collapsing across books by session as we then did, the data were collated across all 16 sessions by e-book being used. Books whose confidence intervals for the children's mean frequency of behaviour did not overlap with the mean of all books were then identified and their design characteristics examined in an attempt to discern what might have accounted for this.

3 Method

3.1 e-Book Materials

We restricted our selection of material to commercially available alphabet e-books/book apps that mirrored print alphabet books in presenting pages that can be scrolled through and read in sequence from A to Z, each page having a featured letter and associated images. Within this constraint, we selected items varying in the amount of animation, audio enhancements, and interactivity. They are all referred to as e-books here. Letters on the pages were large, being between 3 and 6 cm. high, with the exception of one e-book where letter height was 1 cm. The average word frequency of the target objects displayed was 211.14 (*SD* = 76.83) per 1,000,000 printed words in books for children ages 5–9 in the Children's Printed Word Data Base (University of Essex 2002). As a reference point, this database lists the word frequency of kite, apple, bird, and lion as 133, 219, 287, and 314 per million respectively. Among the target words for vowels, 91% exemplified the short sounds /æ/ (ant), /ɪ/ (in), /ɛ/ (elf), /ɒ/ (on) and /ʌ/ (up). For the letters C and G, 82% exemplified the hard sounds /k/ (cat) and /g/ (gate) respectively. Given that the e-books were not in use in the children's classrooms and that few of the children were reported by their parents as using e-books at home, the e-books used were most likely unfamiliar to the children.

Table 1 presents the 11 e-books used and briefly details their design features according to what is in the initial display for each page, the nature of the audio that automatically occurs with each page, whether there are letter/word/sentence/object hotspots and what they activate, any additional icons and what they activate, and the approximate length of time to read the book if activating one hotspot on each page. As one moves down the page from top to bottom, the books become more elaborate and interactive through the inclusion of sound effects; music; animated images; letter hotspots to activate narration of the letter name, letter sound, or appearance of an object; object hotspots to activate noises, animation of the image or new images; and simple touch screen activities such moving a zipper up and down through

Table 1 e-Books used in the study with their elaborateness rank and design features

e-Book title (Publisher)	Abbreviation for figures	Rank	Features
A to Z Alphabet Book (3 Square)	AZB	1	Initial display is "Cc is for CARROTS" + illustration of carrot. Automatic audio in adult voice reads "C is for carrots"
			No hotspots but tapping object or letter sometimes takes reader to new page
			Pages are advanced by swiping. Approx. length 1 min 45 s
ABC Magic (Preschool University)	MAG	2	Initial display is c + illustration of cat. Automatic audio in child's voice repeats phoneme /k/ 2x, then names "cat", then repeats /k/ 3x
			Hotspot on letter activates audio "/k/"
			Hotspot on object activates audio "cat"
			Hotspot on icons at bottom brings the reader to random page or to menu of all letters
			Pages are advanced by swiping. Approx. length 2 min 45 s
ABC Magic 2 (Preschool University)	MA2	3	Initial display is "c" + 4 illustrated objects in row below. Automatic audio in child voice repeats phoneme /k/2 xs and names object for each of 4 objects
			Hotspot on letter activates audio /k/ + letter briefly flashes
			Hotspot on each of 4 objects activates audio naming object + object briefly flashes
			Hotspot on icons at bottom brings reader to random page or to menu of all letters
			Pages are advanced by swiping. Approx. length 6 min
Z is for Zebra! (Visions Encoded)	ZEB	4	Initial display is "Cc" + illustration of cat. No automatic audio
			Hotspot on letter activates adult voice saying letter name
			Hotspot on icon lower right activates adult voice /k/
			Hotspot on object activates child voice naming "cat"
			Pages are advanced by swiping. Approx. length 2 min 30 s

(continued)

Table 1 (continued)

e-Book title (Publisher)	Abbreviation for figures	Rank	Features
Animal ABC (Ooh Lovely)	ANI	5	Initial display is "Cc" + illustration of cat + printed word "Cat". No automatic audio
			Hotspot on animal name icon activates audio naming" cat" + c
			Hotspot on animal sound icon activates cat noise (meow)
			Pages are advanced by swiping. Approx. length 2 min 45 s
Animal Alphabet (7H)	ALP	6	Initial display is large "C" with object in/on it + object name + two smaller objects below with names. Sidebar has smaller C with object +2 adjacent letters with object in/on them. Automatic audio is music
			Hotpot on letter activates voice naming object + simple animation. Music throughout
			Hotspot on word activates voice naming object + simple animation. Music throughout
			Hotspot on smaller objects activates voice naming object + simple animation. Music throughout
			Pages are advanced by tapping letter on side bar or scrolling sidebar for other letters. Approx. length 6 min 15 s
Alphabet Zoo (Third Rail Games)	ZOO	7	Initial display is large C + smaller C in highlighted colour flanked by fainter 2 previous and 2 next letters in row at bottom. Automatic audio names letter
			Hotspot on letter activates audio /k/+ letter pulsates
			Third tap of letter cause image of cat to replace letter
			Hotspot on object activates audio of animal's noise ("meow") and image shakes
			Touching object hotspot again causes "C" + its hotspot to replace image
			Touching small "C" at page bottom activates audio /k/+ letter pulsates. After second tap object appears. After third tap object shakes
			Pages are advanced by tapping bottom letter. Approx. length 4 min

(continued)

Table 1 (continued)

e-Book title (Publisher)	Abbreviation for figures	Rank	Features
This Place is a Zoo! Captain Wallace's Alphabet Expedition (Multimedia)	EXP	8	Initial display is animation of animal (e.g. camel) of 5 to 15 s. + sound effects
			"Cc" appears after animation ends, sometimes integrated into illustration, + animal name "camel"
			Hotspot on "C" activates adult voice saying letter name
			Hotspot on "c" activates child's voice saying letter name
			Hotspot on object cause voice naming the object
			Hotspot on animal activates audio of animal's noise
			Pages are advanced by swiping but not until page animation is done. Approx. length 7 min
Letters A to Z (Refresh Media)	LAZ	9	Initial display is "C" + colourful scene with object (car). No automatic audio
			Hotspot on letter activates voice saying letter's name
			Hotspot on object causes animation of object + sound effects
			Pages are advanced by swiping. Approx. length 3 min 45 s
ABC Funnimals (Sythego Kids)	FUN	10	Initial display is "pulsating C" + phrase "IS FOR CAT" + object, some animated. Automatic audio in child voice names letter + says "C is for cat + provides sound effects
			Hotspot on letter activates child voice naming letter + letter pulsates
			Hotspot on phrase/word CAT activates child voice reading phrase + C in word pulsates
			Hotspot on object activates elaborate animation. C pulsates throughout
			Pages are advanced by swiping or arrow icon. Approx. length 5 min 30 s

(continued)

Table 1 (continued)

e-Book title (Publisher)	Abbreviation for figures	Rank	Features
Interactive Alphabet (Pi'ikea St.)	INT	11	Initial display is "c" + "is for cake" + illustrated object, some animated. Automatic audio reads letter name + sentence + gives letter's sound + object name. Music + sound effects in background and continue when all hotspots are activated
			Hotspot on "c" causes voice to name letter + letter pulsates. Second activation provides letter's sound
			Hotspot on "cake" causes voice to read word and word to pulsate
			Hotspots on "is" and "for" cause voice to read sentence + letter "c" to pulsate
			Hotspot on object causes animation + sound effects. Up to 11 additional taps produce new animation + sounds + sometimes a new object for the letter + narration. Some "hotspots" require dragging object to create animation
			Previous + next letter at page top turns page + ABC brings home page with all letters, each with hotspot to advance to its page. Approx. length 7 min

touching along the image. As such, the books were ranked 1–11 in order of increasing elaborateness of media and interactive features and are arranged in the Table 1 from top to bottom in that same sequence.

The simplest e-book, *A to Z Alphabet Book*, (rank 1) described in the top row, presents on each display (or page) one letter, a static image of an object beginning with the letter, and the text "Xx is for object" along with audio reading that text. It was selected as one of the first books to present to the children to familiarize any children who might have had no iPad experience with this medium and swiping to turn the pages. It along with the e-books in the next four rows has no animations. The books in the sixth and seventh rows have no automatic animation but included a few animal noises and a few hotspots activating simple animations respectively. More hotspots and more elaborate animations characterize those in the last four rows. The most elaborate e-books were those described in the last two rows. These books have sound effects and/or music as well as animated images in the initial display on each page, and word/sentence and object hotspots that activate additional animations.

3.2 Participants

The sample consisted of 35 children (19 boys and 16 girls) recruited at the outset of junior kindergarten in the public school system of a small city in south-western Ontario. The children ranged in age from 3 years, 9 months to 4 years, 9 months (mean age 4 years, 3 months) and attended nine publicly funded schools. Among the mothers of these children, 14% had not graduated from high school, 17% had high school diplomas, 31% had a college diploma or trades certificate, and 37% a university undergraduate degree or postgraduate/professional degree. This distribution of maternal education was similar to that of women ages 25–44 in the province of Ontario for which, according to 2011 National Household survey, the figures are 8%, 21%, 34% and 37% respectively (Statistics Canada 2011). According to parental report, child usage of a tablet in the past was never for 11 of the children, once a month for three of them, once a week for three of them, a few times a week for seven of them and every day for 11 of them.

3.3 Procedure

After receiving parental consent for participation and children's own assent, the children were assessed in the fifth or sixth week of the new school year. Letter knowledge was tested by asking them to name all the letters of the alphabet presented in uppercase and then lowercase form, with four randomly selected letters on each card presented. The children were then asked to give the sound for all 26 letters presented in uppercase form. If a child answered with the soft sound /s/ for C or /dʒ/ for G, or long vowel sounds such as the name of the letter E instead of sound /ɛ/, the examiner asked "What other sound does the letter make?" On average, the children were able to name 11.83 (SD = 10.81) uppercase letters and 9.80 (SD = 8.22) lowercase ones, and to give the sounds for an average of 4.89 (SD 6.41) letters. In addition, children's vocabulary was assessed using the Receptive One-Word Picture Vocabulary Test (Brownell 2000) in which the child points to one of four pictures named by the examiner. The mean standard score obtained on this test was 102.32 (SD 14.11). As reported previously by Willoughby et al. (2015), gains in letter knowledge at post- test after 16 sessions with the books were eight letter names and three letter sounds which did not differ from the two control conditions of paper alphabet books and storybooks.

Children were met in their classrooms, given information about the study, and following their assent, individually assessed in a quiet corner of the school library or in an unoccupied meeting room, resource room, or office. Following the testing, the children were grouped into heterogeneous groups of three to four children through random stratified sampling according to the children's letter knowledge, so that each group contained children with varying levels of letter knowledge. Over a period of 8 weeks, each group met with a member of the research team for

approximately 20 min, twice a week. In each session, the researcher demonstrated one of four e-books to be used in each of the two sessions in any given week. The reader showed the title screen and introduced the e-book by its title and publishing company and kept the screen of the iPad visible to the children as the pages were scrolled through. One hotspot was activated per page, alternating between letter and object hotspots in e-books with both to demonstrate hotspot activation. In e-books with no automatic audio of the letter and object appearing on the page, the researcher named these before activating any hotspots, and occasionally paused before doing so in order to give children room to verbally participate. Otherwise no questions, remarks or comments on the book were made by the reader in order to standardize the reading and keep the book at the forefront. Observations by a second researcher during 19% of the read-aloud sessions indicated that readers followed the protocol in 100% of these observations.

Following the reading, four iPads, each with one of the four e-books for the week, was distributed to the children. Each week a different combination of books was used, with books reappearing in different combinations in later weeks. Given that groups contained a maximum of four children, four books were available each week to allow children to each look at a different book or to look at the same book together, and to potentially cycle through all the books within the 15 min provided after the read aloud. The researcher told the children to pick a book to read and that they could trade iPads as they wished during this group time to access a different book or read a given e-book together with one or more of the other children. After approximately 13 min of independent reading time, the children were advised that there were 2 min left. During the independent reading time, in addition to a researcher who coded behaviour, a second researcher was always present to assist a child with an e-book if needed without delay. In a sampling of sessions, this observer also coded behaviour to establish coding reliability.

In the first two sessions, or first week, three of the simplest e-books were used to gradually introduce any children who had no experience with e-books to this medium and to scrolling the pages and tapping hotspots. Children quickly caught on. In the first session, 155 observations entailed activating object hotspots, 133 observations activating letters, and 30 observations navigating from the start menu. In addition, each child viewed a variety of pages in the books they looked at, and only 19 requests for help were coded.

3.4 Behaviour Coding

During the independent reading portion of the sessions the observer rotated through the children in 5-s observation intervals and coded their behaviour. The codes used were an adaptation of the observational typology for e-book engagement in Roskos et al. (2012). Codes (see Table 2) captured which e-book was being used by the child, where the child was oriented, (i.e., looking at the book, at another child, at the researcher, or elsewhere/off task), whether the child looked at the book alone or

Table 2 Coding categories for observations of children's e-book behaviour

Record	Detail
Group composition	Number of children reading given e-book from 1 (alone) to 4 (maximum group size)
e-Book	Which book is with the child
Letter	Which letter is displayed on the page
Orientation	Where child is oriented: to book, other child, researcher or none of the above (i.e., off task)
Letter sound	Whether child said the sound of a letter (e.g., /c/ as in cat)
Letter name	Whether child named a letter
Object name	Whether child named the object shown on the page (e.g., Apple)
Pointing to picture	Whether child activated picture hotspot on the page
Pointing to letter	Whether child activated letter hotspot on the page
Telling a story	Whether child talked in narrative or reading style while using the book
Search for hotspot	Whether child touched various parts of page in attempt to find hotspots
Navigating	Whether child was on a navigation page of the book/ scrolling through multiple pages
Ask for help	Whether child seeks researcher assistance with e-book
Unknown verbalization	Whether child said something but it cannot be interpreted as telling a story
None	None of the above behaviors such as child behaviour unrelated to book (e.g., looking around room) or looking at book with no other behaviour to code

with 1/2/3 other children, and behaviors with the book such as saying (correctly or incorrectly) a letter name, letter sound or object name; searching for or activating letter or object hotspots; asking for help, and navigating the start menu. Given that more than one behaviour could occur in any one 5-s interval, codes were not mutually exclusive. Inter-rater reliability was substantial for coding children's orientation during independent reading time, $K = .66$, $p < .001$ and for coding specific book behavior, $K = .70$, $p < .001$.

3.5 Data Preparation and Analytic Approach

The data were sorted according to which book was being used and frequencies were calculated for each book per child, collapsed across sessions, for the following book behaviours: looking at the book, saying the letter name, saying the letter sound, saying the object name, and touching/activating letter and object hotspots. Saying the object name may be considered to be a letter-related behavior because in naming an object associated with a letter, the child would be pronouncing the letter's sound as part of that name. A tally was also made of the number of observations made of each child, the number of different books each child used, and the number of

observations in which each book was used by each child. The last served as the denominator in calculating proportions per child for the coded behaviours pertaining to each book. In cases where a child was observed using a book less than five times, the average of the other children was substituted and used in the analyses rather than a proportion based on a denominator of such small frequency. It was felt that a sample of four or fewer observations was too small to be reliable, and would unduly influence book means and standard deviations, in that a large change in proportion would result from a small change in frequency (e.g., the difference between 3/4 and 2/4 is .25).

Means and standard deviations and confidence intervals for behaviours for each book were calculated and compared to the mean of all 11 books. The elaborateness ranks (1–11) assigned to each book were correlated with the book's mean for coded behaviours using Spearman correlation to examine linear associations. Finally, books were identified for closer consideration of their design features when the confidence interval for their mean of a given behaviour did not overlap (be it higher or lower) with the mean of that variable for all 11 books.

4 Results

A total of 7438 observations were made across the 16 sessions. Between 30 and 35 children were present at each session, with each child attending an average of 14.89 (SD = 1.59) sessions. An average of 212.79 (SD 55.52) observations collected from each of them. In 7255 or 98% of the observations, the child had a tablet in his/her hands as the sole viewer or a joint viewer with another child. Sixteen children used all 11 books at least once. Twelve children used different assortments of ten of the books. For seven children this number was nine of the books, and for two children eight of the books. Collapsed across children and sessions, an average of 658.33 (SD = 258.20) observations were made for each book with an average of 19 observations (SD = 7.29) per book per child.

It is worth noting here that Evans et al. (2017) previously reported that there was no significant correlation between pre-test knowledge of letter name or letter sounds and the extent to which children were observed, collapsed across all the e-books, to be oriented to the book, say letter names, say letter sounds, point to or activate letters, or name objects during the first eight sessions (i.e., Weeks 1 and 2) using the books. Additional analyses for the present paper showed that this was also true for all the remaining eight-session periods (i.e., Weeks 3–4, 5–6, and 7–8) in the study. All these correlations were less than .25. Thus there was little relation between children's letter knowledge coming into the study and how they interacted with the e-books.

4.1 Children's Book Behaviours by e-Book

Book Use Table 3 shows the number of participants who were observed using each book at least five times. Books with the highest ranking of elaborateness (ranks 7–11) never had too few observations per child for calculating proportions for the behaviour codes, being used at least five times by all 35 children. Books of intermediate ranks 6–8 as well as the simplest book (rank 1) were used at least five times by 33 or 34 of the 35 children. For books with lower ranks (2–5) seven of the children were observed using them only 4 times or less across the 16 sessions.

The linear correlation between a book's ranking of elaborateness and the average number of times it was observed being used by a child was $r = .55$, $p = .083$. Figure 1 displays this by graphing the mean number of observations and 95% confidence intervals per book arranged across the x axis in increasing order of elaborateness. The mean and 95% confidence interval across all books is also displayed. The graph shows that the mean usage for the four most animated books falls above the average for all books, and for the five least animated books below the average. In addition, the lower boundary of confidence intervals for the two most interactive e-books (*ABC Funnimals* and *Interactive Alphabet,* ranks 10 and 11) is higher than the mean for any other book. The high frequency of usage counts for these books partly stems from these being used by more than one child at once. On average across books, 87% of the observations of children looking at books entailed the child looking at the book alone. However, when children read *ABC Funnimals* and *Interactive Alphabet,* they did so alone just 64% and 63% of the time respectively. Instead 28% and 33.5% of the observations with these e-books respectively entailed two children reading the book together, and in 11.3% and 6.4% of the observations, three/four children together. These same two e-books were also the favoured e-books in all six sessions in which they had been offered to the children, irrespective of what were the other three books in the session.

Table 3 Number of participants using e-book at least five times across the study

e-Book	Rank	Participants
Z is for Zebra	4	27
ABC Magic	2	28
ABC Magic2	3	28
Animal ABC	5	28
A-Z Alphabet Book	1	33
Animal Alphabet	6	28
Captain Wallace's Animal Expedition	8	28
Alphabet Zoo	7	34
Letters A-Z	9	35
ABC Funnimals	10	35
Interactive Alphabet	11	35

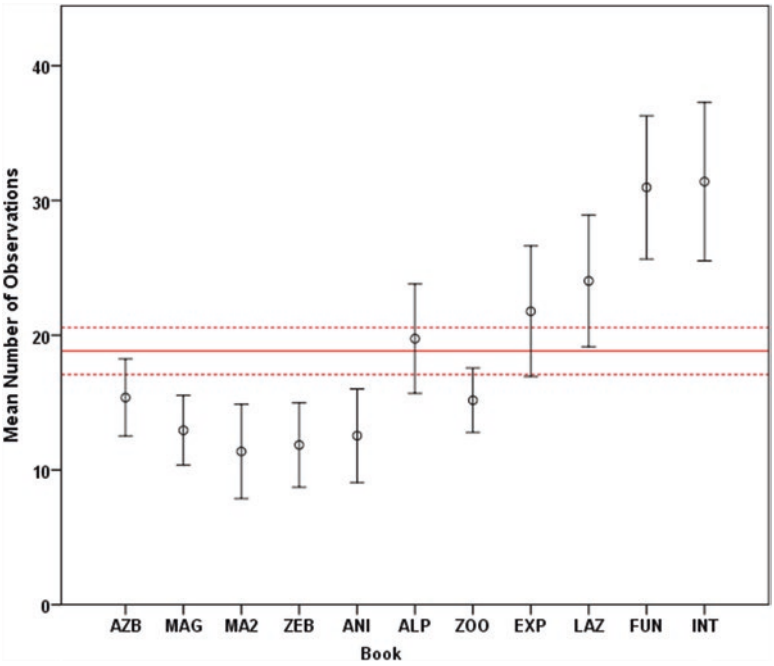

Fig. 1 Mean number of observations and 95% confidence interval per by e-book ordered on *x* axis according to elaborateness of e-book. *Y* axis reference line provides mean and CI across all e-books

The graph also shows one e-book that does not appear to conform to the linear association described above—*Alphabet Zoo*—in being used less than the lower bound of its ranked book neighbours, but at about an average usage level across all the e-books. This e-book requires the user to activate the letter hotspot three times, causing the letter to grow in size and its sound to be heard, in order for the associated animal to appear in place of the letter. Tapping the animal activates a noise for the animal noise and a simple animation.

Looking at Book Figure 2 shows that the amount of just looking at the screen of an e-book was inversely related to the elaborateness of the book ($r = -.62$, $p < .04$). There were two clear outliers to this linear pattern. *This Place is a Zoo! Captain Wallace's Alphabet Expedition* deviated in having a higher proportion of observations in which the child looked at the books during the 5-s observation intervals, with no other behaviour to be coded. This is likely because as each page is scrolled to, this e-book immediately displays the letter in upper- and lowercase along with an animation lasting between five and 15 s with accompanying sound effects. After the animation, hotspots activate the letter name, letter sound, or animal noise but no further animation. Conversely, *Z is for Zebra* elicited less just looking than would be expected given its ranking. This e-book has no animations. Hotspots on the upper/lower case letters and objects activate only a narration of the letter name and

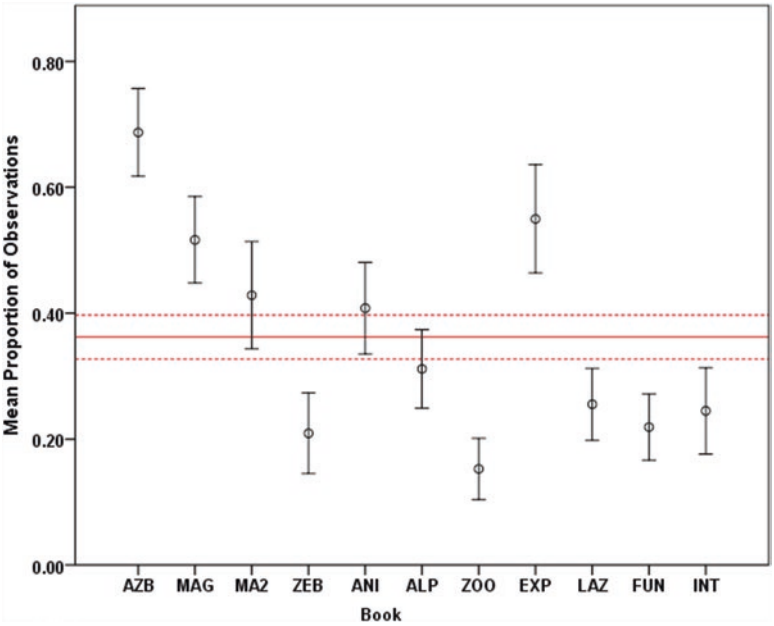

Fig. 2 Mean proportion of observations and 95% confidence interval in which children were observed looking at e-book. e-Books are ordered on *x* axis according to elaborateness of e-book. *Y* axis reference line provides mean and CI across all e-books

object name respectively, and a separate icon activates the letter's sound. For each of these a different voice is heard.

Tapping Object Hotspot On average across books, in 40% of the observations, children tapped on the object displayed. As would be expected the more elaborate the book in terms of what the object hotspots produced, the more tapping of these hotspots $r = .70$, $p = .02$. Figure 3 shows that when children were using *ABC Funnimals* and *Interactive Alphabet,* tapping of object hotspots was highest, and well above the average of all the e-books, occurring in approximately 70% of the observations. In these two books, the resulting animations frequently introduce new animations, additional characters, and sound effects. In contrast, while *This Place is a Zoo! Captain Wallace's Alphabet Expedition* has elaborate animations, tapping on the object produces only an animal noise. Accordingly, it elicited less object hotspot tapping (19% of the observations.) Lastly, it might be noted that despite the absence of hotspots in *A to Z Alphabet Book*, tapping objects (and letters, see Fig. 4) was coded occasionally when children attempted to interact with this e-book in the way that they did with the others having hotspots.

Tapping Letter Hotspot Overall, there was little tapping of letter hotspots to activate the name or sound of the letter. This behaviour was coded on average in just 12% of the observations. In addition, as can be seen in Fig. 4, there was no linear

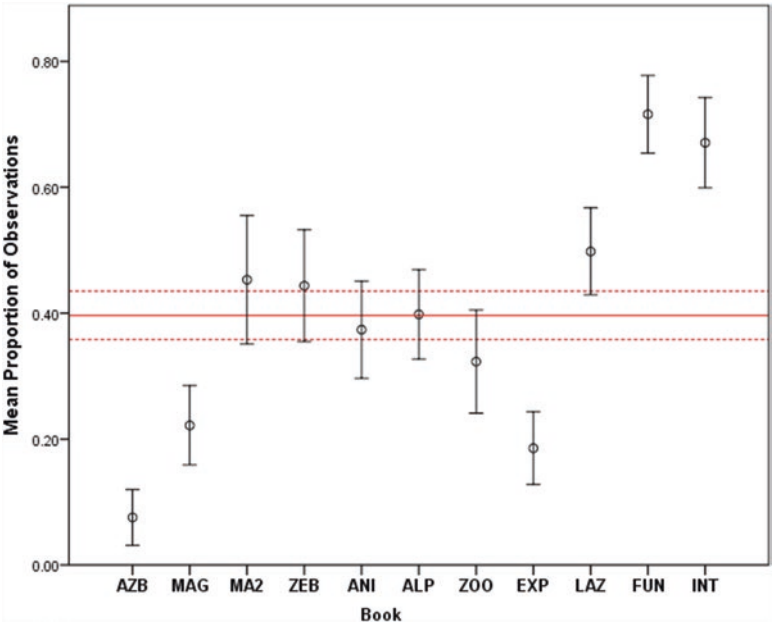

Fig. 3 Mean proportion of observations and 95% confidence interval in which children were observed touching/activating object. e-Books are ordered on *x* axis according to elaborateness of e-book. *Y* axis reference line provides mean and CI across all e-books

relation of tapping letter hotspots with the ranking of the books in terms of how elaborate a book was (r = .03, p = .99) However the graph signals three things of note.

First, when children used *ABC Funnimals* and *Interactive Alphabet,* the two e-books with the most elaborate and engaging object hotspot animations, they very rarely tapped the letters, the mean across children being just 1.53% and .08% of observations for these two books respectively. In fact, only 11 children were observed even just once to activate a letter hotspot and hear its sound or name when using *ABC Funnimals* and only six were observed to do so when using *Interactive Alphabet*. This is even more remarkable given that these two books had an average of over 30 observations per child.

The second item of note is that *Alphabet Zoo* elicited an extraordinarily high activation of letter hotspots (45% of observations) compared to all of the other e-books. The reason likely is that in this book, the only way to access the object hotspot is by first tapping the large letter hotspot three times. Tapping the image again brings back the letter to potentially begin the cycle again. The same sequence holds for the tapping the same letter in smaller font appearing at the bottom of the page.

The last item of note is the contrast between *ABC Magic and ABC Magic 2*. The former elicits more tapping of the letter hotspots (12% of observations) than the

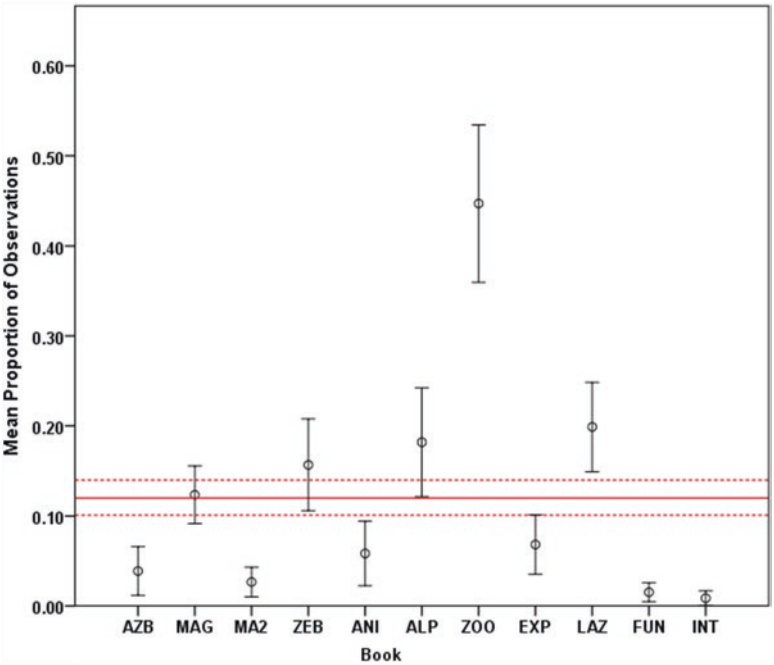

Fig. 4 Mean proportion of observations and 95% confidence interval in which children were observed touching/activating letter. e-Books are ordered on *x* axis according to elaborateness of e-book. *Y* axis reference line provides mean and CI across all e-books

latter (3%) and the confidence intervals for these means do not overlap. In both of these books, at each page there is an automatic audio in a child's voice of the letter's sound two times, followed by the name of the object displayed. Also in both books, each letter on a page has a hotspot producing an audio of the letter sound, and each object has a hotspot producing the object's name. The difference between the two books is that *ABC Magic2* pairs each letter with four objects while *ABC Magic* provides just one object per letter. It appears that the more objects on a page to tap, the less tapping of letters, even if the former results in nothing more than the object's name being heard. This also held true when the data examined was restricted to the 24 children who used both books. Tapping letter hotspots was significantly lower (3.22%) for *ABC Magic 2* having four pictures per letter than *ABC Magic* (12.02%) having one object per letter, $F = 10.64$ (df 1, 23), $p = .003$. In fact, only four of these 24 children were ever observed to tap a letter hotspot to hear the letter sound when using *ABC Magic2,* in contrast to 20 children when using *ABC Magic.*

Saying Letter Name This behaviour was very infrequent. Between 24 and 32 of the children were never observed to say the name of a letter when using a given e-book, making calculation of means and confidence intervals per book inappropriate. Rather, the number of children who were observed to say a letter name at least once when using a given book was counted. Table 4 displays this data. On average

Table 4 Percentage of children observed at least once saying letter name, letter sound, or object name by book used

e-Book	% letter name	% letter sound	% object name
A to Z Alphabet Book	24.2	6.1	35.3
ABC Magic	10.3	13.8	20.7
ABC Magic 2	6.9	6.9	31.0
Z is for Zebra!	10.7	7.1	35.7
Animal ABC	0.0	0.0	17.2
Animal Alphabet	18.2	3.0	18.2
Alphabet Zoo	8.8	8.8	17.6
This Place is a Zoo!	27.3	6.1	27.3
Letter A to Z	17.1	8.6	34.3
ABC Funnimals	14.3	3.0	28.6
Interactive Alphabet	20.0	2.9	40.0

across the 11 e-books, 15% children were observed to name letters but for three books--*ABC Magic 2*, *Animal ABC*, and *Alphabet Zoo* this figure was considerably lower (7%, 0%, and 9% respectively). Again, the features of the books help to explain why.

In *ABC Magic 2,* the letter name is never heard in the audio and, as seen above, children opted to tap the four object hotspots which activated the object's name. In *Animal ABC*, there is no automatic audio. Only if the icon at the page's top right is tapped does the child hear the name of the beginning letter followed by the name of the animal. The bottom left icon competes by providing the noises that go with the animal. Finally, in *Alphabet Zoo*, the sound of the letter predominates. The name is heard once after scrolling to a page and that is all. Tapping the large letter hotspot produces the letter's sound and as noted earlier, this must be done three times to access the object hotspot and its simple animation consisting of the object shaking back and forth. Tapping the image again brings back the letter to tap, hear the sound, and begin the cycle again. This sequence also applies to the same letter in a smaller font at the bottom of the page.

Two books diverged in the opposite direction with letter naming being more frequent. When using *A to Z Alphabet Book,* the simplest of all 11 books with no animations or hotspots, the child heard only the phrase "letter is for object" (e.g. "C if for cat"). This parsimony and absence of any distractions may have encouraged relatively more children to name the letter. In fact, 25% of them did so at least once. In the second book, *This Place is a Zoo! Captain Wallace's Alphabet Expedition*, there is no automatic audio of the letter name. Rather this is activated by tapping the upper/lower case letter displayed after the animation. Importantly, many of the animal animations end with a paw, hoof, horn, nose, tongue, or tail pointing at or holding the page's letter, as though inviting or cueing the children to take their turn and name or activate the letter. For this book 27% of children said a letter name at least once. It may be that attention to the letter and naming of it was encouraged by integrating the letter and object together. This interpretation is supported by the chil-

dren's behaviour with *Animal Alphabet.* Although naming the letter was not observed as often here, with this book as high a percentage of children named letters at least once as children who named objects at least once (18%). This e-book superimposed letters of equal size as the accompanying object over that object.

Saying Letter Sound This behaviour was the least frequent. This is not surprising given than these young children knew fewer letter sounds than letter names and were just beginning to grasp the alphabetic principle that letters make sounds. As shown in Table 4, for 10 of the 11 books, fewer than 9% of the children were observed to a letter sound even just once during the observations.

Saying letter sounds was highest of the books with *ABC Magic* (14%) but not second highest with *ABC Magic2* (7%). The contrast is again instructive. *ABC Magic* displays a letter and one object along with automated audio providing the letter sound two times and the name of the object once, followed by three repetitions of the letter sound. The letter hotspot if activated provides the letter sound a sixth time. In all, the ratio of letter sounds to object names is five or six to one. By contrast in *ABC Magic 2,* with four objects per letter, the automatic audio provided the letter sound two times, followed by the object's name once. This is repeated for each of the four objects paired with the letter for a ratio of two letter sounds to one object name. In other words, letter sounds are provided proportionately less often than object names in *ABC Magic 2* than *ABC Magic*.

Saying Object Name This verbal behaviour was more common than the other naming behaviours, being observed at least once on average in 30% of the children. This percentage was lower (under 19%) for three of the books. *Animal Alphabet*, automatically plays music throughout which may have reduced the likelihood of children naming objects as often as they otherwise might have. *Alphabet Zoo* has no automatic or hotspot activated narration of the object name, providing instead letter name, letter sound, and animal noises. *Animal ABC* does not present the object name unless the hotspot on a peripheral icon in the corner is activated.

5 Discussion

The strength of this study lies in its observational data of repeated interactions with a sample of alphabet e-books over a period of time across a sample of 35 preschoolers. The limitation is that it sampled 11 alphabet e-books from the many, many alphabet e-books that can be downloaded from websites. In addition, the behaviour when reading the e-books stem from children of a certain age (4–5 years) in a relatively controlled experimental context, and as such may not generalize to older children or to younger children (see Courage this volume, for a discussion of age-related and individual differences in executive function and attention) or to situations such as those in which children may intersperse e-book use with play or read an e-book with an adult.

Nonetheless, it is felt that these observations in concert with the analysis of the features of the books provide some helpful clues regarding the effect of e-book design on your children's behaviour with them and potentially regarding the learning that they derive from them. With this in mind, many a time the author went back to an e-book to carefully note further aspects of how it worked, adding details to the essential features noted in Table 3 to capture its design. This level of detail, through verbal descriptions or brief videos of the e-book in action, should be made available to potential buyers of these materials before downloading them to allow them to make their own informed choices. It is hoped that readers will have read through the table to enable them to draw their own conclusions about the linkages between e-book design and behaviour presented earlier, and the generalizations summarized below.

5.1 The Double Face of Animations

While the children were not asked about which e-books they liked the best, the extent to which they used them strongly suggests a preference for the ones with elaborate animations. The more entertaining and interactive the animations were, the more children selected the book for use. The four books with the highest usage *This Place is a Zoo? Captain Wallace's Alphabet Expedition, Letter A-Z, ABC Funnimals,* and *Interactive Alphabet*, were ones which the paired letters with clever object animations of this nature. Moreover, the two e-books with the highest usage were the ones in which the children could control what happened in at least some of these hotspots, such as making an apple increasingly be eaten through multiple taps, or making a zipper go up and down by dragging the tab with a finger. However even the simple effects of having an object shake or make a noise at the touch of its hotspot seems to have positively affected children's e-book choice. This is hardly surprising and mirrors previous research papers showing children's preference for looking at pictures over print when listening to storybooks (Evans and Saint-Aubin 2009; Roy-Charland et al. 2007; Justice et al. 2005) or alphabet books (Evans and Saint-Aubin 2005) and preference for moving letters over static ones when watching Sesame Street (Fisch and Truglio 2001; Flagg 1982). For an alphabet e-book to even "out of the gate" and be selected repeated by a child over and above other alphabet e-books, it needs to be animated.

However, highly elaborate animations likely detract from the educational content of alphabet e-books and compete for cognitive and attentional resources. A like concern has been raised by several other researchers with respect to animated storybooks and the playful enhancements within them (e.g., De Jong and Bus 2002, 2003; Korat and Falk 2017; Takacs et al. 2015; Trushell et al. 2001; Sargeant 2015, and chapter by Bus et al. this volume). In fact, within the books sampled here, the e-books with the most entertaining animations were also the ones where tapping letter hotspots to hear letter names/sounds was the least frequent. In addition, Evans et al. (2017) found that children activated letter hotspots less over time as the ses-

sions progressed, and hypothesized that it may be because the novelty of trying out these letter hotspots wore off as they discovered the more entertaining displays and sounds resulting from object hotspots.

5.2 Enhancing the Alphabet Aspect of Alphabet e-Books

Notably none of the e-books sampled included an animation of the letter itself, but this would not necessarily be a help to letter learning if other aspects of the illustration are more eye-catching or if the way letters are animated does not highlight their differentiating features or provide a mnemonic for remembering them. A challenge for the design of animations in alphabet e-books is to support the alphabet and its learning, and not detract from it. One approach, as shown by Shidman and Ehri (2010) and Ehri et al. (1984), is to create displays that highlight the shape of a letter within an object whose name exemplifies that letter's sound (e.g., an S in a picture of a snake), providing a mnemonic for the letter's sound to facilitate alphabet learning.

One of the books, *Alphabet Zoo,* does not have accompanying objects in the initial display. This in itself may have drawn children's attention to the letter on the screen as the only object to look at. But *Alphabet Zoo* goes two steps further. Appearance of the object and its hotspot is contingent on the letter hotspot being activated three times, with the first two taps causing the letter to pulsate and the letter's sound to be heard. Only the third tap produces the accompanying object and hotspot for a simple animation of the object and accompanying noise. A second tap of the object causes the animation not to be repeated, but rather to disappear and the letter to appear again. In this way this e-book was engineered to emphasize the letters and their sounds over the accompanying objects.

It is not surprising that the children rarely were observed to say the sounds of the letters, given than on average they knew just on average just five of them at the start of the study. However, they could do so by imitating what they heard. The promotional blurb for *ABC Magic* 2 notes that most young children will enjoy repeating the sounds they hear on this app. In the present study, while the children may have enjoyed repeating sounds when they did it, the reality is that they rarely did it. Nonetheless, compared to the other books *ABC Magic* was more successful in eliciting this behaviour and provides a clue as to why. It presents the letter sounds proportionately more often than other labels and more so than the other e-books, in that six letter sounds are heard to two object labels. A simple conclusion is that children are more likely to say what they more often hear, and that for letter names and sounds on alphabet e-books to influence children's letter behaviour and potentially alphabet knowledge, they must not only be there, but be there frequently and more prominently than competing labels, music, and noises. As shown by Robbins and Ehri (1994) at least four repetitions of a new word are a necessary, but not sufficient, condition for young children to acquire vocabulary from storybooks, a generalization which would likely apply to the alphabet vocabulary of letter names and sounds.

Children knew on average about 12 uppercase and 10 lowercase names. A third of them could name at least 20 uppercase letters. However, they were infrequently observed to say the names of the letters. It is possible that the children were "reading" silently, but the fact that they often overtly named objects suggests that this is not the explanation. It is more likely because the object labels were better known to them and because the objects and animations were more the focus of their attention. What seems to encourage letter naming is cuing the child to "read" a letter name by ending an animation to point at the featured letter in some way, as was the case for *This Place is a Zoo! Captain Wallace's ABC Expedition.* Another approach is simply having no hotspots at all as in *A to Z Alphabet Book*, or providing a few seconds of silence at each new page before the audio names a letter to afford the child space for children to name what they see. As suggested by Karemaker et al. (2017) in their study of enhanced and non-enhanced e-storybooks, it also may be that the absence of supportive features (in this case an immediate audio of the letter name) encourages children to put more effort into the activity.

6 Conclusion

The linkages between book design and book behavior highlighted here suggest some ways that education/learning may be enhanced by designers of alphabet e-books without a reduction in entertainment/enjoyment. They are at this point only suggestions, begging for experimental studies comparing the behavior of children with alphabet e-books differing on one design dimension only. The author does not doubt that the designers of the various e-books sampled here put considerable thought into creating what they hoped would be both entertaining and educational products. The promotional blurbs echo these intents, but the limited extant research suggests that the educational value may be overstated. This is especially concerning given a report by Vaala and Takeuchi (2012) that a majority of parents felt that the features of e-books enable children to read alone and another by Neumann (2014) showing that the majority of parents agreed that touch screen tablets would help their child's early literacy development, Also, Etta (this volume) describes that parents report e-books to be educational regardless of the interactive features present. Similarly, Higgins et al. (2000) found that many teachers of special education believed that software marketed for educational purposes provided these benefits.

While parents can augment the educational value of these books by reading them with their child, the format of interactive e-books seems to lend itself less well to supportive parent interactions than do print books. In a study by Strouse and Ganea (2017) parents reported that they engaged in more interaction with their child when reading print books than e-books. Observational studies support this in showing that when reading e-storybooks compared to print storybooks, parents initiate less talk about the story and engage in more talk managing the child's behaviour (Chiong et al. 2012; Kim and Anderson 2008; Krcmar and Cingel 2014; Lauricella et al. 2014; Parish-Morris et al. 2013). These observations underscore the importance of

alphabet e-book features that encourage the child to attend more to the educational material and less to unrelated animations.

Finally, it might also be noted that many items for children feature the alphabet, such as wooden blocks, lacing cards, toy boxes, clothing, dinnerware, and blankets, but have purposes unrelated to alphabet learning. For some, it may be heretical here to note that there is a place within the range of alphabet e-books for ones that are primarily entertaining, with the alphabet as an incidental organizing principle for the activities, animations and sound effects within them. What should be is essential and noncontroversial, however, is that (1) creators and distributors be transparent in how they describe and present alphabet e-books in their promotional material so that buyers can make informed choices for their purposes and goals, and (2) that they refrain from claims about children's behaviours and learning in using them without well controlled research behind them.

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Part II
e-Books and Literacy Practices at Home

Parent Preferences: e-Books Versus Print Books

Roxanne A. Etta

Abstract According to a nationwide survey in the U.S., nearly all (98%) of children between the ages of zero to 8 years have access to a mobile device (Rideout V, The common sense census: media use by kids age zero to eight. Common Sense Media, San Francisco, 2017). The pervasiveness of mobile screen devices has introduced e-books into the home, however, parents report that only 28% of children have ever read a book on a smartphone or tablet (Rideout V, The common sense census: media use by kids age zero to eight. Common Sense Media, San Francisco, 2017). This mismatch between availability and use may be due, in part, to parental skepticism about the value of e-books for their children (Rideout V, Learning at home: families' educational media use in America. Joan Ganz Cooney Center, New York, 2014). In order to maximize the effectiveness of e-books, it is critical to establish whether and how families use e-books with their children, and what features parents look for in e-books. Thus, the current study analyzed Amazon Mechanical Turk survey data on parent-reported reading behaviors, as well as parent perceptions about contexts and feature preferences for children's print books and e-books.

Keywords Parent survey · Book preference · Print books · e-Books · Parents · Preschoolers

1 Introduction

According to a nationwide survey in the U.S., nearly all (98%) of children between the ages of zero to 8 years have access to a mobile device (Rideout 2017). The pervasiveness of mobile screen devices has introduced e-books into the home,

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J. E. Kim, B. Hassinger-Das (eds.), *Reading in the Digital Age: Young Children's Experiences with E-books*, Literacy Studies 18,
https://doi.org/10.1007/978-3-030-20077-0_6

however, parents report that only 28% of children have ever read a book on a smartphone or tablet (Rideout 2017). This mismatch between availability and use may be due, in part, to parental skepticism about the value of e-books for their children (Rideout 2014). In order to maximize the effectiveness of e-books, it is critical to establish an understanding on whether and how families use e-books with their children, and what features parents look for in e-books. Thus, the current study analyzed Amazon Mechanical Turk survey data on parent-reported reading behaviors, as well as parent perceptions about contexts and feature preferences for children's print books and e-books.

1.1 Mobile Screen Media Prevalence for Preschool-Aged Children

There is a plethora of research suggesting that today's youth are becoming increasingly immersed in mobile screen media. On average, children between the ages of zero and eight spend over 2 h using screen media daily, with children from lower-income homes spending three and a half hours a day on screen media (Rideout 2017). Furthermore, children spend about 48 min per day in total using mobile devices for both entertainment and educational purposes, which is a trifold increase since 2013 (Rideout 2014, 2017). Preschool-aged children 2–4 years old are the most avid users of educational media, with 78% of their total screen time devoted to educational content (Rideout 2014).

Overall access to media for children across socioeconomic statuses is becoming more equivalent, with 96% of children from low income families having access to a mobile device. Similarly, children from lower-income families (40%) are as likely to have their own tablet device as children from higher income families (45%) (Rideout 2017). Considering the rising equivalency of device access for children from all backgrounds, e-books have the potential to readily reach at-risk children (Revelle et al. this volume). However, many look to e-books with both apprehension and hope for influencing early reading development (Guernsey et al. 2012; Van Daal et al. this volume).

1.2 The Importance of Reading

It has been well established that reading is of central importance for healthy child development. Reading to children early and often is considered an important epigenetic factor, with implications for later reading skills and success (Mendelsohn et al. 2001). The American Academy of Pediatrics (AAP) recommends that all parents read aloud with their children daily, both to build parent-child relationships and to enhance brain development (High et al. 2014). The period from birth to age

five is a particularly critical time for book reading as a support for early literacy development (Duursma et al. 2008). However, only 57% of children in the U.S. on average are read to on a daily basis; a number that drops to 40% for children from lower socioeconomic status (Rideout 2017).

Furthermore, research has suggested that the number of books (both digital and print) in the home influences academic achievement, with the presence of as little as 25–50 books enhancing test scores by up to a grade level (Evans et al. 2014). This enhancement is greatest for families from lower income levels, where each additional book has the potential to impact performance. (Evans et al. 2014). Historically, socioeconomic status has been linked to children's access to books, but as the digital divide is closing e-books could serve as a valuable boon for lower-income children's home libraries (Rideout 2017). However, on average, children spend 29 min a day reading or being read to, with 26 min spent on print books and only 3 min a day spent with e-books (Rideout 2017). This may be due, in part, to findings that children's access to e-books is heavily influenced by parent perceptions and expectations of media (Rideout 2014). Many parents claim to restrict children's access to e-books, and have ranked mobile screen devices as the least educational platform compared to television, computers, and video games (Rideout 2014). For this reason, it is essential to develop a further understanding about the reasons for and contexts in which parents use e-books and print books in their home, as well as their attitudes about each medium.

1.3 Parent Attitudes Toward Media

In the U.S., over 76% of parents agree that the less time kids spend with screen media, the better (Rideout 2017) but at the same time, three out of four parents agree that digital media use is an important skill for their kids to develop (Common Sense Media 2008). These and conflicting attitudes represent the confusion that parents face while trying to raise children in a quickly evolving digital world. Although books are not new media, electronic books are recent developments that have changed the definition of "reading," and parents have been left to their own devices to select and use these reading materials with their children.

The AAP (2016) suggests that parents select high quality media for their preschoolers, use it with them, and limit screen time to less than 1 h per day. For e-books specifically, the AAP (2016) suggests parents be wary of e-books' interactive enhancements, but should use e-books like they would use print books with their child. However, only one out of five parents are aware of the AAP recommendations, and 29% are not interested in these recommendations (Rideout 2017). For e-books especially, these AAP recommendations are easier said than done.

Children's media are not often designed for a dual audience, and e-books in particular are loaded with interactive features to promote independent use. Ninety-five percent of children's e-books contain narration (Guernsey et al. 2012), which can

minimize the parent's role in joint book reading. Both parents and children become frustrated during joint book reading when the parent tries to read aloud an enhanced e-book with highly interactive features (Chiong et al. 2012). Given these difficulties, do parents actually want to use e-books the way that researchers and practitioners advise them to? This has yet to be established.

1.4 Overview of the Current Study

Children are immersed in technology, and e-books are becoming more readily available. However, parents report that children are rarely using e-books (Rideout 2017). Perhaps parents are hesitant to accept e-books as equivalent social and learning tools compared to print books. Whether or not e-books are satisfying parent needs and expectations has yet to be established. The purpose of the current study is to explore how children and parents are navigating e-books compared to print books in the home. Using an Amazon Mechanical Turk survey, parents (N = 2260, M age = 32.00 years) of preschool-aged children (M age = 4.15 years) answered questions about children's e-book and print book use, attitudes, and preferences. While previous research has investigated parent beliefs around media, this study is the first of its kind to explore the specific features that parents prefer within different book formats that potentially serve different purposes.

2 Methods

2.1 Participants and Design

In total, 2260 parents of preschool-aged children (3–6 years) in the U.S. were recruited using Amazon Mechanical Turk (MTurk). Forty-two (less than 1%) of the MTurk survey participants were excluded from the survey due to failure on quality control questions, such as "This is a quality control question, please select "Strongly Agree'". This is much lower than the average (20–30%) dropout rate for MTurk surveys (Keith et al. 2017). MTurk survey participants are generally a specific subset of people that differ slightly from the overall U.S. population. For socioeconomic representation, MTurk workers are typically highly educated (Berinsky et al. 2012) and middle class (Shapiro et al. 2013). Most MTurk respondents identify themselves as White/Caucasian; compared to the US population, those who identify themselves as Asian/Pacific Islander are overrepresented, while those who identify themselves as Black/African American or Hispanic/Latino are underrepresented (Shapiro et al. 2013). These general demographic findings for MTurk participants match the demographics of the current sample.

Of the 2243 participants (99% of the sample) who responded to the race and ethnicity questions, parents identified as 54.9% White, 31.6% Asian, 7.6% Black or

African American, 3.7% American Indian or Alaska Native, 0.8% Native Hawaiian or Islander, and 4.3% "other". Parents were highly educated, with 19.5% having a graduate school degree, 49.4% college graduates, 23.1% with some college education, and only 8.3% with a high school or GED and below. Parent age was 32 years on average, (*SD* = 6.40, range 18 to 65+). Most parents were employed, with 55% having a full time job, 16.9% with one part time job, 6.7% with multiple jobs, 2.6% students, less than 1% retired, and 17.6% unemployed. Parents also reported their subjective social status by placing themselves on a ladder that represents people who have the least money, little or no education, and no job or a job that is not respected at the bottom (1) and people who have the most money, highest level of education, and highly respected jobs at the top (10) (Adler and Stewart 2007). Parents' average status on this measure was 6.03 (*SD* = 1.81, range 0–10). The parent reported age of their preschool-aged child (43% female) was about 4.1 years (*SD* = 1.07, range 3–6 years).

After opting-in to the study and providing electronic consent, MTurk workers were provided with a short survey that took about 10 min to complete. Previous research on participation rates using MTurk has found that higher pay per task (i.e., 50 cents versus 2 cents) significantly increased participation rate and data quality was not affected by compensation amount, suggesting that low compensation does not have a negative consequence on data quality (Buhrmester et al. 2011). In order to provide participants with competitive pay and have respectable participation rates, participants were compensated 20 cents upon successful completion of the survey.

The survey contained questions about child usage of books, beliefs of book purpose, and preferred book features. To gain information on how children are actually using books in the home, parents were asked to indicate a "main" reason that their child uses both e-books and print books. Provided reasons included: for bedtime routine, for entertainment, for learning, for relaxation or soothing, to occupy child while caregiver is busy (e.g., preparing meals, showering, etc.), for bonding with family members, for fun during playtime, for travel (e.g., car, bus, airplane, etc.), or for safety (e.g., staying out of trouble). Parents were also asked to indicate how frequently their child uses e-books or provide reasons as to why their child does not use e-books. Additionally, parents were asked how often their child uses e-books independently.

For beliefs about book purpose, sample images of four different book formats (interactive e-book, simple e-book, interactive print book, simple print book) and descriptions for each were provided in the question. For each book format, parents were asked to identify the purposes they serve from a list (entertaining, learning, calming, bonding). Parents were allowed to select all answers that applied.

To investigate specific book feature preferences, parents were asked to indicate how much they agree with statements about print book and e-book features on a scale from 1 (strongly disagree) to 7 (strongly agree). Features for both e-books and print books included: narration, visual appeal, sound effects, mini games, positive story messages, educational content, familiar characters, simple features, and low cost. One feature was phrased differently depending on the book format for clarity: "moving pieces" (print books) or "animations" (e-books). Each feature was presented with detailed phrases like "I prefer e-books with mini games (e.g., puzzles, mazes, sorting) for my child to play" for each book format.

3 Results

3.1 Reported Usage of e-Books and Print Books

Parents were asked to report the reasons their children actually use e-books and print books in the home. Simple distributions showed that learning was the most important reason children use both print books (28%) and e-books (23%). While 25% of parents reported print books were mainly used for bedtime, only 5% of parents reported so for e-books (Fig. 1). More parents selected print books for bonding (11%) compared to e-books (4%). On the contrary, 21% of parents reported the most important reason their child uses e-books is for entertainment, while only 12% of parents said so for print books. Similarly, 15% of parents ranked e-books as most importantly used for travel, while only 4% for print books. A slightly higher amount of parents selected playtime for e-books (13%) compared to print books (8%). 11% of parents said e-books occupy children while they are busy, but only 3% said so for print books. Playtime, relaxation, and safety were less common responses in general and had similar patterns of results for both book types. Overall, learning and bedtime were the most important reason of use for print books, while learning and entertainment were the most important reasons for e-books.

Frequency of Book Use Parents were also asked to report their child's e-book use frequency. Twenty-one percent of parents reported that their child uses e-books daily and 28% reported several times a week. Some parents stated their child uses e-books once a week (11%), less than once a week (8%), once a month (4%), every few months (3%), and once or twice per year (2%). Parents who said their child had ever used e-books indicated how often their child uses them independently. Thirteen percent said their child always uses e-books independently, 26% said most of the time, 20% said about half of the time, 29% said sometimes, and 12% said never.

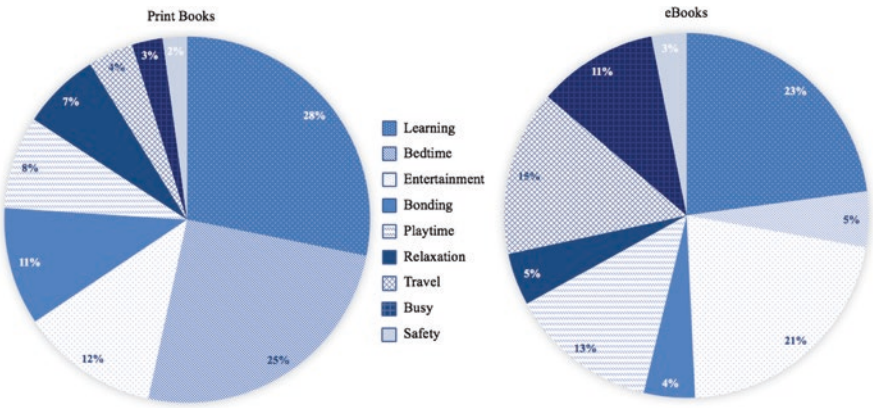

Fig. 1 Most important reason indicated for children's actual use of print books (left) and e-books (right)

Overall, 23% of parents remarked their child never uses e-books. These parents were asked to select reasons their child does not use e-books from a list of options. Adapted from previous parent survey research by Rideout (2014), these parents claimed their children do not use e-books because: they believe their child is too young (21%), they prefer the experience of print books (19%), they wish to limit their child's time with screen devices (17%), they believe that print books are better for learning (11%), they fear that the child will break the electronic device (8%), they worry their child will want to use it all the time (8%), they believe their child gets too distracted by the features (7%), their child is not interested in e-books (5%), there are not enough good e-books available (2%), or some "other" reason not provided (2%), the most common of which was access or cost prevents their child from using e-books. In summary, although some children (23%) never use e-books, the majority (77%) do use e-books, and often independently.

3.2 Beliefs About Book Purposes

Parents were asked to indicate the purpose of four different book formats (noninteractive print, interactive print, noninteractive e-book, and interactive e-book). Simple distributions showed that for interactive e-books, parents selected learning (43%) and entertaining (40%) purposes equally, while bonding (10%) and calming (7%) were less common (Fig. 2). Results were comparable for simple e-books, with learning (36%) and entertaining (42%) purposes high, while bonding (12%) and calming were low (10%). Interactive print books were rated as high for entertaining (53%), somewhat for learning (24%), and low for bonding (16%) and calming (7%). Simple

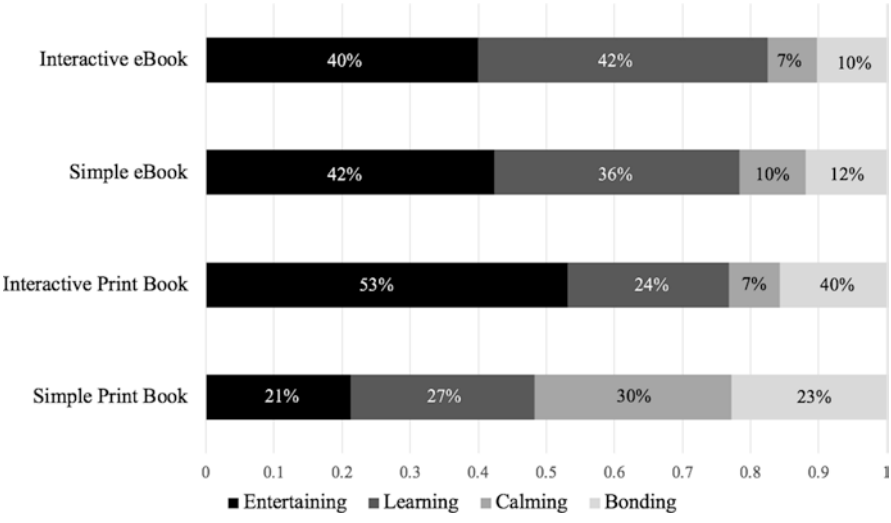

Fig. 2 Percentages for beliefs of book purpose as a function of book format

print books had the most evenly distributed purposes, with moderate entertaining (21%), learning (27%), bonding (23%) and calming (29%) scores. In summary, interactive e-books, noninteractive e-books, and interactive print books, were rated similarly as mostly used for entertainment and learning, but not calming and bonding. However, simple print books were used equally for all purposes.

3.3 Preferred Book Features

Parents were asked to rate the importance of specific features of print books and e-books separately. Given that the data were positively skewed, ranked, and from a within-subjects design, Wilcoxon matched pairs signed rank tests were conducted using SPSS. Results indicated that parents provided significantly higher ratings for print books in categories including the importance of educational content ($Z = -5.61$, $p < 0.001$), visual appeal ($Z = -9.49$, $p < 0.001$), positive messages ($Z = -5.84$, $p < 0.001$), and simple features ($Z = -6.23$, $p < 0.001$) compared to e-books (Fig. 3). For e-books, parents provided significantly higher ratings for the importance of low cost ($Z = -6.44$, $p < 0.001$), movable features ($Z = -4.09$, $p < 0.001$), mini games ($Z = -10.39$, $p < 0.001$), narration ($Z = -15.47$, $p < 0.001$), and sound effects ($Z = -22.24$, $p < 0.001$) compared to print books. There was no difference in preference for familiar characters by book type ($Z = -1.23$, $p > 0.05$).

3.4 Pressures and Perceptions

Parents were asked an optional open-ended question about the experience of print books compared to e-books. Of the parents who answered this question (69%), many claimed that print books offer a fundamentally different experience compared to e-books. For example, one parent stated,

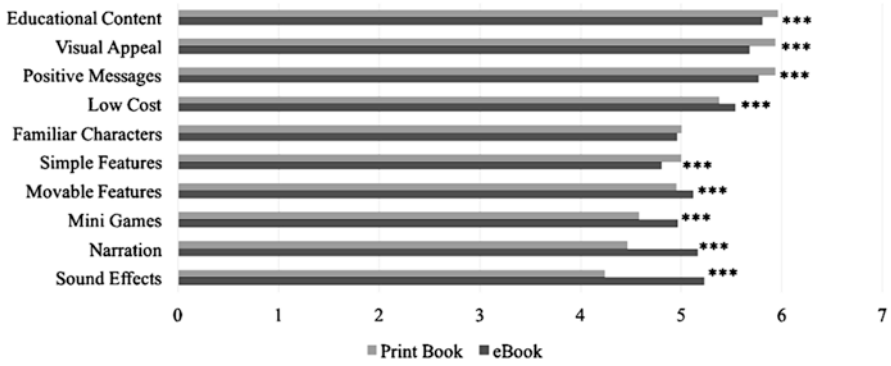

Fig. 3 Reported mean importance of book features for print books (orange) compared to e-books (blue) on a likert scale from 1 (strongly disagree) to 7 (strongly agree). *** $p < 0.001$

> The experiences are different, I feel as though bonding is more prevalent with print books, as ebooks can be a little too "gamey". The game aspect is great for pulling the child in and getting them excited for reading, but when reading with my child I prefer the old fashion print book in bed for bedtime.

This theme of print books as "*old-fashioned"* came up repeatedly, with many parents using statements like "I want my child to be able to appreciate a simple, old-fashioned book". Another parent elaborated on the old-fashioned experience of print books, claiming the materiality of a print book is important: "I'm a big fan of good old-fashioned books you can hold in your hand and actually turn the pages. Somehow, e-books just seem too artificial to enjoy much." As this quote illustrates, children's print books are considered old-fashioned due to their authentic tactile features. Book *physical sensation* was described as important for many parents. Parents described things like "holding the book" and "feeling the pages" during joint parent-child reading experience.

Similar to the importance of physical sensation, the experience of reading print books was described as more emotionally stimulating as compared to e-books. While contrasting the experience of e-books and print books, one parent elaborated,

> They are completely different. One requires a parent to lovingly open a book and turn the pages and use their own voice to read to the child. The other removes the parent from the equation and removes the bonding element.

When describing experiences with print books, words like "bonding" and "spending time together" were commonly used. While parents highlighted print books as catalysts for familial quality time, e-books were not described as such. Indeed, e-books were often characterized as tools for children to use alone. One parent said,

> I tend to like print with my child over eBooks. eBooks (he has a LeapFrog) are better for him alone. He likes to use his iPad a lot too. But reading print books gives a closer bond for us. I personally read eBooks (kindle) myself before bed.

Numerous parents appreciated e-books' ability to be used independently. Specifically, parents enjoy e-books for travel and to occupy children while caregivers are busy. Many stated that e-books can be loaded on one device, transported easily, and read the story aloud to the child. These previous statements underscore the unique affordances and roles that e-books and print books serve within different everyday contexts.

4 Discussion

Results from this survey indicate that children use e-books for different reasons than they use print books in the home. Although both book formats are used predominantly for learning, their other reported uses differ. Print books are more commonly used for *social* purposes, such as bedtime routine and bonding. e-Books, on the other hand, are used more frequently for *babysitting* purposes, such as entertaining and occupying children. Indeed, parents reported their children use e-books often, with

about half of parents (29%) claiming their preschooler uses e-books several times a week or more. Additionally, these children use their e-books alone quite frequently (only 12% of parents report their child does not use e-books alone). These results suggest that e-books and print books serve fundamentally different purposes and are used as such, which is further explained by parent perceptions of children's book formats.

e-Books and print books were broken down into interactive and noninteractive formats to see if interactivity had an influence on parent perceptions of book purpose. The results showed that parents believe e-books serve educational and entertaining purposes, regardless of interactivity. Surprisingly, interactive print books (e.g., pop-ups, pull-tabs) were considered to serve even more of an entertaining purpose than e-books. However, interactive print books are rare and expensive, therefore they may be considered more of a treat compared to other book formats. Traditional print books are believed to serve the most diverse purposes, serving entertainment, learning, bonding, and calming equally. How parents have established these purposes has yet to be explored.

It is likely that existing e-books and print books that are available have influenced parents' experiences and shaped their perceptions. It is very rare for children's e-books to be completely noninteractive (Guernsey et al. 2012). Children's e-books on the market today often contain "hypermedia" functions (Bus et al. 2015). Hypermedia, or highly interactive features, such as irrelevant mini games, animations, hotspots, and the like can be highly distracting. When interactive features are distracting rather than enhancing, children's learning from the book can be compromised (Bus et al. 2015). Similarly, parents have a difficult time reading to their children when interactive features are present (Chiong et al. 2012). Perhaps the overwhelming features that are pervasive within children's e-books have driven parents to brand e-books as entertainers. Print books cannot physically afford the same elaborate interactive features that e-books can, which may make them more enjoyable for parents to jointly use with children.

Another physical affordance of electronic books is a screen. Along with stimulating interactive capabilities, screens also emit blue light, which suppresses the production of melatonin and inhibits proper sleep (Brainard et al. 2001). Parents reported in this survey that print books were commonly used for bedtime, but not e-books. Previous research has shown that reading an e-book compared to a print book before bed delays the onset of sleep (Chang et al. 2015). The physical trait of a light-emitting screen makes e-books inherently worse for bedtime (Lewy et al. 1980), even though the content could be the same as a beloved printed bedtime story. Book physicalities and features seemed to be a strong driving factor in shaping parents' perceptions of different book formats.

Parents care the most about educational content, visual appeal, positive story messages, and simple features for children's books. However, they value these features within print books more than they do for e-books. For e-books, parents value low cost, movable features (e.g., animations), mini games, narration, and sound

effects. Given the affordances of screen devices, the preferred features for e-books are not surprising. These data also match the previous results that parents believe simple print books serve more of a social purpose, where beautiful art, feel-good stories, and minimal distractions seem appropriate. For the purpose of e-books as a babysitter, the importance of low cost, read aloud functions, and bells and whistles seems fitting as well. However, it is interesting to note that parents rated educational content as a more important feature for print books than for e-books. These findings do not match the results on parent-reported book purpose, where e-books were rated with higher educational purpose than traditional print books. However, it is possible that although parents hope for e-books to be educational tools, the current existing print books have higher educational quality than the latest available e-books and are therefore held to a higher standard.

Other book features described in the open ended questions were demonstrated to be highly influential on parent book preferences. Print books were favored for their old-fashioned, physical and emotionally rich experiences. While print book themes were rather sentimental, e-book themes were about practicality. Parents valued e-books for their portability and ability to be used alone by their child. Again, these results align with the purposes that parents have assigned to everyday print books and e-books.

Taken together, these findings illustrate that parents perceive and prefer e-books and print books for different purposes. Given these results, perhaps it is time for researchers to turn the page on the way we talk about book uses and best practices. Similarly, if children are using e-books and print books for different purposes, it is possible that pitting e-books and print books against each other in experimental studies is not the best way to understand their benefits and detriments for children.

4.1 Limitations and Future Directions

This study was a first pass at exploring the different uses and preferences for children's e-books. Although MTurk provided us with a large sample, we recognize that the demographics of this study are not nationally representative. As a function of online crowdsourcing, the quality of the data is another potential limitation. Though it is impossible to know whether all responses were answered truthfully, our survey used prescreening and discrete quality control questions to filter out inappropriate and low quality data. Nonetheless, this method resulted in a much larger and somewhat more diverse sample than we would typically obtain in our typical convenience sample. Future research should utilize converging methods to compare large survey studies such as this one to small, more in-depth interviews and observational studies.

5 Conclusion

Historically, print books have been viewed as the gold standard for children's literacy and learning (Bus et al. 1995), but this study suggests that parents predominantly perceive *e-books* for learning purposes as compared to print books. However, print books are considered very important for familial bonding, while e-books are viewed as appropriate for children's alone time. Based on this knowledge, it is time for the field to turn the page on the way e-books and print books are discussed and researched. As an alternative to the classic e-book vs. print book debate, our findings suggest that parents may perceive these tools as different entities with different purposes, rather than comparing them for singular purposes. Future research could aim to address the individual concerns and strengthen the separate roles of e-books and print books.

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Technology Support for Adults and Children Reading Together: Questions Answered and Questions Raised

Glenda L. Revelle, Gabrielle A. Strouse, Georgene L. Troseth, Susan Rvachew, and Dahlia Thompson Forrester

Abstract This chapter examines the possibility of building technology supports to scaffold effective adult interaction strategies during joint reading with young children. The authors, representing four different research labs, report what they have learned from their separate investigations of technology supports for adults and young children engaging in shared reading experiences. Developing digital tools that support and encourage parents and children to ask and answer questions in dialogue about a story shows promise as one way to support literacy development for children who may not receive optimal linguistic input in the home. If successful, technology scaffolds may provide an efficient, non-intrusive intervention to help adults contribute to children's literacy development. In addition, this line of research may serve to inform the design of socially contingent, intelligent agents that could engage in shared reading experiences with children to help build their literacy skills.

Keywords Joint reading · Shared reading · Dialogic reading · Adult-child reading · e-Books · Young children · Technology supports · Scaffolding · Intelligent agents · Adult-child interaction

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J. E. Kim, B. Hassinger-Das (eds.), *Reading in the Digital Age: Young Children's Experiences with E-books*, Literacy Studies 18,
https://doi.org/10.1007/978-3-030-20077-0_7

1 Introduction

Research has revealed a number of benefits of parent-child joint reading for children's literacy development. One way in which adults can facilitate young children's literacy learning is with "dialogic reading," a style of reading picture books in which adults engage children in conversation about what is happening in a book while reading together (Whitehurst et al. 1988; see also a discussion of dialog in e-book reading in Tønnessen and Hoel this volume). This dialogue can take the form of asking and answering questions, commenting about book content, and making connections between book events and the child's real-life experiences. Across a large number of studies, there is evidence that dialogic reading facilitates children's language and vocabulary development (Bus 2001; Mol et al. 2008; Morgan and Meier 2008; What Works Clearinghouse 2007; Whitehurst et al. 1988).

In addition, early reading success is dependent upon preschoolers' code-related skills, including print awareness and knowledge (Hammill 2004; Storch and Whitehurst 2002). Shared reading of storybooks with adults gives young children the opportunity to acquire this knowledge. Storybook reading is a context in which children receive rich and complex language input in proximity to congruent print content (Weizman and Snow 2001). Therefore, it might be expected that children would acquire print knowledge in the context of joint storybook reading with an adult. However, children do not look at the print in picture books unless they have been explicitly taught letter names and sound correspondences beforehand (Evans and Saint-Aubin 2005, 2009). Therefore, explicit print referencing by the adult reader is an essential component of shared reading, if children are to gain print knowledge in this context.

1.1 Book-Reading Language

Both affluent and working-class families use relatively more talk with richer language while reading than they do during their other daily activities (Hoff-Ginsberg 1991). Book reading seems to elicit parents' highest-quality talk, possibly because the themes of books are more varied and unusual than day-to-day family routines are (Cunningham and Stanovich 1998). However, mothers with more education and resources talk more in general to their children using longer utterances with more varied vocabulary than mothers with fewer resources do (Hart and Risley 1995; Hoff 2003a, b; Rowe 2012), resulting in a "30 million word gap" in cumulative exposure by age three (Hart and Risley 1995) that contributes to an overall achievement gap during the school years (Farkas and Beron 2004; Hoff 2006, 2013; Huttenlocher et al. 2010; Rowe 2008). Although critics of Hart and Risley's early study point out methodological flaws (e.g., Dudley-Marling and Lucas 2009), a substantial language input gap has also emerged in recent research (e.g., Fernald et al. 2013; Gilkerson et al. 2017; Schady et al. 2015). In observational studies, parents with less education and fewer resources are less likely to define new words

for children while reading (Evans et al. 2011) or to engage in reciprocal conversations that allow children to practice using vocabulary (Dickinson and Tabors 2001) compared with parents of higher socioeconomic status.

Significant *within*-SES variation in language input has also been documented in recent studies, for both higher and lower SES families. Some parents with relatively few resources engage in more conversation with their children than other parents of the same SES do (Gilkerson et al. 2017; Sperry et al. 2018; Weisleder and Fernald 2013), including richer, more varied language during reciprocal conversations about objects of shared attention—which relates to children's improved language development (Hirsh-Pasek et al. 2015). There is also substantial variability in the number of words and amount of reciprocal conversation that highly educated parents provide their children, with some economically advantaged children subsisting in a relatively impoverished language environment (Gilkerson et al. 2017). Technology supports that encourage and train *all* parents to converse with their children more during book reading might help to bridge existing gaps in language input across SES.

1.2 Parent Training

Training can be effective for helping adults to adopt the practices of both dialogic reading and print referencing. When parents are trained to use dialogic reading strategies in a lab setting, children show improvement in acquisition of story vocabulary and general expressive language growth (Arnold et al. 1994; Strouse et al. 2013; Whitehurst et al. 1988; Zevenbergen and Whitehurst 2003). Teachers also can be trained to incorporate dialogic questioning interactions into preschool classroom activities, leading to significant advances in children's expressive and receptive vocabulary (Hargrave & Sénéchal 2000). Likewise, when adult co-readers are taught to use print referencing strategies, there are beneficial impacts on children's attention to and learning from print (Justice et al. 2008b, 2010; Zucker et al. 2009). There are not many (if any) studies that incorporate training parents in both dialogic reading and print referencing. These strategies are often used with children of somewhat different ages, with dialogic reading strategies used with younger children. Also, in the context of brief parent training programs, it may be ineffective to ask parents to focus on too many new skills simultaneously (Pile et al. 2010.)

Training adults in techniques that support children's early literacy learning, while effective, can be time consuming and expensive (Blom-Hoffman et al. 2007; Briesch et al. 2008; Flowers et al. 2007; Justice et al. 2008a). According to Hindman et al. (2016), the few effective interventions for families and educators to "bridge the word gap" in vocabulary exposure and build children's language rely on fidelity of training facilitated by intensive, ongoing, on-site support. However, scaling up this level of training is expensive, especially for communities with few resources. A potential solution is offering adults training in dialogic techniques and print awareness using interactive digital media.

1.3 Technology Support for Parents

Incorporating technology support for adult-child reading interactions into e-books may hold promise for children's literacy development. Digital devices that can display e-books have been adopted by families from all socioeconomic groups in the U.S. (Etta this volume; Smith 2013), with most families of all income levels now having a touch screen device. For instance, according to a 2015 study, 90% of toddlers in a low-income, traditionally underrepresented population in the U.S. had used a touch screen by age 2, and 83% of children under 5 had a tablet computer in their home (Kabali et al. 2015). Adoption of smart phones and tablets capable of displaying e-books is increasing rapidly in Canada, with 73% of adults over 18 owning a smart phone in 2015 and 52% a tablet computer (Canadian Radio-Television and Telecommunications Commission 2016).

e-Books typically include an option for audio narration, which could be a boon for parents with poorer reading skills or those not fluent in the language their children must use in school. In addition, the capacity of e-books to highlight the meaning of words with audio-visual effects (e.g., animation and/or sound effects) has been shown to promote literacy skills (Bus et al. this volume; Takacs et al. 2015). Children also like e-books, a promising fact for increasing their exposure to books (Picton and Clark 2015). However, there are indications that, although children may be more engaged with e-books than with traditional paper books, parents talk to their preschoolers less about the story while reading books with digital elements compared with print books (Krcmar and Cingel 2014; Parish-Morris et al. 2013; Richter and Courage 2017). Furthermore, shared reading with e-books increases parent talk that might *distract* attention from the story, such as directives to manage behavior or regulate sharing of the device (Krcmar and Cingel 2014). To alleviate this disadvantage, prompts for parents could be built into e-books to inspire dialogic conversation about the story and encourage print referencing.

1.4 Technology Support for Children

Another possibility is that interactive digital media might provide direct support to children, lessening the need for parent and teacher involvement. With the development of artificial intelligence, the suggestion has been raised that interactive intelligent agents might be able to supply the kinds of input and contingent feedback that adults provide for children in social learning interactions (Brunick et al. 2016; Troseth et al. 2016). One way that intelligent agents may support children is through the development of "parasocial relationships," defined by Hoffner (2008) as emotionally-tinged relationships between people and media characters, which are in some ways similar to the affective bonds that are formed in real social relationships. Children tend to develop parasocial relationships with familiar on-screen characters, which has been shown to promote learning from them (Lauricella et al. 2011). However, some aspects of parent-child interactions cannot be replaced, such as

shared prior experience. Thus, even if socially interactive intelligent agents become a reality, it is not likely that they could fully replace adults engaging in shared reading with young children, at least not any time soon. Instead, socially interactive intelligent agents might serve as reading assistants for the child when adult co-readers are not available. In addition, on-screen characters who appear when parents and children are reading together may model interactions that support learning, helping parents develop their repertoire of interaction strategies to use when reading books with their children.

One recent study indicates that simply building questions into storybook pages (without an on-screen character) does not support low-vocabulary children's learning as well as when an adult co-reader asks the questions at the same places in the book (Strouse and Ganea 2016). However, there is reason to believe that software-provided questions may help children learn if they are delivered by an on-screen character with whom children can interact. Using a video storybook with some animation, Smeets and Bus (2012) examined the effect of having an on-screen "computer pal" (similar to a cartoonish Muppet face) who introduces the book and then asks vocabulary-related questions either during storybook reading or afterwards. The computer assistant also provides feedback based on the child's answers. In the condition with the computer pal asking questions (during *or* after the story), kindergarten children made significantly greater expressive and receptive vocabulary gains than those of children who watched the storybook video with no questions. In a follow-up study, the same researchers determined that having an on-screen character who asked vocabulary-related questions was a more effective learning aid than simply providing labels and definitions when children clicked on target objects in the illustrations. Since there was not a condition with an on-screen character providing definitions in this study, though, it is not clear whether *the simple presence of an on-screen character* engaging with the child helped build children's vocabulary or whether the effect was caused by *the character asking questions and providing feedback*.

1.5 Summary

In this chapter, we examine the possibility of building technology supports to scaffold effective adult interaction strategies during joint reading with young children. If successful, technology scaffolds could potentially provide a more efficient, less intrusive intervention (compared with in-person training) to help adults contribute to children's literacy development. In addition, this line of research may serve to inform the design of socially contingent, intelligent agents that could engage in shared reading experiences with children to help build their literacy skills.

The authors, representing four different research labs, have all been investigating the creation of technology supports for adults and young children engaging in shared reading experiences. Rather than describing each of the different projects separately, we have organized this chapter by integrating the design work of all four labs, then the research methods of all labs, and finally the research results of all labs.

The intention of this organization strategy is to integrate and synthesize the four bodies of work, pointing out similarities and differences at every step of the research process. The goal is to suggest general principles that emerge from this comparison to inform future technology projects to support early literacy.

2 Designing Technology Support for Adult-Child Joint Reading

All of the projects reported here include on-screen characters with a goal of supporting language and literacy. However, differences in the implementation of these characters and the learning goals provide informative comparisons. In this section, we address similarities and differences in the features of the characters, design of the books, and training or instructions given to parents.

2.1 Family Story Play and StoryVisit

Revelle and colleagues have created several different versions of a system to support adult co-readers in dialogic reading with young children (Revelle et al. (2013). Two of these reading systems, *Family Story Play* (Raffle et al. 2010) and *StoryVisit* (Raffle et al. 2011), allow children to experience a sense of togetherness with adults separated from them by long distance, by enabling them to read children's storybooks together over video chat. Both systems were research prototypes that led to the development of the commercial product *Storytime* on kindoma.com. Although there are some technology differences between the two systems, both *Story Play* and *StoryVisit* enable the remote grownup and child reader to see and hear each other, and to see and control the same book.

In both of these systems, modeling of dialogic reading strategies is provided on each page of the book by an on-screen, interactive social agent, *Sesame Street's Elmo* character. When selected, Elmo asks questions or makes comments about the story, designed both to model dialogic reading techniques for adults and to increase child engagement. Elmo's actions, like the rest of the book content, are synchronized for both the adult reader and the child on their separate screens. Character dialogue was produced for every page of every book, so Elmo can ask children contextually relevant questions and draw a child's attention to specific aspects of the story. Elmo never reads the book, but instead asks questions or makes dialogic-reading-style comments, designed to invite children and adults to engage in conversation with him and with each other.

Additional supports for dialogic reading were built into both Story Play and StoryVisit. Before engaging in the remote reading interaction, adult readers were shown a dialogic reading training video, hosted by *Sesame Street's Maria*. In addi-

tion, printed reading tips appeared on every page of the book on the adult's screen, suggesting questions the adult reader might ask or comments to make on that page.

Two additional features were included in *StoryVisit* that were not in *Story Play*. First, in *Story Play*, either the adult or the child could click on Elmo to initiate his comment or question. In *StoryVisit,* the adult was given exclusive control over Elmo and was given choices regarding Elmo's responses, so that Elmo became part of the family's ongoing conversation about the book, rather than being perceived as interacting directly with the child. For instance, the adult could say, "Elmo, what's happening on this page?" and then click on "Talk" to initiate his commenting on the story. The adult also had the option to click on "Yes" or "No," to make Elmo answer yes and no questions or to click on "Ha Ha" to make Elmo laugh. In addition, *StoryVisit* included a "shared pointing" feature, in which either the adult or child could click on something on the page, and the other user would see a pointing hand icon appear on that section of the page. This allows children or adults to point to pictured characters or objects in the book about which they are asking questions or commenting.

2.2 Read with Me, Talk with Me

Troseth, Strouse, and colleagues (2017; Troseth et al. in press) also created supports for dialogic reading in a system called *Read with Me, Talk with Me*, which was designed as an effortless training tool to help parents engage in conversation with their children while reading e-books together. The books are customized versions of *The Big Dog Problem* (Oxley and Aaronson 2016), an e-book based on the PBS KIDS show *Peg + Cat*. The e-book includes a voiceover narration by the main child character (Peg) that plays automatically when each page is flipped. The customized versions include an overlay in which Ramone (a young adult character) appears in the corner of the page after the story narration finishes on each page to model dialogic questioning techniques for parents. Ramone, a character in the television show, was not in the story line of this particular book.

Two versions of the book were created with the Ramone overlay, with two goals in mind: challenging children to express themselves and encouraging parents to take over questioning. In the spirit of dialogic reading (Zevenbergen and Whitehurst 2003), the topics of conversation presented by Ramone during the second reading of the book call for more complex linguistic responses from children than during the first reading. At first, Ramone asks simple questions that can be answered with a tap on the touch screen (e.g., "Who is taller, Peg or Cat?") to engage children and build their confidence in responding. Across the two reads, his questions and topics become increasingly more open-ended and complex, requiring memory, inference, and verbal responses, (e.g., "Why is Peg excited?"). Ramone also incorporates many text-to-life topics (distancing prompts), such as "Who is the tallest in your family?" See Fig. 1 for one page of the experimental e-book.

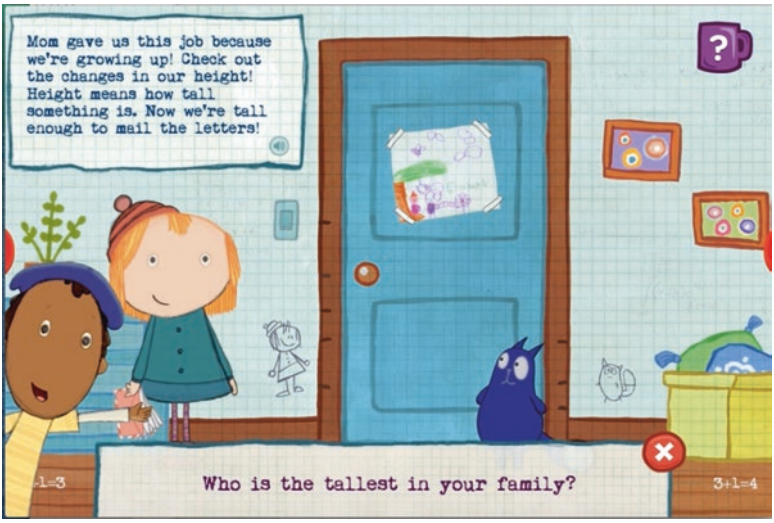

Fig. 1 A page from the *Read with Me, Talk with Me* experimental e-book. (*Peg + Cat* © 2013, Feline Features, LLC. All Rights Reserved. Used with permission)

To promote the second goal, Ramone's support is gradually withdrawn across the two book readings, with the intention of handing control of the questioning over to parents. Ramone pops up automatically in the corner of each page during the first reading, and models dialogic questioning by asking the questions himself. Gradually, Ramone's questions are replaced by suggestions for topics for parents and children to discuss, such that parents have to generate the questions on their own. Finally, near the end of the second book, Ramone stops appearing automatically but is available to be triggered if the parent-child pair want to hear his suggestion for a topic of conversation. The goal is for parents to learn to generate their own questions by the end of the second reading, and for them to feel inspired to generate questions when reading other books with their children (i.e., to generalize what they have learned about dialogic reading).

When Ramone appears on screen and begins to talk, he is accompanied by a text box displaying his verbal prompt. Clicking or tapping the text box repeats the prompt. A "coffee cup" icon also appears, which parents can tap to repeat Ramone's questions. On pages in the second book where Ramone does not appear automatically, parents can tap the coffee cup if they want a hint about questions to ask. Other than the text box and coffee cup, there are no hotspots, and animation throughout is light. On the title page for both books, Ramone offers encouragement about the importance of parent-child talk during reading, but adult co-readers were given no prior training in reading strategies.

2.3 iRead With

Rvachew and colleagues (Rees et al. 2017; Rvachew et al. 2017) have been conducting qualitative and quantitative studies to explore the impact of a series of specially designed e-books, called *iRead With.*[1] These books were designed specifically for shared reading by an adult and child; therefore, although a narration feature is available, the design effort was placed on the "read and talk" mode with the intention that the adult read the text and interact with the child. Each page is clearly divided into two regions: the top two-thirds of the page contains illustrations with embedded hotspots and animations and the bottom third contains the corresponding text, including "living words," which provide animations to reinforce word meaning. Sound effects are associated with certain hotspots and animations. An adult avatar appears on the lower left and a child avatar on the lower right side of each page. These avatars can be personalized by replacing them with photos of the adult and child readers.

Print referencing is encouraged with features to attract attention to certain words that occur frequently throughout each book. For example, in the story "*What's That Funny Noise?*" featuring the media character Caillou, the words *Mommy*, *Daddy*, *noise*, *monster*, and *shadows* appear in a slightly larger bolded font and in a color that is unique to each word. When touched, these words animate to reveal a characteristic feature; for example, a shadow appears under the word *shadows* and horns grow on the word *monster* (See Fig. 2). Touching these words in the text also launches a story- and meaning-relevant animation in the story illustration in the top portion of the page. For example, on one page, touching the word *shadows* toggles window blinds up and down to reveal and conceal shadows on the bed.

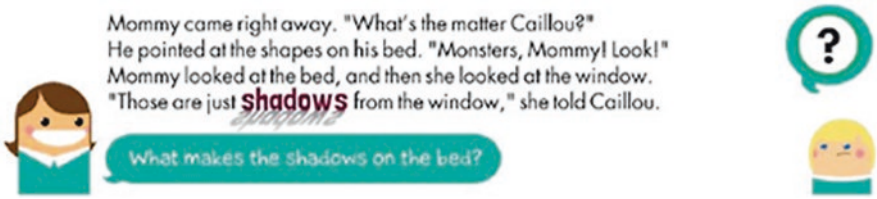

Fig. 2 Bottom portion of page from an *iRead With* book. When the Living Word "shadows" is touched, shadows are shown under the word, the mother avatar releases a prompt to the reader to ask a question about the shadows on the bed and an animation in the illustration (not shown) demonstrates how a light source creates the shadows. (Image taken with permission from Tribal Nova Inc. (2015b). *Caillou: What's that funny noise?* (Version 1.3.3) [Mobile application software])

[1] *iRead With* books were created by Tribal Nova Inc. (currently Houghton Mifflin Harcourt Montreal) with consulting support from the Child Phonology laboratory at McGill University. The books are no longer available for purchase. The special features of these books are described here in relation to their potential benefit as components of digital storybooks in general.

Simultaneously, a prompt bar appears in association with the adult avatar to suggest a dialogic reading-style comment or question that could be posed to the child to support vocabulary learning, story comprehension or emergent literacy skills. With repeated readings, new prompts are added to the book. In research with the books, adult readers were given no training in reading strategies besides familiarization with the e-books and their features.

2.4 Dialogic Actress

A few years ago, Strouse et al. (2013) created a video version of a built-in dialogic questioner in a set of five very lightly animated, narrated children's video storybooks. The character, Miss Sue, appears in a picture-in-picture window in the bottom corner of the page. Miss Sue is a video recording of an adult sitting in an armchair with a TV remote, which she lifts to "pause" the story before asking a question. The video storybook is frozen while she asks her question and for a short pause afterward, giving children time to respond.

Children watched one of five storybook videos at the lab with a researcher who encouraged them to respond to Miss Sue, and took the four additional video storybooks home on DVD to view. As in the case of the *Peg + Cat* books discussed above, easier and more challenging versions of Miss Sue's questions were embedded in two separate copies of each of the storybooks. In the videos, Miss Sue spoke directly to children, not to parents. Strouse and colleagues point out that although children who interacted with the dialogic actress did not get the same kinds of social contingency (responsiveness) or social feedback as those who interacted with a parent, they could potentially experience some learning gains with the dialogic actress due to their enhanced engagement with and elaboration on the story content while answering questions.

2.5 Summary: Designs

Thus, across all of our labs, the design of digital storybooks (in the form of either e-books or videos) with embedded dialogic questioning help was occurring independently. All of the experimental products included modeling of dialogic reading by an on-screen character, but there were a number of differences in their design as well, including the type of character used for the modeling, whether the storybooks included a narrator reading the story, the number and type of features that were offered to support adult co-readers' interaction techniques and children's learning, and other factors (see Table 1).

Table 1 Factors in digital storybook design, research methods, and results across studies

	Family story play	StoryVisit	Read/talk with me	iRead with	Dialogic actress
Design of technology support					
On-screen character?	Muppet Elmo	Muppet Elmo	Cartoon young adult, Ramone	Cartoon avatar for adult	Adult female actress
Role of character	Model dialogic reading strategies	Model dialogic reading strategies	Model dialogic reading strategies	Prompt dialogic reading strategies	Engage in dialogic reading strategies
Narrator text?	No	No	Yes	No	Yes
Text tips?	Yes	Yes	Yes	Yes	No
Added features		Shared pointing		Print referencing	
Research methods					
Child ages	2–4	1–6	3–4	5–6	3
Participants	8 families	61 families	94 families	64 children	81 children
Adult partner	Grandparent	Grandparent	Parent	Volunteers	None required
Dialogic Training?	Yes	Yes	No	No	No
Reading location	Remote	Remote	Co-located	Co-located	Co-located
Reading context	Lab	Home	Lab	School	Home & Lab
Research results: technology-scaffolded e-book versus unscaffolded book					
Talk during reading	(1) More adult and child story-related talk		(1) More adult and child story-related talk (2) More overall utterances, words, unique words	(1) More adult and child story-related talk (2) More print referencing	Parents provided little content-related talk, but children regularly responded to actress's questions
Duration of reading	Reading sessions lasted longer	Reading sessions lasted longer	Reading sessions lasted longer		
Child engagement	Child engagement significantly higher		Similar attention and affect as in other conditions		Children regularly responded to actress

3 Research on Technology Supports for Adult-Child Reading Behaviors

In this section we discuss research that each of our teams has conducted using our respective forms of dialogic reading storybooks. We describe similarities and differences across the projects with regard to research methods used, implementation of the research studies, and the context surrounding usage and testing.

3.1 Family Story Play

In Raffle et al.'s (2010) *Story Play* research, eight families with children between the ages of two and four (5F, 3 M), their parents (6F, 2 M), and their grandparents (6F, 2 M) used both *Story Play* and traditional video conferencing technology to enable them to read books together from different locations. Participants were selected for diversity of income level and ethnicity. To simulate reading together from a distance, family members were taken into separate rooms in a research lab (grandparent in one, child and parent in the other). Each family participated in two reading sessions with a brief break in between: one using Story Play to read an interactive version of *The Monster at the End of this Book* (Stone and Smollin 1971), which included modeling of dialogic reading strategies by the Elmo character and provision of text-based dialogic reading tips for the grandparent, and one using Skype with a traditional paper copy of the same book. The order of reading sessions (*Story Play* vs. *Skype*) was counterbalanced. In the Story Play sessions, grandparents were shown a dialogic reading training video before the call. All reading sessions were recorded on video, and after the sessions, grandparents and parents were interviewed about their experiences.

Videos were coded using a qualitative verbal and social interaction coding scheme developed for this project. Coding focused on behaviors of the child, parent and grandparent while reading each page of the book. The coding scheme included five broad categories, with verbal and non-verbal components in each category: behaviors related to *Book Content* (including dialogic reading-style questions or comments), behaviors reflecting positive or negative *Affect*, indicators of child *Attention/Engagement*, coordination of *Page Turns*, and *Interaction with Elmo*, the on-screen character (see Raffle et al. 2010, for more detail).

3.2 StoryVisit

Research on *StoryVisit* (Raffle et al. 2011) took the form of a field test of a prototype web-based e-book system, available for a period of 4 weeks. A parent/child pair and their long-distance adult relative could simultaneously log into the system from

their respective homes. Families could log on as many times as they wanted during the 4-week period. Sixty-one families used the system for at least one reading session with a long-distance reader, and the maximum number of reading sessions engaged in by any of the families was five. Children of these families ranged in age from 1 to 6 years.

Four versions of the *StoryVisit* prototype were created, varying (1) whether the e-book co-reading experience included the Elmo character modeling dialogic reading strategies, (2) provision of text-based dialogic reading tips for the adult reader, (3) both or (4) neither. Each family was randomly assigned to one of these four conditions when they signed up for the study. All versions included video conferencing with five e-books adapted from the Sesame Street library, and the shared pointing feature.

For all 61 families, basic usage data (amount of time spent per session, number of books read per session, etc.) was logged by the system. In addition, all participants completed pre- and post-surveys, and 19 of the families completed a post-test telephone interview. Four of the families received home visits by the research team, which included observation and recording of video during book-reading sessions and in-depth semi-structured interviews.

3.3 Read with Me, Talk with Me

The effectiveness of *Read with Me, Talk with Me* is currently being examined with two samples of 3- and 4-year-olds and their caregivers (Troseth et al. in press; Strouse et al. 2017). In one sample, 32 families were recruited through childcare centers serving families of low socioeconomic status. Caregivers and children were videotaped while they read either the two versions of the book with the Ramone character offering dialogic questioning support, or the original version of the *Peg + Cat Big Dog Problem* e-book (as released on the *PBS KIDS* website, without the dialogic questioning) twice. In the other study sample, 67 families have been recruited thus far from a database developed from state birth records, word of mouth, daycare centers, and families who volunteered during events at the zoo. This sample includes families from a variety of income levels.

In this study, caregivers and children are assigned to read the two versions of the book with the Ramone character, or to read one of three different versions of the original Peg + Cat book: (1) the e-book with the sound (narration) *on*, (2) the e-book with the sound *off*, or (3) a printed paper version of the book, created by taking screenshots of the e-book. In all of the comparison conditions, parent-child dyads read the original Peg + Cat book (without Ramone's questioning support) twice. Analyses for both samples include *Amount of Parent-child Talk*, *Content of Talk*, *Child Affect* and *Child Attention*, all coded from videotapes. Parents were also interviewed and provided written feedback about their experience with the books.

3.4 iRead With

To assess the impact of the *iRead With* features on adult scaffolding behaviors, Rvachew et al. (2017) conducted a study using a randomized control crossover trial design. Twenty-eight children in an English-speaking school situated in a low-income, urban community participated in a 2-week one-on-one shared reading experience with volunteer adult readers who shared one book with the child three times each week. Of the eight volunteer readers, three were parents from the school community, two were school staff and three were undergraduate students.

In a separate study (previously unpublished), the research team replicated Rvachew et al.'s (2017) study procedure with 36 children in a French-language school in a middle-class suburban community. Of seven volunteer adult readers, four were retired school personnel (three teachers, one principal), one was a parent and two were undergraduate students.

In both studies, adult-child pairs read two stories: *Caillou: What's That Funny Noise?* (Johnson 2009; Tribal Nova Inc 2015b) and *Caillou: My First Play* (Pleau-Murissi 2010; Tribal Nova Inc 2015a). Over the 2-week experience, the reading pairs shared one story in print book form and the other story in e-book form. The adult readers were given no training regarding reading strategies besides some initial familiarization with the books and the e-book features.

The readers were instructed to share the print book and the e-book as they normally would with a kindergarten-aged child and were also told to use their own discretion regarding use of the e-book features. The children were randomly assigned to a counterbalanced reading order as well as to a volunteer reader. Shared reading exchanges were audio recorded.

The recordings of the reading sessions were transcribed and scored for adult scaffolding behaviors during shared reading. All adult utterances that were not verbatim readings of text from the book were coded according to five categories: (1) *Rapport and Behavior*; (2) *Book Mechanics*; (3) *Story Related*; (4) *Word Meanings*; and (5) *Print or Word Structure*. Details of the coding system with examples are provided in Rvachew et al. (2017).

3.5 Dialogic Actress

The dialogic actress ("Miss Sue") embedded in storybook videos was used in one condition of a larger study. Strouse et al.'s (2013) research involved a comparison of learning outcomes (acquiring story vocabulary, story comprehension) for 81 children who watched four storybook videos over a period of 4 weeks at home, with either: (1) parents who were trained in dialogic questioning strategies (20 children); (2) parents who were asked to direct children's attention to story events, but not to ask questions (21 children); (3) parents who were told to act "as usual" while

children watched (typically with very limited parent-child conversation, and children often watched on their own) (20 children); or (4) the on-screen actress in a picture-in-picture window who used dialogic questioning strategies in similar ways to parental dialogic questioning (20 children).

Parents in all conditions were instructed to have their children watch the first two stories 3–5 times per week for the first 2 weeks; they then had their children watch two new stories 3–5 times per week for the following 2 weeks. In the case of the dialogic actress condition, parents received two versions of each story, one with easier and one with more challenging questions. They were instructed to have their child view the video containing two stories with easier questions for 1 week and the video of the same two stories with challenging questions for the next week. Then they repeated this procedure with the other stories over the next 2 weeks. Parents of children in the dialogic actress condition were instructed not to repeat the actress's questions because the researchers were interested in what children would learn from the videos "on their own."

Parents and children visited the lab for vocabulary pre-testing prior to the study. After watching the first two video stories at home for 2 weeks, they returned for post-testing (*Story Vocabulary* and *Story Comprehension*). After another 2 weeks, they returned for vocabulary and story comprehension post-testing for the final two stories. At the final visit parents and children were also video-recorded while they watched one of the stories in the lab; they were instructed to watch in the same way they had done at home during the study.

3.6 Summary: Methods

As with the design of dialogic storybooks across the authors' four research labs, there were some basic similarities across research methods for all of the studies, including ages of children (6 and under) and observation of adult-child interactions during usage. There were also some differences in research methodology, such as the relationship of the adult reader to the child, whether the adult reader received training in dialogic reading or not, whether the two readers were co-located or at a distance, and whether the reading was done at home or in the lab. There were also differences in the type of comparison conditions used. See Table 1 for a comparison of research methods employed.

4 Research Findings

In this section we report and compare the results of research conducted in each of the four research labs.

4.1 Family Story Play

Raffle et al. (2010) found a number of benefits of *Story Play* reading sessions (interactive book with technology support for adults' dialogic reading) over *Skype* reading sessions (adult reads traditional paper book to child over video chat). Both methods of incorporating shared reading into grandparent-grandchild remote interactions significantly increased the length of such interactions compared with Skype conversational sessions with young children, previously reported as lasting 2–3 min (Ames et al. 2010). The Story Play sessions, however, lasted significantly longer (M = 11:48 min) than the Skype reading sessions (M = 8:23 min) in Raffle et al.'s (2010) study. Child engagement levels were high throughout both kinds of reading session, but higher for Story Play (child engaged, on average, 97% of the time) than for Skype (child engaged, on average, 84% of the time).

Participants seemed to enjoy both Skype and Story Play reading experiences. Grandparents expressed approximately equal levels of positive affect with Story Play and Skype, but both parents and children expressed more positive affect with Story Play than with Skype. It is possible, of course, that parents' enjoyment increased for Story Play as a reflection of children's increased enjoyment due to the interaction with the Elmo character. Although inclusion of the Elmo character was successful at increasing children's engagement and enjoyment, some of the adults perceived that Elmo was there solely to entertain the child and did not perceive him to be a welcome part of the reading interaction. Some grandparents were frustrated by Elmo's distraction from their interaction with the child, with one commenting, "I think he likes Elmo better than me."

Regarding dialogic reading, grandparents in both conditions asked children questions related to the content of the book (e.g. "What is Grover doing?" or "Are you afraid of monsters?"), but grandparents in the Story Play condition did so more often (averaging two per page) than those in the Skype condition (one per page, on average). Children answered their grandparents' questions on average once per page in both reading conditions. Grandparents gave children positive reinforcement (e.g., "Good job!" or "That's right!) for answering questions or talking about the story slightly more often in the Story Play condition (11% of Story Play pages, 4% of Skype pages).

4.2 StoryVisit

In this study, Raffle et al. (2011) were not able to examine the effects of supports for dialogic reading on adult reading partners' behaviors directly, since it was a field study and there was no record of participant verbalizations, only computer interactions. Instead, analyses focused on comparing various aspects of the participants' e-book interactions for the various book feature conditions (Elmo modeling dialogic reading, text-based dialogic reading tips, both or neither). Families whose

reading experience included Elmo modeling had significantly longer reading sessions than those who had neither Elmo modeling nor text-based reading tips. In addition, families experiencing Elmo modeling engaged in more total reading time across all sessions than families in any of the other conditions.

Adult readers' use of the text-based dialogic reading tips was also examined. In both of the conditions that had text-based reading tips available, the reading tips were clicked quite infrequently (on less than 5% of the pages read). Comparing families who had reading experiences featuring Elmo modeling *and* text-based reading tips to those who only had the text-based tips, adult readers who had text-based tips alone clicked on the reading tips more often (tips clicked on 7% of the pages read) than those who also had Elmo modeling dialogic reading strategies (tips clicked on 2% of the pages). Comparing whether tips were ever clicked at all across the two conditions, a full 75% of the families with text-based tips alone clicked on the tips at least once, whereas only 20% of those who also had Elmo modeling ever clicked on the text-based tips at all.

4.3 Read with Me, Talk with Me

Results for *Read with Me, Talk with Me* are consistent across the two samples (Troseth et al. in press; Strouse et al. 2017). The number of parent and child utterances and words said during reading is 3–4 times greater for pairs reading the e-book with Ramone's dialogic questioning example than those reading the book without Ramone (see Fig. 3 for data from Troseth et al. in press). The number of parent and child unique words (an indication of language quality) is 2–3 times greater in the Ramone condition. During feedback interviews, some parents claim that they talk more often with print books, or that they would talk more if the e-book narration and Ramone did not automatically play. However, in the second study (Strouse et al. 2017) parent and child utterances, words, and unique words are all significantly higher in the condition with Ramone than in any of the comparison conditions (e-book with narration, e-book without narration, and the print book version).

The number of parent and child utterances focused on story content (as opposed to directing children's attention, talking about the device, or being off-topic) show a similar pattern: 3–5 times higher for the Ramone condition. Content-related talk in the condition with Ramone is 75–90% of talk for parents and children in the two samples.

Parent-child pairs spend about twice as long with the Ramone book as they do with the books in any of the comparison conditions. Despite the significantly longer time, children appear to have equivalently high attention and positive affect throughout the sessions.

Finally, there is some evidence that parents are adopting the dialogic questioning strategies modeled by Ramone in the books. Across the five pages at the end of the second book on which Ramone does not automatically appear with suggestions for questions, most parents very infrequently tapped the coffee cup to trigger Ramone,

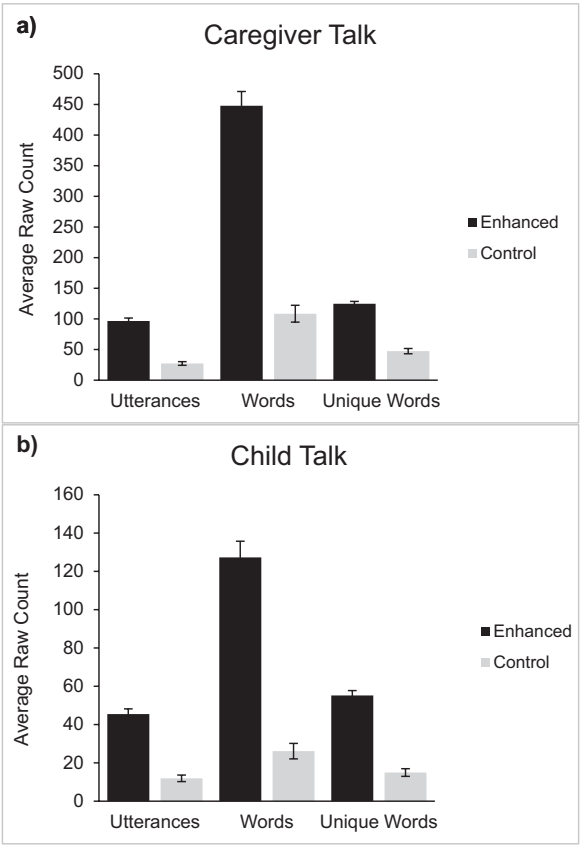

Fig. 3 Parent (**a**) and child (**b**) utterances, words, and unique words spoken while reading the enhanced e-book with the embedded dialogic questioner, or the control book, twice. Data from the sample of families of lower socioeconomic status. All condition differences were significant at the $p < .001$ level

asking their own questions instead. Parents of lower SES asked nearly ten original questions on average across the five pages (Troseth et al. in press). During the feedback sessions, parents commented that Ramone was helpful and gave them ideas about new types of questions they could ask, especially those that connected the book with their child's life.

4.4 iRead With

The results of research on the iRead With e-books are shown in Table 2. Specifically, Table 2 displays the mean (with standard deviation) number of adult comments per shared reading session as coded in each category, averaged across stories within book format. The results for the English language study (Rvachew et al. 2017) are shown on the left in Table 2 and the results for the French language study on the

Table 2 Mean adult comments during shared reading in the English and French schools

Number of adult comments	English language school					French language school				
	Paper book		iRead With			Paper book		iRead With		
	M	*(sd)*	*M*	*(sd)*	d_z	*M*	*(sd)*	*M*	*(sd)*	d_z
Rapport/behavior	14.01	13.33	18.02	11.78	0.35	26.92	17.82	28.21	15.16	0.06
Book mechanics	1.53	2.65	5.02	4.97	0.65	0.04	0.11	4.38	2.56	1.58
Story related	20.77	16.67	22.98	14.3	0.11	30.12	11.33	39.7	21.77	0.41
Word meanings	3.54	4.38	6.53	6.86	0.34	13.14	8.56	15.65	10.17	0.16
Print referencing	0.64	1.69	3.63	4.28	0.61	0.49	0.57	6.82	6.5	0.91

right. The effect size for paired values (d_z) is reported for each category of comments, indicating that the e-book had a large effect on the number of comments related to book mechanics and print referencing in both schools. Overall, the adult readers in the French-language school produced more comments in general in both book contexts compared to the adult readers in the English-language school: the greater number of story- and vocabulary-related comments and questions suggests a more sophisticated dialogic reading style by the adult readers in this school that was located in a middle-class community.

Although these overall results apply to both the English language study and the French language study, the effects are more pronounced in the latter study. The transcripts revealed that the French-speaking adult readers produced more complex questions about the stories and displayed a more sophisticated interactive reading style overall. For example, it was common for adult readers to ask "What did she do?" on the first page of *Caillou: What's That Funny Noise?* prompted by the animation of Mommy kissing Caillou. One English-speaking reader acknowledged the child's correct answer with, "Yeah, she just kissed Caillou," whereas a French-speaking reader followed up with a second question, "Elle l'a bisou, pourquoi?" *[Why did she kiss him?],* leading to a more extended conversation. This result is in line with the more elaborative style of highly educated parents that has been found in prior research (e.g., Hoff 2003a, b, 2006; Huttenlocher et al. 2010).

Given the obvious differences between the French and English-speaking readers with respect to the use of dialogic reading strategies, the similarity between these readers when it comes to print referencing is striking. There was less than one instance of print referencing per print book reading session for both the English speakers (M = .67) and the French speakers (M = .52). Both groups of readers significantly increased print referencing in the e-book condition and, once again, the effect was more striking for French speakers. A five-fold increase was observed for those reading in English (M = 3.41) and an 11-fold increase was seen for French readers (M = 6.23).

4.5 Dialogic Actress

Strouse et al. (2013) found that children whose parents were trained to ask dialogic questions during video storybooks had significantly better story comprehension and vocabulary learning than those whose parents directed their attention to story elements or were in the "watch as usual" control group. Children who saw the videos with the dialogic actress had scores on both comprehension and vocabulary outcomes that fell between these groups, not differing significantly from the results in any of the other conditions. (The sample size only had reasonable power to detect quite large effects.) It is possible that the dialogic actress better supported learning compared to the plain video storybooks, but was not equivalent to in-person parent questioning.

At the final lab visit (after 4 weeks of home viewing), parents and children watched one of the video stories in the lab and were told to act as they had done at home during the study. Recall that parents in the dialogic actress condition were instructed not to repeat back the actress's questions, but otherwise were not restricted in their behavior. Parents in the dialogic actress group made on average only 1.35 story-related comments during this viewing, the lowest of all conditions. However, children were quite interactive with the video, responding verbally to Miss Sue 63% of the time when she asked a question. All parents reported that their children responded to Miss Sue aloud at least some of the time when watching the videos at home. Strouse and colleagues hypothesized that some support for children's learning would occur through the cognitive aspects of thinking about and answering questions about the story, even when these questions were asked by an on-screen character. Based on children's responsiveness to the character, it seems promising to include a dialogic questioner in digital storybooks, even if this agent is not capable of providing feedback to children the way that parents can.

4.6 Summary: Results

Table 1 summarizes the common results across research studies from the four labs. In studies in which adults were asked to participate with the child and verbalizations were measured, there was more talk about book content with the e-books that incorporated scaffolds than those without. Across studies, reading sessions were also longer for the e-books that included these supports, and child attention and affect, when measured, was equivalent or higher with scaffolded than non-scaffolded books. The two studies that measured parents' tendency to trigger text tips found that parents did this rarely, and the one study that examined print referencing revealed that technology support for such behaviors was effective in increasing adult print referencing.

5 Discussion

5.1 Parent Training in Dialogic Strategies

Two of the studies provided explicit training in dialogic reading strategies and three did not. Summarizing across studies, the provision of explicit training did not seem to be necessary, as results were equally strong for those research conditions that simply provided modeling of dialogic reading in the e-book as for those that provided training videos. Studies of dialogic training have not worked as well with low-income groups as with higher SES groups, possibly because training and implementation are complicated and costly (Mol et al. 2008). Thus, having a way to introduce dialogic reading that is simpler than memorizing a complex scheme may be better. According to Hindman et al. (2016), "The success of interventions that aim to close the language stimulation gap rests largely on the degree to which they ultimately help families and educators talk more, using words that children will encounter in texts, in ways likely to help children learn" (p. 2). In the studies reported here, having a dialogic reading agent did this – it got parents and children talking much more about book content.

5.2 Print Referencing

One of the most striking results reported here was in Rvachew et al.'s (2017) study using the *iRead With* e-books that incorporated animations to draw attention to individual target words in the text, such as *noise, monster*, and *shadow*. Adult and child English speaking co-readers from a school in a low-income urban neighborhood exhibited a *five-fold* increase in print referencing compared with those who read a paper book. The results were even more striking in French-speaking readers from a school in a suburban middle-class neighborhood, with an *11-fold* increase in text referencing. Print referencing is an important pre-literacy skill for young readers to master. This result is in line with the general finding from Takacs et al.' (2015) meta-analysis that audio-visual supports (such as relevant animations) in e-books can support young children's literacy development.

5.3 Parasocial Relationships

Most of this work has been focused on existing media characters, to capitalize on the possibility that children's pre-existing parasocial relationships with the characters (e.g., Brunick et al. 2016) would make the on-screen character more effective in engaging children's attention and helping them learn. The authors had the advantage of working with highly developed and familiar media properties (Caillou, Peg

+ Cat, Sesame Street) and with experienced, professional children's media producers and writers to create character dialogue that was both authoritative and informative, yet entertaining and engaging. In the projects described here, children were highly engaged with popular media characters (e.g., Elmo), but children also engaged with and responded to a previously unfamiliar on-screen female adult seated in an armchair (Strouse et al. 2013). Some prior work has indicated that children are more likely to learn from familiar than unfamiliar characters (Lauricella et al. 2011), and also that children can become familiarized and learn from a previously unfamiliar character over a few months of exposure (Howard Gola et al. 2013). Thus, children's response to the female adult in Strouse and colleagues' study may have been supported by repeated exposure during the month-long study. It is also possible that children would have learned even more if the on-screen character had been a familiar favorite.

The likelihood of a character being effective in developing parasocial relationships with both children and adults may also rest on the attributes of character. Elmo is clearly a children's character, and some of the adults who used *Story Play* expressed a feeling of being in competition with Elmo for the child's attention. There may have been a perception that Elmo was there to interact with the child, causing him to be less effective as a model for adults to emulate. Ramone, on the other hand (a character in the Peg + Cat television series), is a young adult person of color, chosen to be accessible to an ethnically diverse audience. The fact that he is not a child character may help adults understand that the prompts he offers are 'for them' and not just between the character and the child.

5.4 Control of Character Scaffolding

Two of our research efforts investigated how the character's modeling of dialogic reading is triggered, whether it is automatically provided or can be requested by either the adult or the child when needed. Parents who read with Ramone reported they wanted more control over *when* and *if* the on-screen character provides prompts. Raffle et al. (2010) received similar feedback, which resulted in a modification to the software used in Raffle et al. (2011). In the first study, Elmo's comments or questions could be initiated by either the child or the adult. Based on user feedback, in the second study Elmo's comments/questions were only made when initiated by the adult co-reader. Although Raffle et al. (2011) did not report formal data regarding adult initiation of prompts, they informally observed that adults did initiate Elmo's prompts because the children enjoyed them so much, and the adults generated their own questions/comments as well. Similarly, when Ramone no longer appeared automatically (on the last five pages of the second version of the Peg + Cat book), parents either triggered Ramone or, more frequently, asked their own questions.

One concern is that, without substantial exposure to dialogic questioning, parents may not adopt the method. Most parents in all conditions of the *Read with Me, Talk with Me* research reported that they "sometimes" or "always" pause to ask questions/talk with children when reading, yet we observed low levels of parent-child talk in the conditions without Ramone's example. It will be important in future research to determine whether giving parents more control over the dialogic questioning model actually results in sufficient parent exposure to dialogic reading techniques.

5.5 Research Conducted in Lab Versus Home

In most of our studies, parents and children were observed in the context of a research laboratory. It is possible that in these contexts, parents talked more during reading than they would have at home, since they knew that they were being observed. We expect that parents may have been on their "best behavior." However, parents' best behavior differed across conditions. For example, parents who had Ramone's example (in *Read with Me, Talk with Me*) talked three or more times as much as those without Ramone. An important future direction for this research is investigating how parents use the product in a more naturalistic environment. In *StoryVisit* testing, parent language was not tracked, but parents and children spent more time with the books when Elmo provided scaffolds, offering indirect evidence that more discussion likely was taking place in this condition even without direct observation by researchers. In addition, parents in the *Dialogic Actress* study reported on a questionnaire how much they talked while their children watched the videos at home, and how much their children responded directly to Miss Sue. During videotaped observations in the lab, parent and child behavior seemed to match what parents had reported at home. Thus, there is some evidence that these products are effective when used in ecologically valid contexts.

6 Next Steps: Generalization of Strategies Learned

Among the important current and future directions for this line of research is determining whether the kinds of effects demonstrated here would be maintained over a longer time period and in different reading contexts. One of the most critical questions is whether adults will generalize the reading behaviors and strategies they learn with the kinds of technology supports used in these studies to their shared reading with traditional paper books or e-books without the technology supports.

Some initial evidence regarding generalization of strategies learned in e-books with technology support to reading contexts without the support comes from Rvachew et al.' (2017) comparison of adult-child pairs who read an e-book with technology support for dialogic reading strategies in Week 1 of their study and then

read a traditional paper book in Week 2. There was no evidence of carry-over of reading styles demonstrated with the e-book in the first week to reading behaviors with the paper book in the second week.

Revelle et al. (2017) examined the effects of children's and parents' shared reading of e-books with dialogic reading support. Lower- and middle-class families with 3-year-old children read e-books together on a mobile phone at a local library or preschool once a week for a period of 8 weeks. A randomized controlled trial design was used, in which half of the parent-child pairs read e-books featuring the Elmo character modeling dialogic reading, as previously described for the *Family Story Play* (Raffle et al. 2010) and *StoryVisit* (Raffle et al. 2011) projects. The other half of the families read the same e-books, but without the Elmo character modeling strategies. Parents received no training in dialogic reading strategies before engaging in the reading sessions. Before and after the 8-week e-book reading period, all parent-child pairs read print books together, enabling a pre-test versus post-test comparison of parents' and children's verbal interactions while reading together. All reading sessions were coded for parents' and children's dialogue, using the same coding categories described for the *Family Story Play* project (Raffle et al. 2010).

Preliminary results indicate that there were no significant differences in post-test (print book) levels of parent-child conversation about book content for the condition in which the Elmo character modeled dialogic reading strategies versus the no modeling condition. For both conditions, neither parent nor child verbalizations showed any significant pre-post change. A consideration of the differences between the conditions in this study versus previous studies reporting increased parent-child talk about book content with modeling reveals a number of potential factors that could have contributed. First, in contrast to the previous research of Revelle and colleagues, there was no dialogic reading training of parents involved. The research of the other co-authors here, however, involved no explicit training and still found significant effects. Second, this was the first study of those reviewed in this chapter that used a mobile phone (rather than a larger device) for shared reading. Perhaps it is more difficult for parent and child to engage in joint reading effectively on a small device. Finally, the fact that this was a "lab study" that required parents and children to come into a research space once a week for 8 weeks could have resulted in "fatigue" and/or boredom on the part of parents and children, which might inhibit their carrying on extended conversation in the post-test session. In the future, a home-based study using a larger device might look for clear evidence of generalization of learning from technology supported e-books.

7 Technology Support for Adult-Child Reading: Questions Raised

There are quite a few open questions about how to best design digital tools to support adult-child co-reading. The studies described here do not provide conclusive answers about whether a familiar character supports learning and engagement more

than a novel character, and whether the child-directed nature of a character like Elmo supports or distracts from parent-child talk. It is possible that a child-directed character is more engaging, but it may make parents feel as though they are interrupting communication between their child and the on-screen character. Similarly, we do not know whether story narration provided by the e-book is better than parent reading under some circumstances, such as when parents are first being exposed to dialogic questioning. Parents might like to control the pace of reading or pause in the middle of a page to talk, and thus feel interrupted by the narration. On the other hand, narration could support parents who are less confident about reading. Narration may be a feature that should be adaptable over repeated readings and for different readers. Finally, we do not know the optimal amount of scaffolding to provide to families, and at what point to give families control to turn off the questioner. Initial research suggests that parents do not often tap to trigger tips, so it may be important to ensure the questioner is on screen long enough to provide sufficient modeling for parents before the questioner becomes optional. In addition to optimal design, there are still questions about how tools such as these would work when deployed in real-world environments. We do not know whether parents who are not directed by researchers would opt to use products containing dialogic reading supports and for how long. We do not know if parents would talk as much without the knowledge that they were being observed by researchers. Additionally, the way these products work when used by parents who volunteer for research studies may not reflect how well they would work with parents who are not the type to volunteer for research. Troseth and Strouse plan a follow-up study using the e-book with Ramone that will address some of these concerns by giving families the opportunity to take the books home to read for 2 weeks, and recording them in this authentic environment, but participants will still be volunteers who will know they are part of a study.

Studies of long-term child outcomes are also needed. We have assumed that by increasing the amount and quality of children's language exposure, these experiences will also increase their vocabularies, as research has shown a strong link between these variables (Hart and Risley 1995; Hirsh-Pasek et al. 2015; Hoff 2003a, b, 2006; Rowe 2012; Weisleder and Fernald 2013). We do not yet know, however, whether the amount and type of language that these products promote is effective in changing child literacy outcomes.

Across these studies, there also are a few lessons learned. First, explicit training in dialogic reading strategies does not seem to be necessary to promote increased talk between parents and children, since simple modeling of these strategies by an on-screen character results in increased parent-child talk about the story. It also appears that parents and children enjoy these experiences – they opt to spend more time with books incorporating characters that question, and engagement and affect are equivalent or higher than for books without the characters. Thus, screen media incorporating characters who model questioning appear to be a good avenue for promoting children's language development.

The "word gap" in children's exposure to language, related to having fewer family resources and less parent education, has been described as a *disparity in oppor-*

tunities to learn language (Carter and Welner 2013). Recent research documents variability in language environment even for children with socioeconomic advantages, some of whom are offered much less opportunity than their peers to learn language (Gilkerson et al. 2017). Developing digital tools that support and encourage parents and children to ask and answer questions in dialogue about a story shows promise as one way to bridge these gaps.

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Part III
e-Books and Literacy Practices in Schools

Digital Reading Programs: Definitions, Analytic Tools and Practice Examples

Jeremy Brueck, Lisa A. Lenhart, and Kathleen A. Roskos

Abstract Access to a growing number of digital reading platforms containing large e-book collections is changing the landscape of independent reading in schools. This chapter provides an overview of digital reading programs and offers insight into available tools that can be used to evaluate digital book design, focusing on the structural qualities of e-book programs that may offer affordances to beginning readers beyond traditional print books. The authors discuss tools to evaluate digital reading programs at four levels: the program level, the book level, the individual screen page level, and the dashboard analytics offered in the program. In addition to best practice examples, the authors also offer guidance about how classroom teachers can use the tremendous efficiency of digital reading platforms to more actively promote the longstanding principle of learning by doing in the act of reading – helping students to focus on practicing the essential skills they need to read and to read with enjoyment.

Keywords Learning platforms · e-Books · Curriculum evaluation · Independent reading · Data analytics · Data dashboards

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J. E. Kim, B. Hassinger-Das (eds.), *Reading in the Digital Age: Young Children's Experiences with E-books*, Literacy Studies 18,
https://doi.org/10.1007/978-3-030-20077-0_8

Time was when independent reading at school was all about print books housed in classroom collections and school libraries. Who among us does not remember those colorful book displays inviting you into the cozy corner library for a quiet "read"?

The long-held dominance of the print book for independent reading, however, is rapidly changing in a digital age. Access to a growing number of digital reading platforms containing large e-book collections is changing the landscape of independent reading in schools. It is widening opportunity for students to practice reading anytime, anywhere using mobile devices, and it is generating mounds of data about their *actual* reading – how much, how fast, how sustainably, how well.

In this chapter, we discuss elementary grade digital reading platforms and how they are transforming independent reading practice at school. We first define this new technology for reading – its mechanisms and how it works – and then we describe how digital books are expanding the relationship between reader and book. A digital book, for example, can be much more interactive than its print twin. Next, we explore the qualities of digital reading platforms and analytic tools, and the platform potential, as well as pitfalls, for supporting and even advancing readers' motivation and skills. New personalized learning technology integrated into these digital learning platforms, for instance, assesses where a student is strong in a specific content and where improvement is needed. The technology then uses that information to focus learning/tools/opportunities on the areas where a student may need to spend more time. Reader experience, in brief, is increasingly quantified. We conclude with a few "close ups" of platform implementation at the classroom level. From this perspective, we speculate about engaging readers in the digital age and the new insights we might gain from the actual reading that they do.

1 Digital Reading Platforms Defined

At a cursory glance, most people would identify curricular resources like Storia, Raz Kids, Epic!, myOn Reader, Tumble Tracker and other similar services as children's e-book collections, and they would be correct. However, upon closer inspection, the children's e-book collection represents only a portion of the services and features that digital reading platforms provide. Digital reading platforms are software as a service (SaaS) which enables children and adults to read, write, communicate and interact with electronic text. Beyond that, these platforms provide a comprehensive web and mobile interface to license and deliver content to districts, schools, teachers, parents and students anywhere at any time.

A learning management system (LMS) is the backbone of the digital reading platform and is used to deliver, manage, assess, and record learning and progress via the Web. An LMS is the technology framework that administers and transmits instructional content, identifies and assesses user learning goals, records user advancement towards achieving those goals, and collects data and displays reports related to the learning process of not only users but an organization (Szabo and Flesher 2002). Digital reading platforms leverage the affordances of an LMS to

deliver content, handle registration and administration, and provide skills gap analysis, tracking and reporting (Gilhooly 2001). Let's take a look at some common features found in many of the digital reading platforms on the market.

Communication Features Almost two-thirds of Americans own a smartphone with 97% of them reporting that they text weekly (Pew Research Center 2015). As asynchronous communication becomes commonplace, it's not surprising that digital reading platforms have adopted features common to SMS (Short Message Service) text messaging. Messaging and notifications systems between learners and teachers common to digital reading platforms include chat, discussion forums, email and blogs.

Content Features The heart of any digital reading platform is its instructional content. The primary material in each platform is an e-book catalogue containing hundreds to thousands of titles. Like any good classroom library, titles are composed of both narrative and informational texts. Many digital reading platforms allow searching and browsing of their catalogues by common delineators such as, title, author, genre, subject and in many cases, reading level. Many platforms include assessment mechanisms such as embedded quizzes and diagnostic features, which can identify a student's reading level and then provide recommendations for just-right reading selections.

The e-books in each catalogue have traditional conventions like a title, pages, and chapters. However, they also can contain illustrations and hotspots that provide a navigation mechanism for the reader. A deeper look at children's e-books reveals a more complex form, a type of software that includes animations, sounds, videos, and often a read-aloud function. Compared to their print counterparts, e-books are portable, facilitating the easy transport of sizeable libraries with little physical effort. The mobility of a digital reading platform allows e-books to be used in any place at any time via handheld or mobile devices. This portability provides learners with knowledge building that had been limited to what was physically portable (Felvegi and Matthew 2012; Godwin-Jones 2007).

e-Books provide scaffolding through narrations, animations and interactive media, which support young children who are developing emergent literacy skills. Common scaffolds include searching capacity, hyperlinks, audio and visual enhancements, and in some cases, hot-spot pop-up definitions for words. For users with learning difficulties or disabilities, e-books offer text-to-speech capabilities and print highlighting, as well as allowing changes in font size, features that are not possible in print books. Early readers and students with learning disabilities can benefit from the use of e-books due to the ability to explore literature with digital scaffolding supports. The digital scaffolds found in e-books provide additional opportunities for independent practice and interactive exploration of a text, available even when an adult is not present to read with a child.

Administration Features While digital reading platforms provide a means for easy access by students and teachers, there is still work to be done behind the scenes to ensure continuous access for all users. Most platforms provide onboarding services

to assist districts and schools with initial set-up. Some platforms even integrate with common student information systems (SIS) to enable easy upload of student, teacher, and school data. Once initial system setup has been accomplished, there will still be a need for a designated administrator to monitor and maintain the platform. Most often, this administrator is an individual in the IT department who possesses a familiarity with web-based systems. Once logged in, the administrative interface will provide the system administrator with the tools to manage content, add and remove users, assign roles, and allow users access to specific areas of the digital reading platform, so that they can change settings.

Like the streaming media services such as Netflix, Spotify, Apple Music, etc., digital reading platforms (DRP) are cloud-based applications. Subscribers can access the DRP via a standard web browser using a desktop, laptop, tablet or Chromebook. In most cases, the platform provider also offers a mobile app or mobile optimized website to enhance access from a variety of mobile devices. Mobile technologies can enable learning "anytime and anyplace," offering ongoing learning opportunities that are individualized and related to learner context and interests (Traxler 2007).

User function of the digital reading platform is centralized at a learning dashboard. Most often, these learning dashboards encapsulate and provide a visual interpretation of learning behaviors, as a means to encourage awareness, reflection and metacognition (Verbert et al. 2014). The primary function of the dashboard is to assist learners in defining goals as well as tracking advancement towards those goals. Results of the analysis by Verbert et al. (2014) indicate that commonly found components of learning dashboards include "artefacts produced, time spent, social interaction, resource use and exercise and test results" (p. 1508).

Student View Upon logging in as a student, the user is taken to their learning dashboard, a personalized portal that provides updates, analytics and communication. Students can search e-book titles and genres, add them to a personal bookshelf and view bookshelves built and shared by their teacher. In some digital reading platforms, students can browse recommended e-book titles that represent a sampling of "just-right picks" that are aligned with their reading interests. Reading goals and awards are also part of the dashboard, intended to encourage and challenge the reader. These goals can be set by either the reader or by the teacher. Most often, some type of meter is present to help the student self-monitor their progress towards the goal. Once a student selects an e-book and begins reading, the digital reading platform tracks progress, provides feedback and assesses student progress and understanding through a short comprehension quiz or a benchmark assessment.

Teacher View Similar to the student view, when a teacher logs in to the DRP, they are taken to a dashboard. The teacher dashboard provides access to view and search the DRP e-book and resource catalogue, enables curation of custom e-book collections, facilitates assignment of e-book collections and titles to individual students, groups and classes, as well as provides access to reports and associated learning analytics. According to Long and Siemens (2011), learning analytics is

"the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and environments in which it occurs" (p. 34). In practice, learning analytics monitor and track the variety of digital touches related to the learning setting (Economides 2009). They also work to decipher, chart and organize the state of these data in real-time, so that teacher and learner might utilize these data for feedback and recommendations that guide the learner (Papamitsiou and Economides 2016). A meta-analysis conducted by Papamitsiou and Economides (2016) indicated that learning analytics can assist teachers in pinpointing which activities "lead to effective student interactions" (p. 16).

There are many benefits to digital reading platforms. First and foremost, these platforms help to organize reading content into one location. When purchased at the district or school level, this ensures that all students have access to and choice of instructional content that is aligned to curricular goals and standards. When districts and schools make the decision to onboard a digital reading platform, the investment assists in keeping school and classroom libraries up-to-date with new literature, as most digital reading platforms add e-book titles and associated instructional resources in an ongoing manner.

Additionally, the digital reading platform provides anytime, anywhere access to data, e-books, resources and materials for students, teachers and families. In some cases, digital materials can be synced to individual devices, providing offline access for students who may not have wireless internet on the bus, in the car or at home. Digital reading platforms also provide a central repository that can easily track learner progress and performance.

While schools are increasingly leveraging the benefits afforded by anytime, anyplace access to mobile technologies, it is incumbent upon educators to avoid the tunnel vision that can accompany ubiquitous access. There is still a need to provide a balance of both digital and print resources so that students recognize that reading exists outside of the platform, whether it is through print books, magazines or newspapers. Equally important, students need to realize the joy of reading for pleasure, not simply reading for the purposes of assessment, tracking and progress.

2 Digital Reading Platforms Under the Lens

The recent surge in cloud-based e-book collections has renewed interest in the role of reading practice in students' reading development and achievement. Most educators believe that time for reading practice at school is valuable and important for overall reading growth (Scholastic Survey 2017). Allocating precious instructional time for reading practice at school, however, remains problematic. In the wake of the National Reading Panel Report (2000), which found no experimental evidence to support school-based sustained silent reading, post-NRP studies (Miller and Moss 2013) show the benefits of independent reading practice for younger students'

reading growth as long as certain conditions are met, namely sufficient time to read, choice, volume, access to a variety of texts, and active teacher participation (e.g., scaffolding). Implementing *what works,* however, is ambitious practice and can easily lose energy in the face of competing instructional demands on a daily basis. The most recent Scholastic survey of reading in school (Scholastic 2017), for example, reports that while 77% of teachers set aside time for independent reading practice, only about 36% do so every day. A full 90% of teachers surveyed cited demands of the literacy curriculum as the primary barrier from implementing independent reading practice consistently.

On the horizon, digital reading platforms offer an innovative solution to this problem of practice (Roskos et al. 2017a). Online e-book libraries provide immediate access to a broad range of leveled, mixed genre texts that can be accessed anytime anywhere; they offer instructional supports (e.g., comprehension checks) that augment or replace direct teacher participation; they increase student control for making choices, goal setting and monitoring reading activity, and they provide instant, actionable data of reading performance for students, parents and teachers. Digital reading platforms, in brief, make independent reading as a routine part of the language arts easier for teachers to implement and more inviting for students to do.

The importance of independent reading for reading achievement cannot be underestimated. Reading a lot contributes to reading development and knowledge acquisition. As Stanovich (1986) observed and considerable research has confirmed (Anderson et al. 1988; Cunningham and Stanovich 2001; Miller and Moss 2013), increases in reading lead to increases in reading skills (and more word comprehension) that in turn fuel more reading to create a growth-producing cycle. Similarly, reading leads to knowledge, which stimulates more reading that in turn generates more knowledge which makes learning easier (Willingham 2006).

According to the most recent Renaissance study (2017), girls continue to outpace boys in reading volume. On average, girls read 705,627 more words than boys by the end of high school. Girls read about 3.7 million words between kindergarten and senior year – 23% more than boys, who encounter just over 3 million. Over half of students (54%) practice reading less than 15 min per day and are exposed to about 1.5 million words by the end of high school whereas those who spend more 30 min per day (18%) are exposed to 13.7 million words over the course of their schooling, a difference of more than 12 million words. High quality daily reading practice can help struggling readers catch up to their higher achieving peers when implemented in conjunction with high quality instruction (Biancarosa and Snow 2006; Gersten et al. 2008). Students continue to prefer fiction to non-fiction books: nonfiction materials represent less than a third of all students' reading, which is disappointing given the emphasis on nonfiction texts in the Common Core Standards (CCS). Books on STEM topics are only 9% of all books read, although slightly more than half of all students surveyed read at least one STEM book.

Although less is known about elementary grade students' digital reading behaviors and habits, a few patterns are emerging (Evans this volume). The 2012 National Literacy Trust survey results showed students' increasing preference for digital over print book reading (68% of children) with boys showing a stronger preference over

girls (Clark 2013). Similarly, the 2012 Scholastic survey showed increasing preference for reading on screen (from 25% to 46% between 2010 and 2012) with reported positive effects on motivation to read (49%) (Scholastic 2012). According to the National Literacy Trust survey, non-fiction reading was more prevalent on computers and smartphones while fiction reading was more popular on e-readers and tablets. Digital reading appears especially motivating for below average students with privacy as one of the top reasons given as to why they enjoyed reading on screen (Miranda et al. 2011). In terms of reading development, results are mixed with some studies showing that digital reading negatively impacts deep reading skills of older readers (e.g., critical reading) (Mangen 2008; Wästlund et al. 2004), while others find that reading animated digital storybooks supports comprehension and vocabulary in young children (e.g.,Bus et al. 2009). Cuevas et al. (2012) demonstrated the effects of an independent silent reading program with digital and print books on high school students' reading comprehension and motivation. Results showed the benefits of reading practice for increasing comprehension skills, and the superiority of digital reading for increasing motivation to read.

While independent reading time at school with print books has been relatively well researched (Miller and Moss 2013; Shanahan 2014; Stahl 2014), few studies have examined the logistics and impact of independent digital reading (IDR) from digital book collections. Using a mixed-methods approach, Barnyak and McNelly (2016), for example, compared outcomes of primary graders' independent reading between e-books and print books on vocabulary, comprehension and motivation in a Title 1 summer reading program. Students expressed a preference for reading e-books, however results indicated that their preference did not significantly impact targeted reading variables when compared to peers reading trade books. The critical role of adult scaffolding in supporting reading practice, whether e-book or trade book, was a key finding of the study, pointing to the importance of well-managed independent reading for fostering growth in the school setting.

Relatedly, Jones and Brown (2011) found a student preference for e-books among third graders who enjoyed the wide selection of titles and freedom to choose their own e-book; they also liked the amenities of e-book reading, i.e., pop-up definitions, word pronunciation, and the narration option, among others. Comparing reading engagement between e-books and print books, they found that format (e-book vs. print) was not as critical to engagement as students' identification with setting, characters, and theme of the book. Some studies, though, indicate that the increased self-control that e-books afford has a strong bearing on reading engagement (Calvert et al. 2005).

Our own studies of independent digital reading in a K-5 urban school site provide several descriptive observations as a case example (Roskos et al. 2015, 2016, 2017b). Our findings reveal the variability in reading frequency across classrooms, perhaps reflecting teacher more so than student preference for digital or print book reading titles. Students in G2, for example, tended to read digital books more often than students in G3 over time, and those in G4 more than their peers in G5. In classrooms where digital reading platforms are accessed routinely during independent reading time, students' digital reading minutes range from an average of 30–70% of

the total time spent in reading practice at school. Students at some grade levels indicated a preference for one digital reading platform over another, although reasons for their preferences were not reported. Trend analyses over 2 years showed no gender differences in independent digital reading or effects on either essential reading skills or motivation. A significant correlation was found, however, between digital reading frequency and beginning of year reading skills, indicating that those students who had better reading skills to begin with tend to read digital materials more. In brief, the 2-year trend analysis points to an emerging (and worrisome) Matthew Effect in digital reading frequency of elementary grade students at this school site.

All in all, even as the research base is growing, we still know relatively little about digital reading practice at school – its frequency, conditions and outcomes. While it is quite clear that digital innovation is changing the landscape of reading pedagogy, the impact of first generation digital curriculum products on students' reading development is far less clear (Bird 2011; Loewus and Molnar 2017). Few studies have critically examined digital reading platforms as an integral part of the literacy curriculum or features of student engagement in digital reading at school. (See, for example, Meyers et al. 2017).

At scale, we cannot expect reading educators and teachers to both evaluate and effectively implement digital reading platforms on a daily basis. The task of reviewing and rating electronic reading materials in a burgeoning digital marketplace is a serious challenge. Yet, for many educators, a fundamental question remains: *how do I know if this digital reading platform is of sufficient quality for implementation at school on a regular basis?*

To address this question, reliable and valid tools for evaluating digital reading platforms are needed. While early steps have been taken to vet e-book titles by expert groups (http://childrenstech.com), methodologies for assessing and evaluating the quality of platforms that offer these books, either singly or in collections, lack scientific rigor (Hirsh-Pasek et al. 2015). Development of reliable, valid tools for practical use is becoming more urgent in a rapidly changing digital book marketplace. A good tool should be theory-driven, iteratively tested, applied in authentic settings and include clear procedures for practical use (Desrochers and Glickman 2009; Wiggins 1998). To this purpose, we are in the process of designing and testing prototype tools for examining qualities of digital reading platforms.

Platform Profile Tool Although increasingly important as a means of information exchange in education, learning platforms are often inconsistently described and lack operational definition, which limits critical appraisal of what they have to offer (Alkhattabi et al. 2010). Drawing on the available literature (Pop 2012; Sarrab et al. 2015), we culled six descriptive categories of platform system quality and related features that provide a beginning framework for assessing platform affordances, i.e., the possibilities they offer for information exchange among users. These are summarized in Table 1.

While limited in scope, a major strength of the platform profile tool is the identification of clear definitional categories and representative features that provide an

Table 1 Categories and features for assessment of platforms

Category	Definition	Feature
Functionality	*Useful to educational purpose; graphical design that reflects effective layout and visual hierarchy (scale, borders, orientation, fonts, shading); allows for integrative functioning*	Navigation structure
		Site map
		Search function
		Menus
Communication	*Supports various communication types (user to user; user to device; synchronous-asynchronous)*	Email
		Forum
		Chat
		Blog
Accessibility	*Describes user status (free, payment, mixed); meets user specific needs; supports mobility; supports different languages*	Status
		Multilingual content
		Plug-ins
Content	*Useful, suitable to meet educational objectives; flexible, simple and self-explanatory; mobile*	Instructional resources
		Dashboard analytics
Administration	*Quick and easy to set up; reconfigurable; easy to upgrade; accurate consistent operation; customizable*	User accounts
		System settings
		Management
		Maintenance
Tools	*Efficient performance; dependable; provides different functionality layers (e.g., integration with other systems); cloud-based preferred*	Standard Browsers
		Friendly user interface
		Processing speed

analytic framework. An obvious weakness is the lack of criteria for quality rating the features of categories beyond whether they are present or not. Thus, at this stage of development, the tool is limited in its ability to assess the quality of a platform, although it can reveal what it does or does not contain in key user categories.

e-Book Quality Rating Tool (EQRT) The purpose of the EQRT is to assess the digital design of an e-book in three basic categories: (a) ease of use; (b) multimedia; and (c) interaction (See Appendix). The tool assesses a total of 18 design items across these categories that are each rated for presence (0/1) and quality on a 3-point scale (very good; adequate; poor). The categories and items are grounded in the substantial knowledge base related to instructional design of e-learning environments, and in particular electronic books (Clark and Mayer 2003; deJong and Bus 2003; Korat and Shamir 2008; McKenna and Zucker 2009).

The tool itself has gone through several iterations and field studies that have refined and specified its coding categories and criteria (Brueck et al. 2011; Brueck and Salem 2017; Roskos and Brueck 2009; Roskos et al. 2009, 2016, 2017a).

The most recent version of the tool further details coding guidance to improve its interrater reliability (k = 1.0 for item presence; .83–.90 for item quality) and adds a rating for overall appeal of the e-book to the reader.

The EQRT is a practical tool for assessing the basic design qualities of a digital book. A major strength is its manageable framework consisting of evidence-based categories and items for examining the digital design of the e-book, per se. Its technical adequacy is improving in terms of reliability and usability; however, its scope, or ability to rate e-book literary quality, and validity remain weak. Still, the tool fills a large gap in the availability of "tested" tools for assessing e-book qualities.

Screen Page Functionality Tool Our intention with this tool is to gauge the extent to which functions at the screen page support readers' skills and align reader-text interactions with expected outcomes as defined by standards--in our case the Common Core Standards-Reading, or CCR. We are in the early stages of developing and testing this tool. Preliminary results suggest that the tool may help to reveal *patterns of reader-text interaction* at word and comprehension levels.

A bit of background to aid understanding the tool's format: Screen page functions are enhancements (digital asset assemblies) that offer reader supports. Highlighting, for example, is a function that draws a reader's attention to a printed word using enhancements such as color and audio narration. The CCR standards consist of 10 anchor standards as well as K-12 grade specific standards that represent major domains of reading skill: *Key Ideas and Details* (CCR 1-3); *Craft and Structure* (CCR 4-6); *Integration of Knowledge and Ideas* (CCR7-9); *Range of Reading and Level of Text Complexity* (CCR 10).

Drawing on the e-book architecture literature (http://e-bookarchitects.com/learn-about-e-books/enhanced-e-books/), we created a prototype tool to test for feasibility, and then based on this information to refine it for future testing of technical adequacy and usability in our research work. The original version of the tool proved helpful in detecting patterns of reader-text interactions at the screen page level on two digital reading platform samples, but it still lacked clarity in coding the alignment between function and reading skill domain, as well as simplicity for ease of use (Roskos et al. 2017a, b). We since modified the tool and are engaged in testing it across a larger sample of digital reading platforms (See Fig. 1). Our goal is to establish acceptable interrater reliability and content validity for research purposes.

This figure illustrates the screen page enhancements, expected outcomes and coding guidance present in the Screen Page Functionality Tool.

Dashboard Analytics Tool Similar to other components of digital reading platforms, there are few tools available for assessing and evaluating the quality of a program's dashboard for purposes of reading motivation and instruction. Drawing on instructional design industry criteria (e.g., Kulisek 2008) and research on learning dashboard design (Verbert et al. 2014), we again developed a prototype tool and conducted some preliminary testing of its feasibility.

Source: **Title:** **Page:**	**Date:** **Rater:** **Directions: Mark +/- if alignment present/not present**			
Function *enhancements*	CCR Skill Domains			
	Key ideas & details (CCR1-3)	Craft & structure (CCR4-6)	Integration of knowledge & ideas (CCR7-9)	Range of reading & level of text complexity (CCR10)
Narration				
Narration text highlighting				
Region/text magnification				
Embedded audio/video				
Background music				
Animations				
Interactive elements (dictionary; journal; game)				

Coding Key The function aligns most closely to...*(select domain where 2 or more elements are present)*	
Key Ideas & Details	reading closely (what the text says explicity)
	determining central ideas
	inferencing about interactions between sentences & passages
Craft & Structure	interpreting words & phrases
	analyzing text structure
	assessing author's point of view or purpose
Integration of Knowledge & Ideas	integrating & evaluating content
	delineating;evaluating arguments & claims
	analyzing how two or more texts address similar themes
Range of Reading & Level of Text Complexity	reading & comprehending independently & proficiently

Fig. 1 Screen page functionality tool

At the outset, we recognized that dashboards differ from one platform to another with some more complex than others. But, we noted, all are built around what might be termed *quantifying the reader*, i.e., tracking frequencies of individual reading behaviors, activity and habits by providing metrics to aggregate activity and/or visualize information, and to share with others. To what end, we next asked, and noted at least two purposes of these metrics: feedback to the reading self and feedback to interested adults (teachers and parents). In both instances, the feedback stimulates awareness, analysis, reflection and comparison to others.

With these goals in mind we created a flexible tool that organizes basic dashboard metrics into five categories: (i) time spent; (ii) activity produced (e.g., titles read); (iii) resources used; (iv) test results and (v) social interaction (Verbert et al. 2014). Given the underlying monitoring function of a dashboard, metrics are linked to key criteria of personalized learning: (i) *self-awareness* defined as analytics to develop conscious knowledge of one's own reading habits (e.g., time spent); (ii) *skill building* defined as analytics that report the exercise of reading skills (e.g., listening to develop oral language); and (iii) *learning progress* defined as data displays that help students (and adults) track their developing reading skills and that motivate them. The tool's flexibility allows for "plugging in" metrics specific to a digital reading platform's dashboard for analysis (e.g., minutes, books started, books completed, words looked up, games played, incentives, etc.). (See sample in Table 2).

Table 2 Dashboard analytics tool

Category	Metrics	Reading development		
		Self-awareness	Skill building	Progress
Time spent	Minutes			
Activity produced	Books started			
	Books listened to			
	Books completed			
Resource use	Words looked up			
	Recordings made			
	Games played			
Assessment results	Assessments completed			
	Incentive points earned			
Social interaction	Posts (*tweets, emails, blog entries*)			
	Post responses			
	Help requests			
	Flags/alerts			

Although in an early stage of development, the strengths of the tool are twofold: (a) it provides a potential framework for examining a reading platform's dashboard and (b) it is flexible in that it could accommodate the dashboard features of a specific platform. Clarity of definitions and terms, however, still need to be ironed-out to ensure reliability in linking a specific metric to a focal area of reading development – an area of technical adequacy we are presently working on.

3 Best Practice Examples of Digital Reading Platforms in Action

In this section, we present two separate school districts and how they make use of digital reading platforms in practice. Both are embedding digital reading albeit in differing ways. In Box 1 we see a first-grade classroom using iPads as the main learning tool. Students use the tool for independent reading and the teacher uses it with small groups of children. In Box 2 a third-grade teacher also uses a digital platform, but in a different way. Students in this school rotate into a bank of computers during center time to access personal libraries selected by the teacher.

Integrating digital reading platforms into day-to-day practice builds on what we know about effective reading practice in school, but also requires some new thinking and activities that ensure time spent is worthwhile. Just as Big Books and Read Alouds are often placed in the classroom's library corner for children to read and enjoy on their own, new e-book suggestions and old favorites can be highlighted on digital reading platforms and available on a range of devices that children have learned to use with care for their own reading pleasure. Comfortable space for

e-book reading in the traditional classroom library corner is a necessity. Teachers can encourage children to book browse and read familiar selections using digital reading platforms and at the same time practice using digital features and scaffolds embedded in e-books to exercise reading skills. Independent e-book reading via digital reading platforms does not always need to be a solo event. Children should be encouraged to share what they are reading with peers – which not only develops reading skills but also important social skills of collaboration and cooperation. Children can learn to share what they are learning from an e-book with one another, either face-to-face or by using the communication tools found within the platform.

As teachers begin to incorporate digital reading platforms in the classroom, a thoughtful and patient approach is essential to success. Teachers need to become comfortable with the e-books and the associated digital features found in the e-books themselves (hotspots and virtual assistants) before they can begin to leverage the electronic capabilities of e-books to help teach early literacy skills. Once an adequate teacher comfort level has been established, it is important to show the children how to navigate apps and e-books effectively. Once a hand over strategy has been successfully implemented, teachers should encourage lots of e-book browsing and sharing. As a part of this encouragement, teachers should be sure to make children aware that the digital reading platform can help them select a "just-right" book on their reading level and catered to their reading interests. Ongoing dialogue between student and teacher around the many features and affordances of the digital reading platform is critical to building independent e-book reading skills in the classroom.

While teachers can and should build on the knowledge they have regarding effective literacy instruction, we still have much to learn about how to use digital reading programs effectively and efficiently – and how to use all the data they provide (which can become overwhelming) in productive, meaningful ways with students.

Box 1: Independent Digital Reading in First Grade

Background: At this elementary school, IDR is an adaptation of the traditional sustained silent reading approach (SSR), which promotes a period of time set aside daily for students' independent reading of self-selected books (Sanden 2014). It is routine in the language arts block and consists of 15 min of independent reading daily in digital books at the upper limits of the reader's Lexile range followed by 5 min of teacher-led sharing/summarizing of personal reading by students either with the whole class or in small groups/pairs.

With teacher assistance and support, students select texts from one of two platforms that are available on their personal iPad devices (screen page icons allow easy access). Students read e-books and complete online comprehension/quiz checks within the 15 min of independent reading. e-Book selection, number of books read, minutes spent reading, words looked up and comprehension checks are logged on personal dashboards that are both student and adult-monitored (teacher; parent).

(continued)

Box 1 (continued)

Close Up: Energy is high as first graders head over to the iPad cart for their personal iPad, which along with paper and pencils will be their primary learning tool for the day. The teaching team – lead teacher, assistant and intervention specialist – readies for the daily language arts lessons that blends print and digital resources. "Great job logging in and locating the app," as students get ready for reading.

The lead teacher projects the cover of a multi-leveled digital book from her iPad to the smart board. "So, my friends, what do you think we are going to read about in this book", she asks. The students offer up several predictions that the assistant jots on the smart board. "Bravo, superstars, we are ready to read. Remember to *use your word reading strategies*, try to *chunk words you don't know* and *use your finger below each word as you read.* Now, please go to the icon on your iPads, log in and begin reading our selection for today. You will see it in your personal digital library."

Without hesitation, small groups of students swipe right, log in and within 30 s are reading the text at their instructional reading level. The team listens in as each child reads aloud (using an inside voice) and uses a finger to track print. Students are encouraged to use decoding strategies for unknown words and if they get stuck to *tap the word to hear it*. All around, students are double tapping, swiping, holding to underline or highlight words, and tapping a word if their problem-solving strategy faltered. The students' engagement and attention to print is impressive!

After reading the students gather in small groups around a teacher and discuss their respective texts. They ask and answer questions, look back to check for accuracy, discuss some BIG words (like *devour*), and connect the text to others they have read and of course their own experience. All agree it was a good "read," as they return to their desks to complete a graphic organizer of story elements (a story map), using an old favorite app Doodle Buddy. "Remember to *save your work* in the gallery on the app," the team reminds their small groups. As the students settle down to work, a first grader whispers to her friend, "Mimi, I have more doodles than you do." "I know," her friend sighs as the two are huddled over their iPads, "but I'm a gooder doodler."

Best Practice Highlights: What makes this an example of best practice? Uppermost, perhaps, is the investment of time to independently read digital books on a routine basis. Time spent in reading practice builds reading stamina as well as the habit of reading. A close second is the easy access to a broad range of book titles, which allows teachers to model book selection at an early age and to encourage wide reading across genres. And third, threaded through both time and access, is active teacher participation that supports student engagement and lots of talk around texts – even for a few minutes. Peer and small group conversations contribute to important speaking and listening skills that foster sharing and critical thinking and that ignite the desire to read more books.

Box 2: Digital Reading in a Learning Center for 3rd Graders

Background: Digital reading takes place in this classroom during centers, which is when teachers offer various, distinct opportunities for learning at individually appropriate levels (Copple and Bredekamp 2006; Epstein 2007). During the language arts block children rotate four times, spending 20 min at three different centers and then a guided reading small group session led by the teacher. One rotation is for digital reading at one of the 5 computers in the classroom. Each child has a personal library of books selected by the teacher on their independent guided reading/DRA level. To take part in the digital reading center, students log into their online library to read or listen to books, take quizzes, or read the book into their microphone in order for the teacher to take a running record at a later time. The running record can be scored right online and be downloaded or printed. The dashboard also provides information on comprehension quizzes the students take periodically, highlighting areas of strength and need. Status of each student's library is also visible, and the teacher uses it to note progress within each level as the child works through her library.

On the last Monday of each month, the teacher assigns a book that is on the expected end of third grade reading level to every child. For example, at the end of third grade this school expects students to read at a guided reading level of "N" by the end of November. In this way, the teacher can get a sense if a child is below, at, or above what a typical third grade reader looks like at each point in the school year.

Close Up: Using his smart board, the teacher sets the timer for 20 min and then counts down from 10 to 1 out loud. The students know that by the time he gets to 1, they should be settled into their first center. "5, 4, 3", "Let's go. You should be at your center now and ready to get started. 2, 1 Ok. Everyone is ready to work. Good job." He then heads over to the small group table to meet with a group. The digital platform provides the ability to look at different reports to determine areas of both strengths and needs. Using the skills report, he noticed that after quizzes on books read independently, the calculated percentages show that some of their lowest skills were in recalling information. This is his lesson for this group today.

Meanwhile, a different group of students are settled at the computers and reading from their teacher-selected library. Some students read messages left by the teacher. One third grader sees, upon logging in, that her teacher has left a message, "I noticed that on your last two quizzes you missed more questions than you got correct. Please reread the last two books and take the quizzes again." Another student is pleased to see this note from the teacher, "Great work! I noticed you improved on your quizzes last week! Here are three bonus stars for your hard work!" The student smiles because she knows she now has enough stars to buy an alien for her rocket ship in the online store. Students are reading and earning stars for every task completed. These stars can be saved or spent in the online store where they can build a virtual space rocket.

(continued)

Box 2 (continued)
With stars they can decorate, add aliens, buy equipment, etc. The more stars they earn, the higher they rank and more (and much cooler) objects to buy are unlocked.

Best Practice Highlights. The intervention specialist sits down next to a student at the computer center who is in need of additional Tier 1 instruction. She's noticed that hearing the story first diminishes some anxiety for this struggling reader, allowing him time to think about the meaning of the passage. "Remember to listen first, then answer the questions." By meeting with him one-on-one, she is able to support him in this online environment and increase his use of online reading of text. She then moves to a new student whose native language is Spanish. Since she is having difficulty with the language, the teacher shows the student how to use the audio support for the Spanish books and quizzes and then adds some Spanish books to the student's library.

4 Where to Go From Here

Digital reading programs are expanding rapidly into the elementary school curriculum, bringing with them increasing opportunity for reading experience attuned to each student's needs. This long sought-after vision of reading practice at school is about to be realized at an unprecedented level, fueled by the ability to capture and store nearly everything about reading behaviors from time on a page to proclivities and preferences, thus giving rise not only to personalized reading, but also vast amounts of data about independent reading as a reading act. Digital reading programs, in truth, automate independent reading activity to a new degree of efficiency in the classroom. They take over many of the time-consuming teacher tasks of developing, organizing, planning, implementing and monitoring daily reading practice for fairly large groups of students. To capitalize on what these programs can and will actually do for developing readers, however, requires a human touch. Teachers can continue to create robust learning communities that support shared discussion, peer collaboration and exchange about reading and books. They can "mine the mounting dashboard data" to get more deeply involved in understanding the reading needs of their students. As a result, they can use the tremendous efficiency of digital reading platforms to more actively promote the longstanding principle of *learning by doing* in the act of reading – helping students to focus on practicing the essential skills they need to read and to read with enjoyment.

Appendix: e-Book Quality Rating Tool

Category	Definition	Item	Criteria
Ease of use	Features of access, page turning, browsing options	Home icon	Quick and easy access
			Coding guidance: Look for clarity; consistency; recognizability; simple form (may be termed cover or title page);
		Start/stop/pause button icons	Large, easy to select, student control
			Coding guidance: Look for clarity; consistency; recognizability; visual features (e.g., color); concreteness; simple form
		Previous/next button icons	Large, easy to select; allow student control
			Coding guidance: Look for clarity; consistency; recognizability; visual features (e.g., color); concreteness; simple form; manual control
		Reading mode button icons	Narration and non-narration options
			Coding guidance: Look for clarity; consistency; recognizability; visual features (e.g., color); concreteness; simple form; manual control
		Page numbers	Obvious on the screen page
			Coding guidance: Look for clarity; simple form, consistency
		Student control and mastery	Student-centered, responsive
			Coding guidance: Look for opportunity; meaningfulness; manageability
		User guidance	Navigation directions and cues
			Coding guidance: Look for clarity; concreteness; legibility; visual features (e.g., color)

(continued)

Category	Definition	Item	Criteria
Multimedia	Features of font, text, graphics, audio, animation	Print font	Sufficiently large and age-appropriate
			Coding guidance: Look for visual features (size, shape, color)
		Text layout	Age appropriate, properly formatted, manageable amount of text
			Coding guidance: Look for text structure; complexity; amount; visual features (e.g., borders)
		Print highlighting	Highlighting options, word/phrase tracking, student control options
			Coding guidance: Look for chunking (word/phrase/sentence); color; manageability
		Text-graphics match	On screen text with on screen graphics alignment
			Coding guidance: Look for contiguity; simultaneity; graphics-text match; integration
		Music effects	Complementary, not distracting to text content; motivating
			Coding guidance: Look for melody, rhythm, tempo in harmony with story content; avoids extraneous sounds
		Audio narration	Appealing voice quality, prosody and pace
			Coding guidance: Look for age appropriate voice tone, pace, clear pronunciation
		Animations	Meaningful addition to the text content
			Coding guidance: Look for coherence; comprehensibility; manageability; distractibility; disruption; seductive features (misleading)

(continued)

Category	Definition	Item	Criteria
Interaction	Button icons or hyperlinks that trigger an action or event	Text interactions	Meaningful reader-text interactions that support word recognition, comprehension and/or vocabulary
			Coding guidance: Look for visual features (supportive icons); complexity; redundancy (visual+audio); disruptions; distractions.
		Educational content interactions	Robust reader-text disciplinary content interactions
			Coding guidance: Look for subject matter referencing; vocabulary teaching; coaching; content extensions; worked examples
		Illustration interactions	Guided attention to details in illustrations that support comprehension
			Coding guidance: Look for text-illustration cues; text-illustration magnification; text-illustration referencing; virtual assistants.
		Embedded games or quizzes	Effective screen-page practice opportunities that support word identification, comprehension and vocabulary learning
			Coding guidance: Look for learner engagement; meaningful tasks that represent essential reading skills; retrieval supports; personalization
		Supplemental games or quizzes	Effective after reading practice opportunities that support essential reading skills.
			Coding guidance: Look for learner engagement; meaningful tasks that represent essential reading skills; retrieval supports; incentives; personalization

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The Power of a Story: Reading Live and Electronic Storybooks to Young Children

Kevin M. Wong and Susan B. Neuman

Abstract Stories play a critical role in the literacy development of young children, providing them with rich experiences that support their growth as readers. In this chapter, we first describe the landscape of stories in e-books and educational media. We then move to examine the potential for media to reach preschoolers from low-income communities, presenting two case studies of children who read stories in both live and digital media. The research question guiding these case studies was: How effectively can digital books reach young children from underserved populations? Findings from the first case study revealed no differences between the digital or live platform. Preschool children were able to learn from digital platforms and had similar early literacy gains as children who experienced live presentations of storybooks. Findings from the second case study demonstrated that the content of the storybook actually had a stronger influence over a child's comprehension than the medium did itself, suggesting children's interest in stories are critical for early literacy. Accordingly, this book chapter does not recommend against the use of digital storybooks, but pushes for a both-and agenda between digital- and live-story use to cultivate emergent literacy among young children and unlock the power of a story.

Keywords e-Books · Preschoolers · Low-income · Early literacy development · Vocabulary · Case study

Stories play a critical role in the literacy development of young children, providing them with rich experiences that support their growth as readers. Before ever setting foot in a school, children are exposed to letters, sounds, stories, and illustrations in their home environments, which shape their interests, imaginations, and inner representations of text. Child development specialists agree that these literacy skills

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J. E. Kim, B. Hassinger-Das (eds.), *Reading in the Digital Age: Young Children's Experiences with E-books*, Literacy Studies 18,
https://doi.org/10.1007/978-3-030-20077-0_9

that are cultivated in stories are foundational for reading development and oral language comprehension (Justice and Kaderavek 2002; Justice and Piasta 2011).

However, longitudinal studies demonstrate that children with limited oral language comprehension are at risk for encountering difficulties in their early literacy development and future schooling (Cunningham and Stanovich 1997). Research reveals that oral language comprehension and vocabulary knowledge are closely related to the quantity of books that children are exposed to, which is unfavorable for children residing in "book desert" communities – low-income neighborhoods where books are notably sparse due to structural inequalities (Neuman and Moland 2016). To provide children from book-sparse communities with greater exposure to stories, researchers are turning to digital platforms to reach more children and provide them with access to early literacy skills that are used in schools (Korat and Shamir 2007; Van Daal et al. this volume; Verhallen et al. 2006).

In fact, global trends indicate that children today are reading digitized books more than ever before (Rideout 2013). The number of households with non-television screened devices has doubled over the past 5 years in the United States alone (Anderson 2015). Yet, research continues to investigate the conditions under which interacting with digital stories can support or hinder literacy development in young children (Bus et al. 2015; Courage this volume; Bus et al. this volume). In this chapter, we first describe the landscape of stories in e-books and educational media. We then move to examine the potential for media to reach preschoolers from low-income communities, presenting a case study of children who read stories in both live and digital media. Together, this research raises the critical question: How effectively can digital books reach young children from underserved populations?

1 The Importance of Stories

Shared storybook reading promotes emergent literacy in young children. In the preschool years, children gain knowledge about reading and writing through adult-child reading interactions, observing and participating in informal literacy events in the home. These events provide children with foundational literacy prerequisites that help them understand the role of print as a communication device (print awareness), the sound structure of oral and written language (phonological awareness), the nature of letters and other print symbols (alphabet knowledge), and the vocabulary used to describe literacy constructs (metalinguistic awareness; Justice and Kaderavek 2002). Children who acquire these emergent skills before school are more prepared for the demands of conventional school literacy than their counterparts who have not had opportunities to master these specific skills (Stuart 1995).

Relatedly, it is not uncommon for preschool teachers to receive a class of 4-year-old children with strikingly diverse literacy needs. Coming to school with varying levels of word and world knowledge, many teachers find that some children can name all the letters of the alphabet with appropriate letter-sound correspondence, while others can name only one or two letters. Some children enter classrooms able to identify

and label words in a print-rich classroom environment, while others remain unaware of the role that print plays in their surroundings (Justice and Piasta 2011). These differences are reliably correlated with income inequalities, and are also associated with the amount of exposure children have to storybooks in their preschool years.

Consequently, scholars make a case for early storybook reading, highlighting ways that stories can support emergent literacy skills. First, vocabulary acquisition is supported when books contain words that children rarely encounter in spoken language. These vocabulary words can also be repeated multiple times as parents read and reread books with their children, facilitating vocabulary development (Sénéchal et al. 1996). Second, print knowledge – a multidimensional construct of children's emerging knowledge of forms and functions of the written language – is also supported through storybook reading. Through adult-child interactions, children gain a variety of emergent literacy skills including book and print organization, print meaning, letters, and words, which are foundational for later reading achievement (Justice and Piasta 2011).

Besides vocabulary and print knowledge, there is also increasing evidence that the type of book – or genre of book – influences children's conceptual knowledge and understanding. More specifically, different genres of children's books encourage different types of adult-child interactions while reading. On the one hand, storybooks that include predictable sentence patterns or consistent rhyming patterns facilitate back-and-forth dialogue between parents and children as parents may encourage children to complete sentences or guess the next rhyming word. Nonfiction texts, on the other hand, which are saturated with academic language and situated within specific contexts, often encourage parents to ask questions that relate content to children's prior knowledge and lived experiences (Pappas 1991). Like storybooks, they have the potential to encourage conversation between parent and child. Moreover, exposing children to different genres and text types scaffolds their cognitive skills and prepares them for cognitively demanding literacy tasks like making predictions and drawing inferences. In sum, research demonstrates that the amount, genre, and quality of storybooks are reliably correlated with both reading development and schema-building world knowledge.

2 The Potential for Media

Since the mid-1990s, digital storybooks have become increasingly popular in the preschool book market (Burnett 2010; Rideout 2013). Sales in children's electronic books have risen exponentially from 7 million dollars in 2011 to 23.3 million in 2017 (Publishers Weekly 2017). As screens become increasingly ubiquitous in households, many program developers and media producers create educational media programs that claim to promote early literacy, leading researchers to evaluate the circumstances under which technology-enhanced storybooks and educational media might actually promote emergent literacy (Bus et al. 2015; Wong and Neuman 2019).

In a review study on the affordances and limitations of electronic storybooks on young children's emergent literacy, Bus et al. (2015) examined when children would retain information from electronic storybooks. Evaluating the effects of digitized narratives, which included both oral text and multimedia information sources (e.g., animations, visual and sound effects, background music, hotspots, games, dictionaries), Bus and associates recommend that e-books and other multimedia be "developmentally appropriate in form and function for young children" (p. 81). In other words, electronic books should recognize the cognitive demands placed on children as they juggle both story comprehension and on-demand forms of assistance, like dictionaries or word pronunciation features. Children will unlikely develop emergent literacy skills when stories "include task switching between the story text and embedded features" (p. 92).

Still, theories supporting electronic books as appropriate platforms for emergent literacy skills stem from Paivio's dual-coding theory (Paivio 1986), which posits that information is processed in two distinct areas of the brain: one for visual information (on screen) and the other for verbal information (through speakers). Together, the two channels of information provide a robust representation of information presented in e-books. Dual-coding theory is corroborated by Bus et al.'s (2015) review study as "close congruency" between the narration and non-verbal information offers opportunities to promote story and text comprehension on digitized platforms. In an empirical study that used multimedia-enhanced read-aloud vocabulary instruction in pre-kindergarten through second grade classrooms, Silverman and Hines (2009) reported positive effects for English learners (ELs) that narrowed the gap between EL and non-EL vocabulary knowledge. This may be attributed, in part, to the dual-coding scaffolds that digital media might provide ELs (Wong and Samudra under review).

Although digital books appear to be an accessible source of information for diverse populations, there has been increasing concern regarding children's ability to comprehend stories in this form. Anderson and Pempek (2005), for example, have coined the term 'video deficit,' to account for the differential between learning from real-life events and learning from video. Studies report that while young children can imitate what they see on video, word learning and comprehension is limited, indicating video deficits that may persist beyond 36-months of age. Still, electronic picture storybooks exhibit many advantages for young children's emergent literacy (Bus et al. 2015). This is substantiated by cognitive-based theories of learning through media (Neuman 1991, 1997; Paivio 1986), and a number of empirical studies (Neuman et al. 2017; Roskos and Burstein 2013; Smeets and Bus 2012, 2014; Verhallen and Bus 2011; Wong and Samudra under review).

3 Blending Reading Experiences in the Digital Age

Research on the effects of medium (i.e., digital or live) on emergent literacy skills present mixed findings. While some studies demonstrate the advantage of digitized stories over live presentations (Korat 2010; Segal-Drori et al. 2010),

others uncover stronger gains in print presentations than electronic books (Terrell and Daniloff 1996). Such mixed results suggest that the distinction between what is printed in books and displayed on screens may not be so different after all. Instead, as screens move towards becoming everyday household objects, literacy development begins to emerge naturally through live *and* digital representations of storybooks, blending the reading experience in both media (Neuman et al. 2017).

Consequently, studies that draw opposing conclusions need to be interpreted within the specific contexts of both the child and the platform (Bus et al. 2015). For example, Korat (2010) examined the effects of e-books and printed storybooks on the reading comprehension of kindergarten and first-grade Israeli children. Assigning 90 children to treatment and control groups, and running posttest measures, Korat found that children in the e-book condition exhibited greater progress in word meaning and word reading compared to those in the printed condition. On the other hand, Terrell and Daniloff (1996) compared the effects of reading to 78 preschoolers through computer, video and live presentation. In these presentations, novel words (e.g., nouns, verbs and adjectives) were incorporated into the story. Findings indicated that live reading was significantly more effective, though the effect sizes were small. Interpreting these two studies side-by-side, learning through digitized storybooks varied according to the medium (e.g., e-book vs. computer), the child (e.g., preschool vs. kindergarten; Hebrew- vs. English-speaking), and the study design (e.g., story comprehension vs. novel words). For this reason, Bus et al. (2015) sought to synthesize and understand both "whether, and under what conditions technology-enhanced storybooks can be a viable option for the development of emergent literacy" (p. 80).

With the potential to foster emergent literacy among preschoolers, particularly among children who are at risk, books *and* e-books serve as important tools with the potential to affect the trajectory of their long-term achievement (Hirsch 2006). Video representations of narratives on digitized platforms bring stories to life through ostensive and attention-directing cues that work in concert to promote literacy development (Neuman et al. 2019). Interactive storybook read-aloud activities that mimic the read-aloud experience provide children with the ability to gather additional information about characters, definitions, and pronunciations of words in stories and can support low-income children's vocabulary development and print knowledge (de Jong and Bus 2004; Korat and Shamir 2007). Also, socially contingent videos that facilitate quick, incidental vocabulary learning are parallel to naturally occurring adult-child interactions while reading a storybook (Krcmar and Cingel 2014; Neuman et al. under review). In sum, both blended and independent presentations of storybooks have the potential to provide multi-sensory supports for vocabulary and content learning. In light of this, the current chapter examines a case study conducted by the authors to understand the overarching question presented earlier: How effectively can digital books reach young children from underserved populations?

4 A Tale of Two Stories: Digital and Live Platforms

This case study draws from a larger study conducted by our lab at New York University. The purpose of our study was to investigate the influence of digital and non-digital storybooks on low-income preschoolers' oral language comprehension. Employing a within-subjects design, we collected data from 38 children in a Head Start program aged 4.15 years old (*SD* = .22) and used the *Speakaboos* platform to provide storybooks to children (Neuman et al. 2017). Drawing from this sample, the current case study qualitatively examines three children's responses to the live and digital storybooks, illustrating the influence that these media have on children's oral language comprehension and vocabulary learning.

Speakaboos is an award-winning reading app for children aged 2–6 years old that "turns screen time into reading time" (Speakaboos 2017). Providing a library of interactive educational storybooks to children, *Speakaboos* has been named "one of the great websites" by the American Library Association, received an A+ from Education World, been a Featured 5-star app in the App Store and received accolades from *Parenting*, *Kidscreen* and *Publisher's Weekly* (Crunchbase 2017). *Speakaboos* also offers a number of interactive features that distinguish it from traditional e-books, highlighting read-alongs to capture attention and build early reading skills, and providing touch screen interactions to engage children in reading and improve comprehension.

To compare the effect of both live and electronic storybooks on children's comprehension, we created the same story in both formats. Because digital books are much more challenging to create than printed books, we selected four stories from *Speakaboos* for the study. The four digital books selected were comparable in length, lexical difficulty, and clarity of storyline (i.e. setting, plot, conflict, resolution). They were also fiction and varied in theme to cater to different student interests. Books included *Sid the Science Kid: Hello Doggie*, *Ish*, *The Valentine Contest*, and *Superkids: A Sticky Situation*. Table 1 provides details of each story. Unlike cartoons, these electronic books had animated pages that turned, characters that moved, and text that lit up during narration. Non-digital versions of each story were created using screenshots of each page and boxes for the text (see Fig. 1). Because *Speakaboos* books were read aloud by a narrator and characters in the story, we added a few words in the printed versions to indicate when characters were speaking: e.g., "I want to play with the dog," *said Sid* (changes noted in italics).

To isolate differences between live and digital storybook reading, we wanted to make two comparable story reading experiences. In the live presentation, children were read to by trained research assistants. Researchers read the book to children at a regular pace, using natural inflections, tone, and pause throughout the story. They also did not stop to ask children questions, and quickly addressed children's questions if they commented on the story's content. To make the experience parallel to the live reading presentation, we did not choose the "Read and Play" function of *Speakaboos*, which would provide children with the autonomy to turn pages at their own pace and click on hotspots to make characters speak and move on screen.

Table 1 Description of storybooks included in study

Title	Synopsis	Duration	Vocabulary words	Difficulty level (Flesch's scale)
Ish	Ramon loved to draw all the time. One day his older brother laughed at a drawing of his vase. After that, Ramon felt like he couldn't draw well. He tried over and over until his little sister helped him see that his drawings didn't need to look like a vase, but to look vase-ISH	6:04	Vase Silent Crumpled Gallery Haunted	90.5; easy to read
Sid the Science Kid: Hello Doggie	Sid hears a dog barking outside his window and wonders whether animals can talk. At school, he learns about how different animals communicate using sounds and body language. In the end, Sid is able to guess what some animals are trying to say	7:53	Bark Chest Communicate Attention Popcorn	102; easy to read
Superkids: A Sticky Situation	Noodle Boy goes to Superhero School to become a superhero. However, he thinks the other SuperKids have better superpowers than he does. When Dr. Goo goos up their playground, Noodle Boy and the other SuperKids go to stop him. In the end, Noodle Boy saves the day	7:30	Bounce Zoom Goo Whirlwind Villain	80.7; easy to read
The Valentine Contest	At this year's Valentine's Day party, Princess Ana wants someone to dance with. King Carlos holds a contest to see who can create the perfect valentine for Princess Ana. From the three contestants, Princess Ana chooses Morris the Monster's yucky valentine	7:50	Contest Bakery Yucky Glittery Valentine	79.5; easy to read

Note: Vocabulary words were given in order, arranged according to level of difficulty

We also did not select the "Read it Myself" option as this would eliminate the narrator and character voices. To mimic the live reading experience on the digital platform, we used the "Read to Me" function in the *Speakaboos* app. In this version, pages of the storybook would automatically turn after the narrator or character finished reading through the text on the page.

To examine the effects of digital books on reading comprehension and motivation in our larger study, we used a within-subjects study design. In the within-subjects design, each student received both the experimental (digital) and controlled (non-digital) conditions, serving as his/her own control, which reduced between-subjects variability, extraneous variables, and threats to internal validity. Children were escorted by a research assistant one-by-one to a quiet corner of the library at the Head Start center. Over the course of 2 days, children listened to four stories. Each child was randomly assigned two stories in the experimental condition (digital) and two stories in the controlled condition (non-digital). In the experimental condition,

Just as the SuperKids arrived at the playground, they heard a loud KAPOW! BLAMMO! SPA-LOOSH! SQUATCH! Standing at the top of the slide, was the ooey-est, gooey-est, slimiest bad guy the SuperKids had ever seen!

"I am Dr. Goo! The baddest bad guy around! And I've covered your playground with… GOO! No one will ever be able to play… AGAIN!"

"No! We love our playground! You won't get away with this!"

"Yes I will! No one can stop me and my slippery goo wand!"

Fig. 1 Resolution of the *Superkids: A Stick Situation* story

children listened to the book with headphones and were asked to refrain from touching the tablet screen. In the controlled condition, the research assistant read stories to children. The current case study closely examines the experiences of three of these children.

After each storybook experience, research assistants completed three assessments with children. First, drawing from Morrow's (1988) work in story retelling among preschoolers, we asked children to recall events in the story to assess comprehension. Children were only prompted one time during the assessment. Free recalls were recorded and transcribed verbatim. Two assessors then coded transcriptions according to Morrow's story retelling checklist. This checklist looked for seven elements: an introduction, main character(s), supporting characters, story setting, story theme, plot episodes, and resolution. The inter-rater reliability between these two assessors was .87.

Second, to capture another facet of children's story comprehension, we constructed a receptive sequencing activity that included five pictures. These pictures presented five distinct scenes in the storyline to children. A card with the title page

was placed at the beginning, and a blank card was placed at the end. Children were then given the remaining cards in randomized order and asked to sequence them. The assessment was scored with a Spearman's rank order coefficient.

Third, five vocabulary words were selected from each story. These words were identified as "sophisticated" *Tier 2* words in Beck, McKeown, and Kucan's heuristic (2002), which were screened by ten children to determine familiarity. The number of known words did not reach above chance and were included in the study. The meanings of these words were supported by the text and picture during the reading experience. They were also presented to participants in order of difficulty, starting with the easier words. In the protocol, an assessor said the word aloud to the child, which was immediately followed by a sentence that contained the word in the story. Children's responses were recorded and transcribed verbatim. These transcriptions were coded on a three-point scale as correct, partially correct and not correct. The inter-rater reliability was .91. The order of these measures was intentionally sequenced to maximize comprehension output. Each story and assessment protocol took approximately 20 minutes to complete, and included a five-minute break between books to prevent fatigue.

5 Case Study 1: No Influence by Medium

This first case study addresses the main question guiding this study: How effectively can digital books reach young children from underserved populations? Looking at the medium, we examine the responses of two preschoolers who encounter complementary versions of stories in digital and live media. Child 1, for example, receives the *The Valentine Contest* and *Superkids: A Sticky Situation* in live book format, while Child 2 receives these two stories in electronic formats. Similarly, Child 1 receives *Sid the Science Kid* and *Ish* in digital form, while Child 2 receives these on paper. The two preschoolers selected for this case study are in the same class, 4 years old, male, African-American, and have comparable levels of literacy measured approximately one standard deviation below the norm by the Peabody Picture Vocabulary Test-IV (Dunn and Dunn 2007).

We analyzed the two children's responses in two ways (Table 2): First, we examined them side-by-side, comparing free recall, story sequencing and vocabulary knowledge by story to understand how stories are interpreted across medium (by row). Second, we examined responses according to each child to understand how

Table 2 Analysis of storybooks for first case study

Storybook	Live version	Digital version
The Valentine Contest	Child 1	Child 2
Superkids: A Sticky Situation	Child 1	Child 2
Sid the Science Kid: Hello, Doggie	Child 2	Child 1
Ish	Child 2	Child 1

medium might affect comprehension within each child, corroborating findings and enhancing the trustworthiness of our claims (by column).

Comparing the two children side-by-side, there are striking similarities in their responses. Whether by book or digital format, both children demonstrated analogous levels of understanding. Using an adapted version of Morrow's (1988) story checklist, children received similar scores for each story. For example, in the first story, *The Valentine Contest,* children received 4 out of 7 points for story recall in both contexts, suggesting no effect on the medium. They also received 3 out of 5 points when sequencing the story in both contexts, further substantiating this conjecture. Examining transcripts qualitatively, children in both contexts applied cognitive activity to recall the narrative of each story. In the first story, *The Valentine Contest*, Child 1 was able to recall the three suitors who created valentines to win the princess' affections.

> The cooker man made the the cookie one with frosting on it and he put gum on it, and, and, he che…, and the dragon made it, the dragon valentine one.
> And the monster one made the yuckiest one and the girl said the monster is the winner. And the cooker man and the dragon who made valentine thing and they were sad.
> Cause the princess picked the dragon.
> No the monster. (Child 1, *The Valentine Contest*, live presentation)

After reading the live presentation of the book, the child systematically recollected the cooker man, the dragon and the monster. In the digital version of the story, Child 2 did not identify the specific characters involved, but recalled that "everybody tried to make the best [Valentine], all three." He similarly noted that the monster "made the yuckiest valentine" and eventually won. In both the live and digital storybooks, children recalled the main characters, supporting characters, plot episodes, and resolution.

A similar trend was found in *Superkids: A Sticky Situation* where there were no differences between medium. *Superkids* was a story with six plot episodes: (1) Superkids were at Superhero School, (2) Superkids compared each others' super powers, (3) Noodle Boy had an un-super superpower, (4) Superkids attacked the villain at the playground, (5) Noodle Boy saved the day, (6) Superkids became friends with the villain. Children in both the digital and live presentations scored 1 out of 5 correctly in the story sequencing task, indicating a similar understanding of the story across platform. Children were also able to provide key details in the free recall in both conditions, identifying three to four plot episodes in each format. Interestingly, both the setting at Superhero School (1) as well as the resolution (6) were recounted in both conditions.

Looking closely at what these children described between the beginning and resolution, we noticed that children in the live presentation condition quoted what characters actually said, but did not do this in the digital condition. In *Superkids*, the child who read the live presentation said, "And then the gooey man said, 'You will play with me? How?'" In contrast, the child who read the digital book described the events from a narrator's perspective, saying, "Gooey man make the playground all

yucky. And they [the superheroes] made the playground all nice and clean." This distinction between what children decided to recall is striking. When children listened to a book that was read to them in person, they recalled impressionable quotes from characters that helped drive their recount of the story forward. This was consistent in three of the four books, leading us to wonder why children might have used these quotes in their free recalls.

In *The Valentine Contest*, the child quoted the princess when he said, "the girl said, 'The monster is the winner.'" In *Superkids: A Sticky Situation*, the child quoted Dr. Goo when he said, "And then the gooey man said, 'You will play with me? How?'" In the third story, *Sid the Science Kid: Hello, Doggie*, the child quoted the dog when he said, "The dog bark at the … then he say, 'Woof!' Then he trying to say, 'Hello!'" In each scenario, the child changed the inflection of his voice to mimic the voice of the character. Looking closely at these three instances, the quotes all occurred near the end of the story narrative, capturing the climax of the story. In *Valentine*, the princess finally chose a winner of the contest. In *Superkids*, the villain, Dr. Goo, shared about how he became bad and confessed that he just wanted to play with other kids. Figure 1 shows a screenshot of this plot episode where the *Superkids* offer to play with Dr. Goo, to which he says, "But how?" Like in *Valentine*, the child captured the final – and arguably most critical – plot point in the narrative, using character speech to convey this message. Likewise, in *Sid the Science Kid*, the big idea of the story was that animal sounds are used to help animals communicate. Throughout the story, and particularly at the end, Sid discovers that dogs say "woof" to communicate.

In this first case study, we note that there are no differences in oral language comprehension when children are presented storybooks in either digital or live formats. There are, however, interesting nuances between the two conditions that warrant further exploration. Although neither condition included elements of dialogic reading, whereby adults prompt children with questions and engage them in discussion while reading, it appears that children were more likely to recall what characters specifically said when they listened to stories in person. This may be related to the different voices put on by adults when reading what characters say while storytelling, which are noticeable to children (Wright 1995). In contrast, children used narration to cohesively describe the story from beginning to end when reading the digital book. These findings are aligned with previous studies that show differences in story recall among elementary-aged children who recollect story actions or verbs that drive the story forward when read to on screen (Meringoff 1980). Future studies may consider examining this discrepancy on a larger scale, analyzing trends and patterns of recall in both formats. This may have important implications for genres of text that feature conversations between characters (e.g., fiction) or emphasize factual statements (e.g., non-fiction). It would be interesting to explore, for example, whether children comprehended fiction texts better in live presentations and non-fiction texts in digital formats, as there would be direct applications for school-based electronic book use and home-based reading.

6 Case Study 2: Stories Matter

This second case study examines the question about how digital books reach young children from underserved populations by looking beyond the medium to the content of what children are reading (i.e., the story). In the first case study, we noted no difference between medium, but uncovered trends in the quality of children's responses in the free recall. We noted this pattern in the first three books, but also noticed that children's responses to the book, *Ish*, were both quantitatively and qualitatively different from the other three stories. More specifically, children did not appear to comprehend the story as well as the others, according to the free recall, story sequencing, and vocabulary assessments. These differences informed this second case study, where we examined one child's (Child 3) responses to all four stories (Table 3). Comparing the influence of stories side-by-side, we deduced that when there was no extratextual talk about the story, the content of the storybook actually had a stronger influence over a child's comprehension than the medium did itself.

The child chosen in this case study has a similar background to the two children in the first case study. Looking at his assessments across storybooks, there were few differences between the first three stories in the free recall, story sequencing task, and vocabulary assessment with this child. Most notable of the three assessments was story sequencing, where the child was asked to order five screenshot images of each story chronologically. In *Valentine*, *Sid the Science Kid,* and *Superkids*, this child was able to order all images correctly, scoring 5 out of 5. However, with the book, *Ish*, the child only sequenced one image correctly, suggesting confusion or a lack of comprehension.

Also striking, the child was able to define vocabulary words in the first three books, describing words like *contest* as when "you want to win", *attention* as "looking at people", and *villain* as "he gooed the slide everywhere" (referring to what the villain did in the *Superkids* story). Like the story sequencing task, the child was not able to define the words taught in the *Ish* story. For example, he defined the word *vase* as "papers" and the word *gallery* as a "horse, like gallop". This suggests that his lack of comprehension of the narrative may have influenced his understanding

Table 3 Analysis of storybooks for second case study

	Valentine	Sid	Superkids	Ish
Format	Live	Digital	Live	Digital
Free recall	3/7	4/7	4/7	2/7
Story sequencing	5/5 correct	5/5 correct	5/5 correct	1/5 correct
Vocabulary	Contest: you want to win	Chest: beating	Villain: he gooed the slide everywhere	Vase: papers
	Glittery: glitter and shiny	Attention: looking at people	Goo: sticky	Gallery: horse, like gallop
Enjoyment	Yes	Yes	Yes	No

of new vocabulary words, or vice versa. This is unsurprising considering the interrelationship between vocabulary and comprehension in the literacy development of young children (Sénéchal et al. 1996).

Adding to our understanding of this child's ability to sequence and recall vocabulary are issues of child interest. After each story presentation, children were asked whether they enjoyed the story. While Child 3 enjoyed *Valentine*, *Sid the Science Kid,* and *Superkids*, he said that he did not like the story *Ish*. From the free recall, we noticed that the narrative stopped after the first few plot episodes, as he said,

> There was pictures on the wall.
> And the boy was drawing pictures.
> And he was mad.
> He was throwing the papers. (Child 3, *Ish*, digital presentation)

Unlike the other stories, his recount of *Ish* did not include the climax or resolution of the story. It only included one main character and one plot point, which is why it received 2 out of 7 points on Morrow's (1988) checklist. The other stories received 3, 4, and 4 points on the checklist. There were also approximately double the number of words used to describe the stories in *Sid* (38 words), *Superkids* (54 words), and *Valentine* (44 words) than in the *Ish* recount (21 words), suggesting he had more to share about the stories that he comprehended better.

Overall, evidence from this second case study uncovers the importance of the story in facilitating children's comprehension and vocabulary development, regardless of live or digital platform. In other words, if children are interested in a particular story, they are more likely to follow its narrative and gain vocabulary knowledge (Neuman et al. 2017). It appears then that no amount of bells and whistles offered by electronic books in this *Speakaboos* context could compensate for a child's lack of interest in a story. Thus, the power of a story should not be underestimated in our current age of digital books.

7 Reading in the Digital Age: A Both-And Approach

As our case studies revealed, reading books on digital platforms was not a magical one-shot answer to preparing children from low-income backgrounds with early literacy skills. Despite the proliferation of electronic devices in households across North America, where parents are using tablets as digital "babysitters" in restaurants, doctor offices and airplanes, this study cautions parents to consider *what* the children are engaging in as going digital does not equate to better learning. Still, findings from the first case study demonstrate that there were *no* differences between the digital or live platform. Preschool children *were* able to learn from digital platforms and had similar early literacy gains as children who experienced live presentations of storybooks. These findings should be carefully interpreted as the study was originally designed to strictly compare the differences between live and digital

media, which resulted in live presentations that did not include dialogic reading or extratextual conversations that may enhance comprehension. Accordingly, this book chapter does not recommend against the use of digital storybooks, but pushes for a both-and agenda between digital- and live-story use to cultivate emergent literacy among young children.

Building on this agenda, our second case study validated the importance of story content and child interest in stories on both live and digital platforms. Children enjoyed *Valentine*, *Sid the Science Kid*, and *Superkids* more than they did *Ish*, which uncovered striking differences in their oral language comprehension and vocabulary knowledge of the storybooks. The four stories were comparable in lexile difficulty, story structure, length, and genre. Still, the medium did not have as powerful an influence on children's comprehension as did the story. Rather than adopting an either-or approach to storybook reading, where parents and educators choose to read stories to kids exclusively in one medium or another, adopting a both-and approach integrates both media in an intentional manner to promote emergent literacy in young children.

Still, how does one implement a both-and approach intentionally? Recognizing the blended landscape of reading in this digital age, the takeaway message from our study is that when stories are picked well, they have the power to enhance literacy development in low-income preschoolers, and the potential to prepare children for the literacy skills demanded in schools. Without a doubt, further studies need to examine how and under what circumstances digital and live presentations of books should be provided to children. Important questions surrounding this exciting field include pinpointing optimal proportions of digital and live presentations of books according to children's varying stages of linguistic and cognitive development. As suggested in our first case study, research may also investigate whether different genres of books or other distinguishing features of stories might be better suited for digital or live platforms. Exploring answers to these questions could provide parents and early childhood educators with key principles and strategies for reaching low-income children and preparing them for the literacy demands of school.

8 Reaching Families Where They Are

Responding to Bus et al.' (2015) recommendation that e-books and multimedia should be "developmentally appropriate in form and function for young children" (p. 81), findings from our study extend this statement by emphasizing the importance of reader interest. Though children were able to learn through both forms of media, their interest in the story played a relatively influential role in their learning. If we are to reach families where they are and provide them with early storybook reading experiences that promote literacy development, findings from our study suggest that these experiences need to be interesting and relevant to children's lives.

One question then is to identify who is reading these stories and to understand what is considered interesting and relevant. If electronic books are to serve as a tool

to provide children from low-income communities with school-based literacy experiences, then books need to reflect the cultural makeup of their readers and use their contextualized background knowledge to promote literacy development (Hirsch 2006; Neuman et al. 2014). Drawing from theories of cultural relevance that marry cultural background, learner interest, and learning gains together (Ladson-Billings 1995; Paris and Alim 2014), this means that authors, illustrators and producers need to work together to create stories that powerfully appeal to all young children.

Answering the overarching question of this chapter, we can conclude that digital books *can* effectively reach young children from underserved populations. More specifically, this study demonstrates that electronic books as a shared storybook reading platform has the potential to promote emergent literacy in young children from low-income communities. To investigate *how effectively* digital books can reach preschoolers, we suggest that e-books do facilitate literacy development to a large degree when they are developmentally appropriate and sensitive to the interests of young children. While this study does endorse the use of digital books to promote learning among preschoolers, we admonish readers to never underestimate the power of a story that appeals to young children.

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The Effects of Digital Literacy Support Tools on First Grade Students' Comprehension of Informational e-Books

Heather Herman and Katia Ciampa

Abstract This mixed-methods study examined the patterns between 14 first graders' use of digital literacy support tools (annotating connections, annotating *I wonders,* and looking back in the text) and comprehension scores when reading informational e-books. Quantitative data sources included e-book comprehension quiz scores and literacy support tools' tally system. Two types of qualitative data were collected: teacher interviews and researcher's anecdotal notes. A chi-square analysis indicated significant patterns between the e-book comprehension scores and the usage of the literacy support tools, $X^2(6, n = 211) = 25.79$, $p = 0.001$. The qualitative data highlights the students' digital literacy support tool preference, their ability to use the digital literacy support tools, and understanding the relevant application of the digital literacy support tools. This study is an initial attempt to shift teachers' and researchers' views of independent informational reading to include digital text, such as e-books to supplement the classroom library.

Keywords Digital literacy · Literacy support tools · Informational · e-Books · Reading · Comprehension · Annotating

The definition of literacy has expanded from the traditional notions of reading and writing to include the abilities to learn, comprehend, and interact with new literacies. New literacies are defined as forms of communication mediated through technologies (Leu et al. 2011). In the United States, the Common Core State Standards (CCSS) is a state-led initiative that acknowledges the need for consistency in real-world learning goals to ensure that all students are graduating from high school prepared

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J. E. Kim, B. Hassinger-Das (eds.), *Reading in the Digital Age: Young Children's Experiences with E-books*, Literacy Studies 18,
https://doi.org/10.1007/978-3-030-20077-0_10

for college, career, and life (CCSS Initiative 2016). These standards recognize the need to prepare students for future success by calling for literacy learning through the use of technology (Larson 2013). Additionally, many professional associations, including the International Literacy Association (2009) and the National Council of Teachers of English (2013) recommend that technology be integrated into classroom lessons so that students will be well prepared for the literacy demands of the twenty-first century (Bostock 2012; Brown 2016; Coiro 2011; Larson 2010; Leu et al. 2004a, b).

The use of electronic books (or e-books) offers young students ways to develop and enhance new literacies, which are essential for communication in a global world (Bostock 2012; Dede 2010; Larson 2010; National Council of Teachers of English 2013). Electronic books contain key features of traditional print books, such as a central topic or theme and pages that *turn*, but e-books may also contain digital enhancements that make the reading experience different and possibly more supportive (Brueck et al. this volume; Zucker et al. 2009). Much like traditional books, the electronic versions embrace print and illustrations; however at a minimum, e-books present the text with an oral reading option and some form of hypermedia, such as embedded images, sounds, video, animation, and so on (Larson 2009, 2013). As the definition of text expands to include e-books, the traditional reading and thinking strategies become insufficient to comprehend e-books (Coiro 2011). Many e-books require readers to pay attention to a range of modes and navigate the digital literacy support tools while making meaning, such as through the use of annotating tools and the ability to "look back" in the text to find evidence to support comprehension (Zucker et al. 2009). Since using the digital annotating tools and "looking back" in the e-book are similar strategies to traditional reading and thinking strategies, the focus for using these tools is more on the comprehension of e-books, instead of on the digital enhancements. These two particular digital literacy support tools demonstrate that comprehension instruction can be supported in the classroom using e-books.

Additionally, the CCSS call for a 50/50 split between informational texts and literary texts in kindergarten through grade 5. These texts are selected to systematically develop the students' knowledge about the world. However, the percentage for more immersion in informational texts gradually increases to a 70/30 split in high school due to a much greater emphasis on literacy in history/social studies, science, and technical subjects. This is to ensure that students can independently develop knowledge in these areas through reading and writing (CCSS Initiative 2016). Children see all types of informational texts in their everyday lives including grocery lists, magazines, information books, and instruction manuals, such as Lego sets and Scientific Explorer's Educational Make-It Yourself kits (Lego 2016; Scientific Explorer 2016). Notwithstanding, it has been documented that classrooms lack informational text in the primary grades (Duke 2000; Jeong et al. 2010). A plausible explanation for the lack of exposure to informational texts in the primary grades is that texts convey and communicate factual information, which can be challenging for young readers to comprehend (Forzani and Leu 2012; Ray and Meyer 2011). These texts may contain more unfamiliar vocabulary and concepts, fewer ideas related to what is happening

now, and less information directly related to personal experience (Forzani and Leu 2012; Hall et al. 2005; Ray and Meyer 2011).

When reading informational e-books, students have the option to utilize the digital literacy support tools to comprehend text, as well as effectively select reading strategies to fully understand the text (Brown 2016). Given the overwhelming importance of expanding literacy to include new literacies in an online age and the increasing emphasis on informational text (Common Core Initiative 2016), the digital literacy support tools of informational e-books can act as supports that mediate between young readers' existing capabilities and their potential for new learning (Forzani and Leu 2012).

Despite the increased need for primary grade teachers to prepare their students for the literacy demands of the twenty-first century, there is still an insufficient amount of studies that have been conducted using informational e-books with first-grade students. Moreover, very few studies have examined young readers' abilities to effectively utilize the digital literacy support tools in informational e-books to make meaning. Instead much of the research and practice with new literacies often have focused on upper elementary students (Chen and Chen 2014; Coiro 2011; Larson 2009; Marsh 2011; Simpson et al. 2013). This is puzzling since the ability to read, write, and communicate online will be a great part of a young student's future (Forzani and Leu 2012). These young students may walk into the classroom with the knowledge of technology, however that does not mean that each child's opportunities and experiences with using technology as a learning device or tool will be the same (Bostock 2012). It is unnecessary to wait to introduce new literacies to first-grade students, especially since the interactive nature of new literacies are suited to the needs and learning styles of young children (Forzani and Leu 2012).

Accordingly, the purpose of this mixed-methods study is to examine the patterns between the use of literacy support tools (i.e., annotating and look-backs) and reading comprehension when reading informational e-books. The following research questions guided this study: (1) What are the patterns between the first-grade students' use of annotating personal connections, annotating *I wonders*, look-backs, and the students' reading comprehension score? and (2) What are the perceived experiences of the first grade students during informational e-book reading?

The present study was designed to make noteworthy contributions in at least three ways. First, this study provides guidance in bridging new literacies and print-based text using existing digital literacy support tools that have been proven to be effective practice (i.e., annotating and look-backs). Students are able to use the literacy support tools that they are accustomed to using with print-based books and apply that knowledge to e-books. Secondly, since new literacies are persistently evolving and changing (Larson 2013), traditional definitions of reading and writing are insufficient in today's world as students encounter and interact with e-books (Coiro 2003). Therefore, by determining the usage of the digital literacy support tools (such as annotating and a look-back option) found within the e-book as a means of comprehending the text, this study adds to existing research that indicates that the digital literacy support tools found within the e-books support the comprehension process (Larson 2010, 2013). Finally, the results of this study have

implications for policy, particularly the stress on literacy learning through the use of technology and the increased focus on informational text (CCSS Initiative 2016). The infusion of new literacies for fostering inquiry-based learning enable students to support their comprehension processes through responding to the text and asking questions through virtual annotation, and looking back in the text for evidence to support comprehension. It enables students to manipulate and interact with the information in order to make sense of it, as well as it provides a venue for students to seek answers to their own questions (Larson 2009, 2010, 2013).

1 Theoretical Framework

A dual-level theory of New Literacies informed the current research (Leu et al. 2014; Tang 2015). The two levels include New Literacies (uppercase) and new literacies (lowercase). New Literacies (uppercase) is the broader concept that identifies the Internet and other information and communication technologies (ICTs) as central technologies for literacy within a global community in an information age. Although much of the research on new literacies looks at online comprehension and the ability to navigate the seas of online information, the dual-level theory of New Literacies also recognizes the finding of other ICTs, such as e-books (an example of a lowercase literacy), and its potential for expanding our understanding of literacy and the relationship of its literacy support tools on comprehension of informational text (Leu et al. 2014).

The lowercase new literacies are more specific than the broader level of New Literacies. These literacies explore a particular area of the dual-level theory of New Literacies and/or a new technology (Leu et al. 2014). The ICTs are the tools used to support the development of New Literacies. They refer to the hardware and software that facilitate users to access, retrieve, process, and exchange information, such as e-books, blogs, word processors, video editors, World Wide Web browsers, e-mail, spreadsheets, presentation software, instant messaging, bulletin boards, avatars, and many more (Leu et al. 2004a, b). These tools provide powerful capacities that enable teachers and students to retrieve information beyond print-based books, such as through e-books and their digital literacy support tools (Brown 2016; Hsu et al. 2012; Larson 2009, 2010; Zucker et al. 2009).

However, the mere presence of e-books will not provide students with the access to reach this lowercase new literacies' full potential when processing and comprehending the text. Instead, it is the literacy support tools of e-books that will unleash the potential for this evolving new literacy. The digital literacy support tools allow the reader to interact with the text to support the comprehension processes (Larson 2010). Accordingly, this study seeks to find evidence to support the digital literacy support tools' impact on first grade students' reading comprehension of informational e-books. The possible capabilities of this new literacy have the potential to provide additional data to support literacy learning within a global

community in an information age that begins with early readers in the primary classroom.

1.1 Stages of Reading Development

Being literate is a developmental process that begins at birth (Fountas and Pinnell 1996, 2006). The process of reading shifts over time and spans across four categories: emergent (2–7 years, preschool-first grade); early reader (5–7 years, kindergarten-first grade); transitional (5–7 years, kindergarten-second grade); and self-extending (6–9 years, first grade-third grade) (Fountas and Pinnell 1996, 2006). The children at the emergent stage are not yet ready for informational reading since they are focusing on book handling skills, directionality of print, phonemic awareness, and simple decoding skills (Brown 2016). This study focuses on early readers and transitional readers who are in first grade. Early and transitional readers are generally able to talk about what is happening in the illustrations or photographs, can orally retell the story, are learning to preview a text, identify and explain their favorite part of a story, as well as make text-to-self connections (Beaver 2006). These readers rely less on pictures and use more information from the print, recognize a growing number of high-frequency words, and can read fluently (Beaver 2006). Their repertoire of comprehension strategies begins to emerge and include monitoring, searching, cross-checking, and self-correction (Fountas and Pinnell 1996). Other studies of transitional readers (Brown 2016; Wright et al. 2013; Larson 2010) have demonstrated that these students are able to utilize the reading behavior features effectively with e-books. Therefore, it would be important to find out how the literacy support tools in informational e-books affect comprehension at the early and transitional reading stages and which features that choose to use most often.

1.2 CCSS: An Increased Emphasis on Informational Texts in Primary Grades

The CCSS (2016) recognize that to thrive in the newly wired world, students need to practice working with informational text in order to be prepared for college, career, and life. It is vital for students to have the opportunities to build their knowledge through informational texts so they can learn independently (CCSS Initiative 2016). As abovementioned, it has been documented that classrooms lack informational text in the elementary grades (Jeong et al. 2010). Jeong et al. (2010) compared the availability and use of informational texts and narrative texts across second-, third-, and fourth-grade classrooms. Jeong et al. (2010) found no substantial increase in the children's access to informational text from second to fourth grade;

the classroom libraries did not have a balance of informational and narrative texts across grade levels.

Informational text conveys and communicates factual information. It can be challenging for young readers to comprehend (Forzani and Leu 2012; Ray and Meyer 2011). These texts may contain more unfamiliar vocabulary and concepts, fewer ideas related to what is happening now, and less information directly related to personal experience (Hall et al. 2005; Ray and Meyer 2011). Young children tend to have difficulty comprehending informational text due in part to their limited cognitive development and experience (Ray and Meyer 2011). Both younger and older readers have knowledge of how texts should be organized, but older readers may have a more sophisticated and developed sense of organization (Ray and Meyer 2011). Therefore, it is important for students to develop a repertoire of literacy support tools when reading informational text since there are multiple structures and text features used in these texts (CCSS Initiative 2016; Hall et al. 2005). Since the availability of informational e-books is virtually unlimited (Larson 2013), they can supplement the print-form informational texts or be utilized in the classroom during small group reading.

1.3 CCSS: An Increased Emphasis on Using Technology

The CCSS recognize the need to prepare students for future success by embedding rigorous reading standards and calling for literacy learning through the use of technology (Larson 2013). Students are asked to "integrate and evaluate content presented in diverse media formats, including visually and quantitatively, as well as in words" (CCSS Initiative 2016, p. 1). Reading instruction in grades K-12 has a well-established tradition built on print-based texts across all content areas (Felvegi and Matthews 2012). However, the transforming effects of new literacies are redefining what defines text. Electronic books are a model of these new literacies and a virtually unlimited resource for informational text (Larson 2009, 2013).

Electronic Books Electronic books (e-books) are defined as self-contained digital texts whose basic structure and features mimic traditional books (e.g., text, illustrations, page turning) but are viewed on an electronic display, and can be housed on the Internet (Felvegi and Matthews 2012). Electronic books are different from static print texts since readers are required to pay attention to a range of modes and literacy support tools while making meaning (Brown 2016). Most e-books also contain a combination of digital literacy support tools, such as annotating tools where readers can add comments or questions by inserting virtual notes (Larson 2009, 2010), and a "look back" feature to find evidence to support an answer during a comprehension quiz (Zucker et al. 2009).

There is some concern regarding the distractibility of the digital literacy support tools used in e-books that may distract the reader's attention away from the text. De

Jong and Bus (2002) compared 48 kindergarten children's attention for meaning, phrasing, and text features based on the method of story narration (adult, e-book with games, e-book without games, audiotape) and if the differences resulting from the book format related to the children's overall ability to recall the story. The results from this study indicated that the features offered through these e-books distracted the reader's attention away from the text (especially when there were games present), but the overall ability to recall the story was similar, despite the delivery method (De Jong and Bus 2002). In the present study, the e-books being used do not have a game component. The digital literacy support tools include the following: virtual annotation and the option to look-back during the comprehension quizzes. A microphone for recording and a built-in glossary are other features, but they deviate from the purpose of this study, which is to look at the impact on comprehension, not fluency or vocabulary.

Traditional reading and writing practices are not adequate to prepare students for literacy in the twenty-first century (Felvegi and Matthews 2012). As books continue to evolve into e-books, their changing formats and enhancements require changes in the skills and strategies used to read and to comprehend e-books. Therefore, it is important for students to be able to navigate the digital literacy support tools of e-books in order to support the comprehension of this new literacy and retrieve information beyond print-based books (Courage this volume).

Digital Literacy Support Tools: Monitoring Comprehension During e-Book Reading with Annotations and Look-Backs Comprehension monitoring is a critical metacognitive strategy that involves thinking about one's own thinking (Oczkus 2004). Readers must keep track of their own comprehension and take responsibility for keeping it in working order; readers must constantly ask themselves if their understanding makes sense and if there is anything that they do not understand (Oczkus 2004). Research clearly indicates that comprehension monitoring is an important strategy that separates the strong from the weak readers (Boushey and Moser 2009; Harvey and Goudvis 2007; Paris et al. 1991). Therefore, it is necessary for students to be taught how to check for understanding, identify a problem, and use the necessary fix-up strategies to resolve any problems with comprehension (Oczkus 2004). As will be further discussed below, text annotations and look-backs are two comprehension monitoring strategies that can be effectively taught and used during e-book reading.

Digital Annotation: Reading Strategy to Support Comprehension Annotation is a literacy support tool and writing-to-learn strategy that reinforces checking for understanding since the reader makes notes about what is going on in the text while s/he is reading or rereading (Porter-O'Donnell 2004). As students are reading, they transfer their thoughts into written annotations as quickly and efficiently as possible in an effort to reflect their understanding of the text (Larson 2010). It enables the reader's dialogue with the text to become visible, as students make predictions, ask questions, state opinions, analyze author's craft, make connections, and reflect on the content of their reading process (Porter-O'Donnell 2004).

Larson (2010) found second graders using the digital literacy support tools of e-books to support reading comprehension while responding to narrative text. Larson's (2010) small case study focused on two girls with different reading skills: one student was reading on level and the other student was reading two grades above level. The participants were welcome to use any of the features but were not required to do so. Both students added annotations to the text, which were categorized into the following: understanding the story, personal meaning-making, questioning, answering questions, and response to text features (Larson 2010). The on-level reader asked more questions, retold her understanding of the plot and characters, and wondered about the author's conventions and writing style (Larson 2010). The above-level reader, on the other hand, transacted with the text at a deeper level by conversing with the author and engaging in personal meaning-making as the plot unfolded (Larson 2010). The digital annotating feature provided a space for active meaning making through interpretation and personal engagement (Brown 2016) as well as provided the teacher with valuable insights into each child's reading behaviors and comprehension skills (Larson 2010).

Text Lookbacks: Digital Literacy Support Tool Looking back into a text is a comprehension strategy that enables the reader to go back into the text to locate answers to questions. It is an opportunity to resolve comprehension failures as readers evaluate their understanding while they are reading (Zabrucky and Ratner 1986). Various researchers have posited that students younger than eighth grade rarely use this strategy for several possible reasons. First, students might not realize that they have not understood (Markman 1977, 1979). Another possible reason is the students might realize that the text did not make sense but then make inferences to make sense of the text rather than look back (August et al. 1984). Finally, students might expend so much attention on decoding and meaning construction that they do not have enough resources left to compare new information to prior knowledge and evaluate the consistency between them (Paris et al. 1991). However, it has been shown that direct instruction over 5 days can improve students' strategic look-backs in text (Leslie and Caldwell 2016; Garner et al. 1984).

Look-backs are also an assessment tool since they allow the researcher to differentiate between comprehension and memory (Leslie and Caldwell 2016). A reader may comprehend while reading but then forget the information when asked a specific question. If the reader can find the correct answer after looking back in the text, the researcher can assume they comprehend what they are reading. They are particularly informative when the student has read unfamiliar and/or difficult, concept-dense text, such as informational text (Leslie and Caldwell 2016).

In sum, the focus of this study is on first grade students and their ability to comprehend informational texts using e-books. New literacies incorporate digital literacy support tools that provide a new and important gateway for learning that has the potential for improving comprehension of electronic informational texts. This study intends to advance the field toward a clearer understanding of the impact of two digital literacy support tools (annotating and look-backs) when used with informational e-books.

2 Methods

2.1 Selection of Site and Description of Participants

The research site for this study was a suburban public elementary school located in northeastern United States. In the 2015–2016 school year, the K–5 school served 562 students who were 6.23% Asian (not Hispanic), 4.98% Black or African American (not Hispanic), 13.17% Hispanic, 3.74% multi-racial (not Hispanic), 71.71% White (not Hispanic), and 0.18% Native Hawaiian or other Pacific Islander. It is a Title 1 school with 21.17% being economically disadvantaged. Overall, 67.8% of students performed at or above grade level in reading during the 2013–2014 school year as measured by a statewide-standardized assessment (Pennsylvania Department of Education, Pennsylvania Value Added Assessment System 2016). The percentage of classes taught by highly qualified teachers is 100% (Pennsylvania School Performance Profile 2015).

The participating teacher was chosen by the principal and described as an exemplar teacher. She had at least 3 years of experience and received a ranking of proficient on her previous end of year report for the 2015–2016 school year. The researcher and the participating teacher worked together to implement the use of e-books from RAZ-Kids during the 2015–2016 school year and became proficient at using the literacy support tools through repeated practice and professional discussions. The participating teacher used e-books in her small group reading sessions as an additional library to access informational text, as well as to aid comprehension. The iPads were chosen as the preferred medium for this study because they were easily accessible to the researcher. Moreover, the iPad's easy handling, page turning option, and the teacher's ability to see what the child was reading while in a small group setting were additional reasons for its use in this study.

There were 18 students in the participating teacher's classroom. The regular education students accounted for 78% of the population in her class. The remainder of the population was 22% special education students (pullout). There were no students in her classroom that were English language learners. All regular education students were included in the study if English was their first language; however, all children in the classroom received the condition and the traditional instruction. A consent form was sent home to parents in the summer before school started explaining the study and asking for their permission for their child to participate. Fifteen permission slips were returned. Only one permission slip declined participating in the study. The other 14 students were able to participate in the study.

There was the possibility that first graders would prefer reading informational text electronically and using the literacy support tools that were accessible with the iPad due to the novelty effect; a tendency for performance to initially improve when technology is instituted not because of any actual improvement in learning or achievement but in response to increased interest in the new technology (Hur and Oh 2012). However, the first-grade students who were participating in this study piloted the use of iPads in their kindergarten classrooms as daily stations as well as during their regularly scheduled library period.

2.2 Research Design

For the purposes of this study, a mixed-methods approach was used with a dominant use of quantitative methods. A single-subject design was utilized in this study. Fourteen participants engaged in 20 informational e-book sessions over a three-month period. Qualitative methods (i.e., semi-structured teacher interview and researchers anecdotal notes) were used to garner the teacher's and researcher's perceptions of the first-grade students' preferred literacy support tool(s) during independent reading of informational e-books.

2.3 Materials

Informational e-Books Informational e-books from the RAZ-Kids™ website via an iPad. The RAZ-Kids™ website provides print-based leveled books that easily differentiate instruction as well as delivers interactive computer-based e-books with online computer quizzes. There were three reading levels (basic, proficient, and advanced).

Literacy Support Tools The literacy support tools available on the RAZ-Kids™ website were used in this study. A drop-down menu provided access to virtual sticky notes to type annotations; such connections and/or *I wonders* to support their comprehension as they read. The look-back option was available during the online quiz. An icon within the quiz enabled the students to go back in the text at any time. Once they were back in the text, they had access to their previous sticky notes.

Post-reading Comprehension Quizzes At the end of each informational e-book session, the students completed a RAZ-Kids™ comprehension quiz. Each quiz consisted of multiple-choice questions. The number of multiple-choice questions varied depending on the level. For example, Level P had 10 multiple-choice questions, while Level H had five multiple-choice questions. Each multiple-choice question tested a specific skill, which coincided with the Common Core Standards

Grading Rubric for Post-reading Comprehension Quizzes Each correct closed-ended multiple-choice question was scored as one point. Incorrect responses received zero points. The total number of points that could be scored depended on the total number of questions.

Literacy Support Tools Tally System A literacy support tools tally system created by the American Library Association http://www.ala.org/advocacy/advleg/statelocalefforts/snapshotday) was adapted to keep track of what was happening while each student was reading the informational e-book during their independent reading time. The tally system kept a record of the number of times (frequency) that literacy

support tools (annotation tool and the look-back tool) were attempted or completed while reading the informational e-book. The term *attempted* indicated that the student began using the literacy support tool but did not follow through with it until it was completed (i.e., the student opened the annotation tool and began typing a W for *I wonder* but then closed out of the annotation tool before finishing his/her thought). The term *completed* indicated that the student completed using the literacy support tool. A new form was used for each session. Several lines for anecdotal notes were added to the bottom of the literacy support tally system forms. They were used to record specific actions and dialogue that extended beyond the use of the literacy support tools during the observations.

Teacher Interview The teacher was interviewed at the end of the study for approximately 20 min. The interview questions consisted of the following sample questions: (1) Which literacy support tool did your proficient readers prefer when reading *informational e-books* during independent reading? (2) How did your proficient readers feel about using literacy support tools when reading *informational e-books* during independent reading?

2.4 Procedure

During the pre-study phase, the classroom teacher was trained on how to implement the study's protocol with specific guidance on modeling, providing small group practice, and supporting independent reading while utilizing the literacy support tools when reading informational e-books. The participating teacher divided the first-grade students into three reading groups based on their Developmental Reading Assessment (DRA; Beaver 2006) scores, namely: basic, proficient, and advanced.

The next phase consisted of teacher modeling and small group practice with the literacy support tools using e-books. Students took the online comprehension quiz after reading the e-book, but the teacher provided guidance during quiz-taking as students evaluated and answered the questions. Once the quiz was finished, the students discussed how they used the literacy support tools and their reasons for using them at particular parts of the text. At the end of the small group sessions, students read e-books independently at their independent reading level and took the quizzes on their own.

2.5 Data Analysis

To answer the first research question and determine the patterns between the first-grade students' use of annotating personal connections, annotating *I wonders*, look-backs, and their reading comprehension score while reading e-books, a chi-square for independence was used (3 × 5). Variable A was reading comprehension score

(30–33, 34–37, 38–41, 42–45, 46–49) and Variable B was literacy support tool (annotating personal connections, annotating *I wonders*, and look-backs) for e-book. To create the comprehension score categories, the range of comprehension scores for informational e-book was divided into equal groups of comprehension scores. For example, the score of 30 was the lowest comprehension score and the score of 49 was the highest comprehension score. There was a span of 20 between the scores 30 and 49. Therefore, 20 divided by five groups yielded a range of four comprehension scores (i.e., 30–33) in each group. To initially analyze the data, the descriptive statistics for the observed count was compared with the expected count using the adjusted standardized residual.

To answer the second research question, the researcher's anecdotal notes from the observations along with the teacher interview data were used to garner the perception of the first graders' experiences during independent reading of informational e-books. The semi-structured teacher interview was audio-recorded and transcribed by the researcher. During the first cycle coding, the evaluation coding categories that were necessary to answer the research question were determined. During the second cycle coding, the emerging patterns were mapped out and correspondingly coded. The qualitative analyses were reconciled with the quantitative data to find if there were patterns between the first grade student's' use of the different literacy support tools and their reading comprehension score.

3 Quantitative Findings

3.1 Investigating the Patterns Between First-Grade Students' Use of Literacy Support Tools and their Reading Comprehension Score

The chi-square of independence analysis was conducted using the total average e-book comprehension scores with the frequency of use for each literacy support tool during the e-book reading sessions.

The chi-square of independence analyzed the patterns between the student's total average comprehension score and their overall usage of each literacy support tool (i.e., annotating connections, annotating *I wonders*, and look-backs). Table 1 contains observations of the frequency of use for each literacy support tool among four comprehension score ranges when reading informational e-books. There were no student scores that fell within the 34–37 range. The comparison between the observed count with the expected count determined the adjusted standardized residual. The larger the absolute value of the adjusted standardized residual, the greater its considered contribution to the chi-square value. An absolute value greater than two is considered significant. The descriptive statistics presented in the table support the chi-square results. The analysis indicated that there were statistically

Table 1 Crosstabulation of comprehension score total and literacy support tool using informational e-books

	Literacy support tools		
Comprehension scores	Personal connections annotations	*I wonder* annotations	Look-backs
30–33	20	6	0
	(1.8)	(0.4)	(−2.6)
38–41	32	9	6
	(1.1)	(−0.2)	(−1.1)
42–45	62	19	15
	(0.9)	(−0.2)	(−1.0)
46–49	15	9	18
	(−3.8)	(0.2)	(4.5)

Note. Adjusted standardized residuals appear in parentheses below observed frequencies

significant patterns between the total average e-book comprehension scores and the frequency in which participants used the literacy support tools, $X^2(6, n = 211) = 25.79$, $p = 0.001$.

4 Qualitative Findings

An interview concerning the first-grade teacher's perceptions coupled with the observation anecdotal notes verified and determined the students' e-book reading experiences. Three major patterns emerged from the data, namely: preference, ability to use the digital literacy support tools, and an understanding of the relevant application of the tools.

4.1 Rock, Paper, Scissors… Annotation? A Parallel Between Students' Literacy Support Tool Preferences and Reading Level

According to the first grade teacher, all of the first grade students preferred using the digital literacy support tools for annotating more than the look-backs when reading informational e-books. Their interest level while using the tools, as well as the tool they used most frequently, delineated this preference. However, the students at different reading levels (basic, proficient, and advanced) varied in the manner in which they took notes about what was going on in the book. For example, while reading informational e-books, the teacher stated that the basic reader "preferred annotating connections" (Teacher interview, May 23, 2017). On the other hand, the

teacher mentioned that the proficient reader "enjoyed writing *I wonder* statements the most. They had a lot to wonder about" (Teacher interview, May 23, 2017). The advanced reader was consistently using both annotation types (i.e., connections and *I wonders*). However, the teacher declared, "My higher readers enjoyed using the *I wonder* statements. They enjoyed using the different features the iPad had available, so they had more questions to ask" (Teacher interview, May 23, 2017).

4.2 To Write or Not to Write: The Battle of the Keyboard Versus the Sticky Note

The ability to use the tools was the overall theme when annotating using e-books. Primarily, it took the students longer to respond to the e-book when typing on the keyboard than when typically writing on a sticky note. Therefore, frustration became a key component when using the iPad keyboard for all reading groups. The teacher stated, "I think these students [proficient readers] have difficulty with using the tools because it was hard for them to type on the iPad" (Teacher interview, May 23, 2017). For the basic readers, she strongly stated, "My basic readers really had difficulty using the iPads which made it frustrating for them to use the tools correctly" (Teacher interview, May 23, 2017). According to the teacher, the advanced readers "enjoyed using the different features the iPad had available," but she reiterated that they also found it "frustrating when trying to type their answers into the iPads" (Teacher interview, May 23, 2017).

The researcher did not notice frustration when the students were typing their annotations. The students did not make comments or utter disgruntled sounds. In one instance, a student was reading *Weird Bird Beaks* from RAZ-Kids on the iPad. The boy exclaimed, "I wonder how these birds eat" as he flipped through the pages (Researcher's anecdotal notes, February 28, 2017). On several pages, he added virtual sticky notes that addressed each bird's beak. He typed, "This bird's beak reminds me of a spoon," and "I wonder how this bird eats its prey" (Researcher's anecdotal notes, February 28, 2017). Another student read *Country Animals* from RAZ-Kids on the iPad. She wrote comments about all nine of the animals. In her comments, she typed the following annotations: "(1) Nana and Pappy live in the country, (2) My Pappy loves deer, (3) My dad has geese decoys, (4) On animal research, I did a fox" (Researcher's anecdotal notes, January 17, 2017).

The researcher noted in the anecdotal notes that the students questioned one another about their virtual annotations. They shared digital photographs from the text that were interesting, such as the boy eating a spider in the e-book entitled, *You Like What?* (Researcher's anecdotal notes, March 15, 2017), the tree house that looked like an eyeball in the e-book entitled *Terrific Tree Houses* (Researcher's anecdotal notes, March 23, 2017), and the photograph of the Tiger Shark's large mouth in the e-book entitled *Tiger Sharks* (Researcher's anecdotal notes, December 13, 2016).

4.3 First Graders Can Do It!: Making the Connection Between School and Home

The first grade students demonstrated an understanding of the relevance of the literacy support tools [particularly annotation] and further showcased their understanding of the text by making connections to events that occurred outside of the school day. One student read *Where's the Joey?* from RAZ-Kids™. He typed, "I wonder if the Joey is in the pouch?" (Researcher's anecdotal notes, April 12, 2017). The following week, the same student announced that he "saw a baby Joey in the kangaroo's pouch at the zoo and read a paper about the baby Joey" (Researcher's anecdotal notes, April 19, 2017). The first grade teacher stated the following,

> I think using the connections during their reading is most important. The students were able to identify with the text by doing this. The students seemed to carry this information over with them while reading outside of school. The students would share connections they had with books they read at home with mom and dad. (Teacher interview, May 23, 2017).

It was noted in the anecdotal notes that the advanced readers and some proficient readers were using the annotating literacy support tools when reading narrative e-books on RAZ-Kids after they were finished with the assigned informational e-book. They were typing virtual notes as they read about the plot of the story or about a character. One student wrote, "I like the fall" (Researcher's anecdotal notes, April 26, 2017), while another student wrote, "The boy in the story is mean" (Researcher's anecdotal notes, April 26, 2017).

5 Discussion

5.1 Investigating the Patterns Between First-Grade Students' Use of Literacy Support Tools and Their Reading Comprehension Score While Reading e-Books

There were significant patterns between the students' use of the digital literacy support tools (e.g., annotating personal connections, annotating *I wonders*, look-backs) when reading informational e-books. More specifically, the observed usage of certain literacy support tools exceeded the expected usage for certain literacy support tools in specific comprehension ranges. This suggested stronger patterns between that particular literacy support tool and that particular comprehension range. For example, look-backs had a much higher observed usage among the highest comprehension score range than *I wonders* in the same comprehension score range when reading informational e-books. This stronger pattern may be due to the student's reading development.

In the present study, patterns were found to exist between the first-grade students' use of the literacy support tools (i.e., annotating personal connections, annotating *I wonders*, look-backs) and their reading comprehension score when reading informational e-books. The students with the lowest comprehension scores made connections more often than *I wonders* or look-backs to support their comprehension. Making connections is often the first strategy instruction introduced to young readers, since readers naturally make connections between books and their own lives (Harvey and Goudvis 2007). When children understand how to connect the texts they read to their lives, they begin to make connections to the larger world and can ask questions (i.e., *I wonders*) about more expansive issues which dive deeper into the text. This allows the reader to make sense of the important information (Harvey and Goudvis 2007). Students' comprehension scores may have been lower since they were focusing on a general understanding of the text and not on the essence of the text (Harvey and Goudvis 2007). The digital literacy support tools enabled the readers to spontaneously respond to an informational e-book that might have seemed daunting at first, thus providing them a way to annotate bit-by-bit as they made connections to the text. The seemingly small and insignificant connections (or *bits*) actually drew the readers in closer to the text and enabled them to make meaning from the bits as they put them together, thus strengthening the beginning of a series of interactive strategies that encompass comprehension (Block and Lacina 2009). As early readers read for meaning by making connections, they begin to solve problems by asking questions in an independent way, thus transitioning into more proficient readers. The ability to learn from reading (i.e., through connections) in addition to solving problems (i.e., asking *I wonder* questions) independently are characteristics of a proficient reader who is developing his comprehension monitoring or the automaticity in utilizing comprehension strategies (Block and Lacina 2009; Fountas and Pinnell 1996; Rasinski and Samuels 2011). Readers who have acquired this automaticity have become self-extending readers (Fountas and Pinnell 1996).

At the same time, the students with the highest comprehension scores were observed using look-backs more often than connections and *I wonders* when reading informational e-books. These self-extending readers were aware of their thinking as they read and monitored their understanding by making connections and asking questions. Making connections and asking *I wonders* were becoming automatic and less obvious to an observer. However, when something did not make sense, these proficient readers slowed down and looked-back in the text to clarify their understanding (Block and Lacina 2009; Harvey and Goudvis 2007). The look-backs provided students with a *strategic thinking* opportunity to resolve comprehension failures as they evaluated their understanding while they were reading (Zabrucky and Ratner 1986).

5.2 The Perceived Experiences of First-Grade Students' Reading Comprehension of Informational e-Books

The students from various reading levels merged their thinking with the learning they acquired from the literacy support tools (particularly annotation) when they began making connections, asking questions, and responding to their own questions outside of the classroom. Students brought connections or questions into the classroom as well as found answers to unanswerable questions in the text outside of the classroom that came from their daily lives and routines. These text-to-self and text-to-world connections enabled the students to have a richer experience since they were seeing the bigger picture. The students were connecting new information with their existing knowledge. It is critical for comprehension to see the patterns among the elements (Anderson 1984). Therefore, the more connections a reader makes to the text, the better her comprehension (Harvey and Goudvis 2007; Tolvani 2000). When students asked questions and searched for answers, it was evident they were monitoring their comprehension and interacting with the text to construct meaning (Harvey and Goudvis 2007).

The proficient and advanced students also began using the literacy support tools when they were reading during unstructured time. The teacher observed that students were using the annotating literacy support tools on their own when they were reading e-books on RAZ-Kids™ after they were finished with their assignments. These students were monitoring their understanding of the text by using the comprehension strategies to make meaning from the text while adopting the literacy support tools to help document their learning (Massey 2009).

6 Implications for Practice

Given the overwhelming importance of expanding literacy to include new literacies in an online age and increasing the emphasis on informational text, it seems imperative that classroom teachers start utilizing informational e-books to supplement their classroom libraries. The intertwining of informational text and new literacies needs to begin when a child is beginning to develop her repertoire of comprehension strategies when s/he is reading. It is suggested that the comprehension strategies that are used for checking for understanding, identifying a problem, and using the necessary fix-up strategies are modeled and guided during small group instruction (Fountas and Pinnell 1996). During small group instruction, the teacher has the ability to meet the students' varying needs through reading increasingly difficulty texts with understanding and fluency while providing guidance to support them as they construct meaning. It is key that students are provided with opportunities to practice using their comprehension strategies with

both digital and print-based books. Therefore, teachers need to continue to model and guide students on the use of various comprehension strategies with different types of text and/or when confusion is encountered. Although comprehension strategies such as making connections, asking questions, and looking back in the text for evidence are the same for both digital text and print-based text, the literacy support tools that support said strategies require different skills when utilizing them in the different modes (Blanchard and Farstrup 2011; Moody and Swafford this volume). For example, highlighting in a print-based text requires a highlighting pen, while in a digital text, it requires finding the highlighting tool and swiping over the words that are meant to be highlighted.

7 Limitations

This study has several limitations that merit noting. First, it involved a relatively small sample size of first-grade students from one teacher's classroom. Future studies will increase sample size and multiple locations would be beneficial. Second, although the teacher participating in this study had a few years of experience with small group reading using print-based texts, this was her first year using e-books during small group reading as well as implementing the literacy support tools in conjunction with reading comprehension. Therefore, teachers with several years of experience using informational e-books and the literacy support tools may have produced different results. The history threat also posed a problem to internal validity. Some observations were cancelled due to assemblies and other teaching obligations. In addition, at the end of the school year, the first grade teacher had a lot of requirements that took away from the fidelity of the study, such as a student research project, parent/teacher conferences, and finishing a writing unit.

8 Implications for Future Research

With the increasing focus on informational text and technology, it is imperative that more studies focus on the instruction and application of comprehension monitoring strategies and literacy support tools when young students who are entering the early reader and transitional reader stages begin to read informational e-books.

Future studies could also increase the number of participants in the study as well as include students from varying demographics. These studies should include teacher participants with similar teaching practices that serve as models for best practices in primary literacy instruction that includes digital texts, such as e-books.

A longitudinal study that followed a group of participants who continued to have teachers that provided small group practice for using digital literacy support tools when reading informational digital texts throughout their elementary school years

would offer great insight into whether the repetitive use of the digital literacy support tools further supported and increased comprehension scores. It would be interesting to note if the effects of the digital literacy support tools when monitoring comprehension of digital text extended into middle school when the small group instruction stopped.

9 Conclusion

Although more research needs to be done on this subject, this study is an initial attempt to shift teachers' and researchers' views of independent informational reading to include digital text, such as e-books, to supplement the classroom library. There is a plethora of digital resources available to provide early and transitional readers with informational text that is accessible and interesting to the student while recognizing their reading level. In addition, e-books are equipped with digital literacy support tools that can be the vehicles for comprehension strategies when properly modeled and practiced with teacher support.

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Designing Dialogs Around Picture Book Apps

Elise Seip Tønnessen and Trude Hoel

Abstract In Norwegian kindergartens there is a strong emphasis on communication and language stimulation. In this educational context the reading of picture book apps offers an opportunity for extended dialogs, which have great didactic potential in that they integrate language knowledge with cultural knowledge. In this chapter we discuss what dimensions of the picture book text (words and pictures), medium (app on digital tablet) and situation (adult-child relations) that the teacher needs to take into consideration when designing dialogs to encourage early language and literacy development in kindergarten. This work represents the first phase of a major innovation project that will develop a research-based online assessment tool for picture book apps. The part of the project presented here focuses on how different semiotic affordances and technologies may affect dialogic reading. Theoretically, this project is rooted in New Literacy Studies, which sees reading and language as social practices where competence develops in interaction with others. One of the main objectives of our contribution is to present central dimensions within the text, the medium and the situation that preschool teachers need to take into consideration for reading in the digital age.

Keywords Picture book app · Dialogic reading · Shared reading · Digital reading · New literacy studies · Affordances · Language stimulation · Extended discourse

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J. E. Kim, B. Hassinger-Das (eds.), *Reading in the Digital Age: Young Children's Experiences with E-books*, Literacy Studies 18,
https://doi.org/10.1007/978-3-030-20077-0_11

> Six 5-year-old boys and a kindergarten teacher lie on their stomachs in a circle around an iPad. They are about to read *Unni and Gunni travel* [Unni og Gunni reiser]. The app's recorded reading function is turned off, while hotspots that activate animations and accompanying sound effects are turned on. The teacher determines when a page is turned. Each boy has put forward a hand to quickly reach hotspots, as the boy who finds a hotspot first gets to tap on it. While reading, the boys activate the animations nonstop so that sounds of a compass, of whistling, of an engine, etc. accompany the session. The teacher comments on this once by stating "Has he whistled enough now?" The teacher invites to explorative dialogs during the reading, for instance, by stating "We should have had a flying carpet." "Yes" several of the boys respond. "Where would we travel if we had a flying carpet?" "To outer space!" responds one of the boys; "To lava!" answers another. "What are we going to do in space then?" the teacher asks, and the conversation continues.

In this chapter, we explore the potential of apps that perform picture books on tablets and discuss how they may encourage dialogs between children and teacher in an educational setting. The apps we focus on display literary texts that are mainly adaptations of picture books that have already been published in print by established publishing houses. In the process of remediation from print to digital technologies, new meaning resources are added, such as sound and animation, the minimum involving a voice performing the verbal text (Al-Yaqout and Nikolajva 2015). In some cases, there is also an element of gamification whereby the reader is invited to enable additional modes, such as sound effects, or to perform tasks to move the story forward.

Our aim is to discuss what is required to make good use of picture book apps in a kindergarten educational setting. This will serve as a starting point for innovative work that enables preschool teachers to make qualified decisions when preparing digital reading with children. We focus on educational contexts, and readings are envisioned as dialogical to support children's development of linguistic competence as well as literary understanding. We discuss which dimensions of the book (words and pictures), medium (book or app on tablet), and situation (adult-child relations) are essential for dialog based on literary texts to encourage early language and literacy development in kindergarten. After presenting an overview of our selection of picture books, we discuss how to analyze the affordances of the text, the medium and the reading situation designed by the teacher. Based on these dimensions we present a model for analysis, which is then illustrated by an example.

1 Background

When a new medium enters the public scene, it always takes time before it is adopted in educational institutions. This may be partly attributable to the fact that educators must familiarize themselves with a new medium, with how it can be used, and with the forms of texts it may convey to establish new and relevant literacy practices. When touchscreens and tablets were first introduced in January 2010 (in Norway, where this research is conducted, the iPad was first introduced in April 2010), their use spread quickly and particularly among families with children

(MedieNorge 2017). Tablets have introduced digital technologies to new groups of readers and opened new digital venues to very young children who were not already keen users of digital technologies that required the skills of reading and handling a computer mouse. This raises questions about the influence of the medium (see, for instance, Wong and Neuman this volume). The first picture book apps developed by Norwegian publishers appeared in 2011. However, neither tablets nor picture book apps were in common use in kindergartens and schools until around 2015 (Jacobsen et al. 2016, p. 25).

The discussion presented in this article represents the first phase of a major innovation project – "Books and apps: Developing an evaluation tool for e-books targeted towards children" (VEBB). The project aims at developing a research-based online assessment tool that determines whether selected digital picture book apps can facilitate children's language learning during dialogic reading in kindergarten.[1] The project as a whole compares traditional book reading with digital reading. In this chapter, however, we focus solely on digital reading.

The part of the project presented in this chapter focuses on how the use of different semiotic modes and technologies may affect dialogical reading featuring digital media. One of our main objectives is to present central dimensions within the text, the medium, and the situation that kindergarten teachers need to consider when reading in the digital age.

Our discussion is rooted in theoretical perspectives of the fields of education, literature, and media studies and focuses on a selection of apps that we describe in the Methods section below. Our discussion forms the basis for testing the apps in empirical studies in kindergartens where reading sessions are videotaped for close analysis. In this chapter, however, the aim is to uncover relevant dimensions that a kindergarten teacher needs to be aware of in her planning of and practical work with digital reading.

1.1 Literacy and Literature in Kindergarten

Children's participation in extended discourses – in combination with a rich vocabulary – is vital to their language learning and emerging literacy skills (Dickinson and Tabors 2001). Thus, children's participation in dialog during shared reading is central to the use of such resources in educational settings in kindergarten.

In Norwegian kindergartens (Early childhood education care (ECEC) institutions for 1–5 years olds), there is a strong emphasis on communication, language, and text. Note that there are no individual outcomes linked to these educational goals. The national framework plan states that dialog and interaction are central to language stimulation in kindergarten, and that "all children shall be able to participate

[1] The project is funded by the Research Council of Norway (2016–2019): https://lesesenteret.uis.no/category.php?categoryID=19984

in activities that promote communication and comprehensive language development" (Ministry of Education and Research 2017, p. 23).

When young children are introduced to narratives and picture books in various media forms, this can constitute part of the kindergarten's work with children's language learning, depending on the design of the dialog. Literature serves as a good starting point for dialog in that children can activate their own experiences and skills and construct new knowledge (Solstad 2016). Language used in such conversations - when children are active and creative throughout the reading process – tends to be more decentered and decontextualized than children's everyday language. In this way, literature creates opportunities for children's participation in what is referred to as extended discourse (Dickinson and Tabors 2001).

Traditionally, the print book has been used as the main basis of kindergarten reading activities, but with the development of digital technologies, other opportunities for the mediation of multimodal texts have emerged (e.g., apps downloadable on mobile phones and tablets). The tablet has other affordances than the print book, as we elaborate on below. These affordances are also discussed in Brueck, Lenhart, and Roskos' chapter in this book in terms of interactivity, and in Bus, Sari, and Takacs chapter in terms of guiding children's visual attention. In Courage's chapter, she discusses how such features may affect learning and adult-child relations. In this chapter, our main focus is on features of narrative apps promoting children's participation in dialogs.

2 Theoretical Perspectives and Applications

Cross-disciplinary perspectives must be employed when discussing dimensions that involve an understanding of how multimodal literary texts may work for educational purposes in a digital medium. As an outset, we find perspectives from New Literacy Studies (NLS) useful in regard to reading and language as social practices where competence develops in interaction with others. Such interaction takes place within culturally defined frames, which create a basis on which designs and patterns of meaning are made available and on which they are redesigned through active use, according to the interests of the reader (New London Group 1996; Barton 2007; Kress 2003).

2.1 Design

The New London Group (1996) seeks to describe literacy as dynamic processes of design. The term *available design* refers to resources available for design on many levels from socio-cultural conventions of (in our case) reading literature to the grammatical and systematic organization of semiotic modes involved (NLG 1996, p. 74). What is available for design varies through history and across orders of

discourse (Fairclough 1995). In our case picture book apps combine the traditional design of words and images in picture books with new interactive designs of the touch screen medium. Taken into the kindergarten this available design forms the basis for how the teacher can design the reading situation in ways that encourage dialogs. The result of design processes is referred to as 'the re-designed,' which is a new meaning. In the next instance, the re-designed turns into available design for further design processes.

This dynamic view of literacy processes implies that the outcome of any reading event must be understood in the context of immediate reading situations and of broader institutional and cultural contexts. In the case of reading picture book apps in kindergarten, both the conventions of literary reading, and the designs made available via the digital touchscreen medium must be understood within the traditions and contemporary practices of literacy and language stimulation in kindergartens.

2.2 Affordances

This view calls for analytical concepts that will help us study how the semiotic and technological resources of picture book apps can be put in play to inspire dialogs in Norwegian kindergartens. The potential for meaning making in the words and images of a picture book may be described in terms of semiotic affordances. The concept of affordances originates from J.J. Gibson's (1979) theories on visual perception. In the field social semiotics, the term has come to be used in a manner similar to Michael Halliday's (1978) description of language as a potential for meaning. According to Theo van Leeuwen (2005) semiotic affordances concern potential and actual uses of semiotic resources. This means that semiotic modes carry with them the results of 'cultural work' (Vygotsky 1978) over time and the potentials for new and creative ways of making meaning. Gunther Kress (2003) offers some clues as to how these theoretical affordances may be analyzed based on the materiality of various semiotic modes, which shape the ways that they are organized, such as verbal language in a linear stream and images as composition in space. Kress also points to technologies through which different media offer different affordances (Kress 2003).

2.3 Research on Affordances of Text and Medium

In her study of narrative pleasures across media Margaret Mackey's (2011) emphasizes how meaning making from literature, films, and computer games is best understood as an active process. Referring to Wolfgang Iser's (1978) reception aesthetics focusing on the specific reading event, she sees literary reading as "something we perform" (Mackey 2011, p. 1). This understanding of literary reading views the reader as active and as taking part in reading as a form of meaning making.

Ghada Al-Yaqout and Nikolajva (2015) examine which performed actions a picture book app features and distinguish between the performance which is built into the medium (e.g. the narrator's voice) and the performance the readers may conduct in interaction with the medium. In both print books and picture book apps, the text invites children to touch. In print books, this occurs, for instance, when readers explore illustrations. For picture book apps, tapping, touching and tracing (actions resulting in sound and movement of characters or objects) constitute the medium's affordances, which invite active participation in performing the story.

Within the discipline of language learning, several studies suggest that interaction between text (the affordances of the picture book) and medium (technological affordances) has consequences both for children's comprehension and learning of new words and for the adult – group interaction, which is essential for children's language learning.

Several empirical studies have examined the role of technologies in shared reading, e.g. Revelle, Strouse, Troseth, Rvachew, and Thompson Forrester's chapter in this book which discusses how technology may scaffold the adult's interaction strategies. Three meta-studies (Takacs et al. 2014, 2015; Bus et al. 2015) find that interactive affordances may support and deepen children's comprehension of a narrative in similar ways that an adult mediator may support children's comprehension. They also find that interactive affordances may hinder children's comprehension depending on whether interactive elements, animations, sound effects, games, etc. are consistent with a given narrative. In the review article "Children's interactions with iPad books: Research chapters still to be written" (2013), Natalia Kucirkova notes:

> it seems to be the case that in comparison studies, iPad books fare less well than traditional books, but when studied in their own right [in qualitative studies], iPad books are reported to engage children and to have positive effects different from simple digital books. (p. 2)

Also, within the field of psychology, studies have compared the shared reading of print books and digital books. Yuill and Martin (2016) compare how paper and screen media might alter children's shared reading experiences and specifically examine interactions between cognitive, emotional and motor aspects by comparing "interaction warmth" and "postures" – the positioning of the body – of children and adults involved. The results show no differences in cognitive goals, but the authors find that levels of interaction warmth are lower when tablet reading is executed than when print books are read, and they find a marked decline in the time children spend reading from screens. They point out that "the way the device is held has implications for how easy the device is to share, and this can influence the closeness of the interaction" (Yuill and Martin 2016, p. 10).

A small-scale comparative project conducted in Norway in 2014 compared shared reading of picture books in kindergarten with reading of picture book apps (Solstad and Tønnessen 2014). The main findings of this study show both similarities and differences. In response to both media, participating children *negotiated* with the text by asking questions, making comments, and identifying relevant previous experiences. Another common feature involved *playing with the text* or with the

text as an outset. This was observed when children engaged with the text in a playful manner, for instance by acting out dialog, engaging bodily with the events shown in the images, or creating parodies of wording used. Finally, text co-creation, through which potential extensions of what was depicted through characters and events, was observed. In addition, the digital medium inspired children to negotiate on ways to use the medium and to take turns while playing with the medium. Differences were also observed across reading situations in that the digital medium appeared to be less flexible than the book. This applied more to certain apps than to others depending on options made available (e.g., to replace the prerecorded verbal text with an adult reader). Differences between reading from book and tablet mainly appeared as a result of different affordances of the medium, which in turn affected reading practices and relations between adult and child (or group of children).

2.4 Designing the Dialogical Reading Situation

When designing the reading situation, the teacher needs to take the affordances of text and medium into account, but also to consider how to make these available to the children. The teacher acts as a mediator who chooses a text, which offers potential for dialog (Alfheim and Fodstad 2014; Hoel et al. 2011; Mjør 2009). In fiction texts such as picture books, not all is told; there are gaps or openings (blanks) in the text. These openings provide the readers with opportunities for interpretation and they allow the readers to be active co-creators (Iser 1978). Dialogs may be encouraged through themes of the book, illustrations, or written text or through affordances enabled via the medium. Whether using print books or digital books, it is important to make "space" for dialog, and for digital books, such opportunities may be offered through the medium.

When designing the dialog, the mediator both initiates and maintains dialog whereby children contribute their thoughts and opinions (Burger 2015). Invitations to dialog can take several forms, such as open and closed questions, follow-up and clarification cues, questions that extend beyond the immediate context (Smith and Dickinson 1994) and exploratory questions related to the text (Gjems 2007). The mediator may pause to elaborate on a story through what Ingeborg Mjør (2013) refers to as "strategies of expansion." The mediator may linger on illustrations and point to them, give names to objects or ask questions and thereby encourage the children to take part in the dialog and in meaning making. In participating in such dialogs, the children activate their own experiences and skills and thus develop their own knowledge of texts and their language skills. The mediation of text and dialog related to texts constitute key facets of the reading experience; thus, dialog based on literary texts offers great didactic potential in that it weaves linguistic and cultural knowledge together.

Still a larger context also influences the design of situations and dialogs, such as the kindergarten where shared reading is carried out. Several of the studies in this

field examine literary reading executed in dyads; mother – child or teacher – child. Group readings in a kindergarten setting represent other challenges, but also other opportunities.

While previous research seems to focus on educational settings or on literature reading as an aesthetic experience, the VEBB project seeks to combine the affordances of literary picture book texts with the educational value of dialog-based reading for language stimulation in kindergarten.

3 Methods

The VEBB project involves all together 12 kindergarten teachers in six kindergartens. Each teacher carried out four reading sessions, reading two titles both in print book version and app version, with the same group of children. These reading events were videotaped, making the total number of filmed sessions 48. In addition to the video data, the parents, the teachers, and the children have answered questionnaires regarding their interest and engagement in reading, the children's experiences with reading activities at home and in kindergarten, their motivation, access to digital technologies in kindergarten and at home, etc.

The picture book apps we apply were selected for empirical testing in dialogic readings in kindergartens (as noted in our description of the VEBB project above). The aim was to present stories ranging from apps that very closely reflect the books that they remediate, to apps that differ from the book in that they introduce additional modes and activities. This may render the reading experience very different from the experience of reading a paper book. Four stories available as both paper books and picture book apps were selected for a front list, for use in videotaped reading situations for further investigation. In addition, 12 picture book apps (most of them are also available in paper book format) were selected for a supplementary list, distributed to the participating kindergartens to establish a digital reading practice more generally.

Some assumptions were applied in designing these lists. For linguistic and cultural reasons, picture books and apps were selected from apps produced by Norwegian publishers.[2] We sought topics that would interest both boys and girls of ages 4–5 and texts (in an expanded sense) that we expected would generate good and varied dialogs on words and images. We also sought stories using a variety of verbal language from simple words and sentences to more complex language in which the wording might generate curiosity and invite readers to explore vocabulary, metaphors, etc.

The apps were selected based on four categories sorted from most book-like to more independent productions. This process was guided by categories established in previous studies (Tønnessen 2014): (1) visual audiobooks, where basically the

[2] The app *What happened then?* developed by Finnish Tove Jansson is published in Norwegian by a Norwegian publisher in cooperation with the Finnish publisher and a game company.

app adds a performed reading of the verbal text; (2) picture books with additional effects whereby the reader is invited to activate sound effects, animations or other visual effects; (3) picture book apps offering a higher degree of gamification while inviting – and sometimes demanding – the reader to engage in interactivity via digital technologies; and finally (4) digital first productions. These categories come with fuzzy boundaries and were first and foremost designed to ensure variation in the selection of texts. The last category can be criticized for not being logically related, as its only defining characteristic is that the app is not based on a book. We have kept this category for our supplementary list because it demonstrates a time of transition where the new medium remediates traits from former media (Bolter and Grusin 1999). This independence from the book medium raises other principles of narrative organizing than the series of spreads we know from picture books. Hence, this category may include apps inspired by other media, such as computer games (organized into levels) or films (organized as sequences of scenes). Overall, however, there is no logical reason why digital first productions should be qualitatively different from apps of categories 1–3. The titles used are listed and briefly presented in Table 1.

4 Discussion of Relevant Dimensions

4.1 Affordances of the Text

A central feature of the text is the theme. Thus, in our selection of narratives we consider – among other things – how the theme of texts appeals to children's (age-influenced) interests (Appleyard 1991). Interest serves as an important source of motivation and commitment (Hoel et al. 2011), and some themes are interesting to many children due to the way children are positioned in the world. For example, some texts address being small and vulnerable in a dangerous world. All of the texts included in our list present themes that children can relate to (e.g., emotions, different forms of togetherness and friendship). Some of the texts are humorous and some are exciting. When the children's background knowledge and experiences – their pre-understanding (Hoel et al. 2011) – are linked to a text's themes, this creates a solid springboard for meaning making and dialog. In addition, we consider gender orientations included in the texts. We include no texts that are exclusively targeted at girls or boys, as both boys and girls participate in the kindergarten reading groups, though some of the texts may appeal more to one of the groups.

Picture books are multimodal texts wherein verbal text does not normally describe details shown through illustrations. Instead, picture books combine two modes of telling and showing – one verbal and one visual. The actual meaning of such a book is realized through interactions between these two modes of storytelling. Thus, we consider verbal languages, illustrations and the interplay between verbal language and illustrations as basic features of the text. Verbal language

Table 1 Overview of the front list picture book apps sorted from most interactive to most book-like

Title	Story	Iconotext + additional semiotic resources	Interactivity	Flexibility
What happened then? (Moomin) [Hvordan gikk det?]	Series of tableaus from a well-known storyworld (Moomin valley)	Verbal: Rhymes and rhythms	Tap for sound, animation and gaming (find the pearl)	Menu: Read or be read to
		Detailed images	Swipe to see through	Show/hide written text
		Colors illustrating moods	Make drawing	
		Soundscapes		
		Movement		
Yesper and Noper [Jakob og Neikob]	Power and problems of saying yes and no	Stylized images	Tap for sound and small animations	Voice and sound effects on/off
		Sound effects		Record own reading and sound effects
		Theme song		Show/hide written text
		Movement: Small animations		
A fish for Luna [En fisk til Luna]	Philosophical story on language and communication with a flying fish	Detailed images	Last spread only: Tap for the narrator to read "moon" in different languages	Sound on/off (connected voice and soundscapes)
		Fixed soundscapes illustrating moods		Show/hide written text
		Electronic soundtrack designed for the app		
		Movement: Panning and colors		
The seed [Frøet]	On living with divorced parents and soliciting help from a horse to connect two worlds	Detailed images	None	Sound on/off (connected voice and soundscapes)
		Much verbal text		Show/hide written text
		Fixed sound effects		
		Animated transitions between spreads		
		Movement		

should not be so advanced that it comes at the expense of children's comprehension. At the same time, verbal language may provide children with new and challenging ways of using language and of applying concrete, abstract and relational concepts. Some of the narratives included in our list contain little verbal text while others include more. Some texts use poetic language and provide access to rhyming elements and repetitive structures, inviting children to play with language, and some texts explore functions of verbal language such as pragmatics and communication. Some texts invite semantic reflections. One text *When everyone is asleep* [*Når alle sover*] (Houm and Markhus 2011) about a giant coming to town every night to destroy everything, opens with a definition of the word "vandal" as a starting point for understanding the narrative and as an invitation to discuss the meaning of a word. The verbal language of texts thus also provides a basis for dialog.

Images are a vital feature of the picture book text, and they serve as a basis for dialog perhaps especially for children who do not read the verbal text (Solstad 2016). Different illustration techniques and styles, uses of color, visual universes and levels of detail are fundamental to children's interpretation and understanding of – and involvement in – texts. Some of the texts included in our list provide less detailed illustrations while others include highly detailed illustrations. In some texts, pictures build on familiar visual universes while others present a completely new visual universe. In some texts, pictures are dark and mysterious, while in other texts illustrations are bright and spatial. In some texts, images are geometric and simple while in other texts images are detailed and expressive.

This variety of visual languages may create several paths toward dialog based on a picture book text. They may be found in the themes and motifs of the narrative or they may be related to dramatic structures that offer turning points to recognize or wonder about. Other keys may be found in the aesthetic form of images and words in the particular literary ways of showing and saying things. A key element in the design of dialogic reading is to identify openings in multimodal text. Openings can be found in verbal text, in illustrations and in interplays between these. In digital texts, they may also be found in digital affordances, in menu systems and in hotspots that activate elements of the narrative, contributing to the act of making meaning from the text (Zhao and Unsworth 2017). Thus, interactivity is not only a function of technology but also a resource for meaning making. Such actions may become embodied additions to reading and viewing that may again enhance the user's affective engagement. Whether these actions enhance a reader's engagement depends, according to Al-Yaqout and Nikolajva (2015), on whether a picture book app encourages "meaningless shaking and jumping of various static elements" or "cleverly emulates the intricate layout of the book". The latter adapt narratives to the digital medium and add interactive elements that contribute to narratives and that encourage the reader to not only explore but also to become a co-creator of meanings.

4.2 Affordances of the Medium

Technologies shape texts, and in apps, more features are made available than in print books in terms of narrative voices, music, content, and sound effects, motion (animation and camera movements) and interactivity. The apps included in our list represent a range of possible audiovisual and interactive affordances, of which we can assume that some will support children's comprehension while others may not. These affordances also represent gaps in the text - opportunities for interpretation – and may serve as a starting point for extended language and dialog relating to the performance of verbal text or to music's cultural references.

The ways in which we handle this technology also affect the reading. When reading a print book, the mediator following the verbal text with his or her finger may determine the reading direction. Pointing to pictures may also help the reader emphasize actions, identify characters and explore details of illustrations. In an app the touch screen may turn the screen into a semiotic space, defined through programming, e.g. of hotspots. For some picture book apps, a finger touching the verbal text can make the written text invisible, in others this function is accessible from a menu. In some apps, pointing or tapping initiates sound, animations or page turning. The touchscreen's media-specific affordances include finger movements like tapping, holding and panning – adding a tactile process to the continuous interplay between reading, watching, listening and talking. Such finger gestures play a dual-role: navigating on a macro level and activating games and animations on micro level. According to Ture Schwebs (2014), "the physical reader-screen interaction may stimulate a sort of excitement or 'liveliness' as the text comes to life in response to the fingers of the reader" (p. 9). This tactility can be associated with a sensuous experience with the materiality of the screen medium, where the screen experience differs from that with a book and may empower a potential for meaning making.

Another important feature of the medium lies in its flexibility; thus, we have assessed flexibility levels in our selection of apps (see Table 1). Can one determine independently whether to use recorded readings, music, contentum and sound effects, or motion (animation and camera) and interactive elements? Are all sounds removed when one chooses to read oneself rather than using the recorded reading? Such elements of flexibility could have a major impact on the space for and the design of dialogs.

4.3 Designing the Reading Situation to Facilitate Dialog

The design of the reading situation constitutes a crucial facet of designing dialog. Based on their knowledge of children's interests, language skills and relational conditions, kindergarten teachers create reading groups. These reading groups are revised and changed depending on each child's participation, commitment and mastery. Due to staffing standards of Norwegian kindergartens, shared readings are

conducted in groups and often with at least six children in each group. This has an important influence on the design of dialogic reading, because when six children are involved not everyone can see the text as well or from the same perspective, and not everyone can touch the paper or screen to the same degree. The teacher must take this into consideration.

The teacher selects the time and place for reading – away from noise and distractions from surrounding areas – and considers where his or her children should sit to optimize their view of the text and access to the medium. When the text presented is digital, the mediator must also determine whether or to what degree she or he will use menu settings offered in the app.

Shared reading in kindergartens offer certain advantages, such as the opportunities to provide all children – with different backgrounds and experiences – with vital language experiences in taking part in extended discourse. Still, literary text, which for a tablet is designed to be used by one person at a time, may not be used to its fullest potential. In groups, the kindergarten teacher can choose to address this by not using selectable narrative units like narrative voice or animations. In turn, the children cannot take advantage of fundamental affordances of the app, but they can still participate in shared reading activities.

Underlying the design of dialog is the aim to promote children's participation in extended discourse. It is the teacher's responsibility to involve the children in a dialog by encouraging the examination of illustrations, by asking questions about the story told or about prominent words in the verbal text and by allowing the children to recall their own experiences and to draw connections on what is being read. The teacher can prepare for this task by familiarizing him or herself with the book being read (themes, language used, illustrations, openings in the text) or by even preparing (exploratory) questions to extend the dialog beyond the immediate context. It is equally important to remain responsive to the children's own inputs and questions during the reading. Child readers often notice and value other things than adult readers (Hoel 2015). In this way, the design of dialogs with picture book apps deals extensively with being responsive and open to children's interests and associations and with improvising when the dialog embarks in new and perhaps unforeseen directions.

5 A Model for Analyzing Picture Book Apps as Available Design for Dialog-Based Reading

In summing up this discussion, we conclude that a model for assessing picture book apps for use in dialog-based reading for language and literacy development in kindergarten must account for three main dimensions:

1. *The affordances of the multimodal text*. Analytical questions that may apply first and foremost concern the narrative: do motifs in the story seem relevant to the child readers, and will themes create an interesting starting point for dialog?

Does the dramaturgy offer surprises and excitement? Furthermore, what are affordances of the verbal language used: Does it offer new vocabulary, specific forms of poetic language, or wording to wonder about? Are there gaps and missing or unclear pieces to talk about in the verbal or visual mode or between modes?

2. *Affordances of the medium.* How is the digital picture book app different from the picture book it remediates? What modes and tasks are added, and how are they integrated into the plotline and into storytelling? What bodily engagements with the tablet are afforded? Does the medium offer alternative means of reading a story (e.g., following a story line, independent play cued through a story, or more subversive ways of reading)?
3. *The reading situation.* How does the design of reading situation, (e.g., group size and organization) affect the instantiation of semiotic and technological affordances of an app? Rather, what may be missed when (some) children do not have access to the screen? Is the picture book app format suited to repeated reading, and what influence may previous knowledge of apps and/or books and of the story world have on the dialogs in the reading situation?

6 Case Study: Yesper and Noper in the VEBB Project

The app entitled *Yesper and Noper* [*Jakob og Neikob*] (Stai 2011) is based on a picture book written by Norwegian author and illustrator Kari Stai. Through the story, readers become familiar with Yesper and Noper who live together and are friends. Yesper always says 'yes', and Noper always says no. However, when Yesper fills the house with lamps and drums, he must build his own house, and eventually he must move. Yesper grows bored and tries to get Noper to join him to do something nice. He succeeds, and the friends embark on a road trip on which they experience strange things.

6.1 Affordances of the Text

Friendship and friendship conflicts are highly relevant motifs among child readers. Children can draw on their own experiences with friendship and quarrels when talking about the motifs in *Yesper and Noper*. The dramatic nature of the story may also lead to excitement. Tensions rise when it appears that Yesper is unable to stop a thief (Fig. 1), and they are eaten by a crocodile they meet on their road trip. The story comes to a climax when it turns out that their problems are solved by Noper's capacity to say 'no!' The story is characterized by its exploration of language (double-negatives), and the plot is built around the dichotomy of Yesper's "YES", and Noper's "NO". This is what gets them both in and out of trouble. In this way, the story invites dialogs on language and language use.

Fig. 1 Spread number 15 in Yesper and Noper. The written text says: "They see a hitchhiker by the side of the road. Noper thinks that he looks suspicious. The hitchhiker asks if he can hitch a ride to another country. 'YES,' Yesper says." (Screenshot reproduced with permissions from Kari Stai and Samlaget)

6.2 Affordances of the Medium

Through the app, one can determine whether to see the written text (yes/no) and activate sound effects (yes/no) and whether to have the text read aloud (yes/no). One can also record one's own voice and play a game with illustrations from the book. Illustrations shown in the app are the same as those of the paper book, but they are sometimes customized for digital formats through the use of close-ups and camera movement. In using the app, the reader can tap to turn the page. In addition to verbal text, illustrations, a little melody (that characterizes Yesper and Noper) and the possibility for read aloud, the app also offers simple additional effects. Tapping things initiates sounds (drums, car driving), simple animations (lights on and off, buns that are eaten) and expressions/sounds from the characters ("Do you want to buy a lamp?"). With the exception of the inscription on Yesper's hat saying "Press me!" and on Noper's saying "Not me!" (see Fig. 2), no visual markers of the many hotspots are included. This invites readers to explore the illustrations with their fingers while searching for sounds and movements, although it is questionable to what extent these activities are well integrated or contribute to the narration of the story. In the VEBB project, the teachers were free to choose how they wanted to facilitate the children's interaction with the medium. Some teachers explored the hotspots in the text together with the children, while others made the device available for the children to tap one at a time.

Fig. 2 Opening page of the app *Yesper and Noper*. (Screenshot reproduced with permissions from Kari Stai and Samlaget)

6.3 The Design of the Reading Situation

> Six children are sitting on a low bench and opposite to them, the teacher sits and shows up the tablet. They are reading *Yesper and Noper*, which they know from an earlier reading of the print book version. The app's prerecorded reading function is on and while the professional narrator reads, the teacher emphasizes with her facial expression that Jakob is sad. The teacher has selected some hotspots that are closely linked to the story, and when the narrator's voice is finished, she invites the children to press these, one child at a time. Afterwards, she asks questions. Sometimes the children retell what is happening in the story, and sometimes the dialog becomes more associative, like when she asks "What would you do to make friends again?"

The *Yesper and Noper* app – to a greater degree than its paper book counterpart – invites bodily interaction with the medium (to press Yesper and Noper and make them say "Yes" or "No" and to search for hotspots on the screen). When facilitating kindergarten reading groups, a teacher can organize his or her group of children differently. One option is to encourage all children to tap on the screen and to explore the affordances of the medium. We present an example of this approach in the beginning of this chapter: six boys and a teacher lies in a circle around an iPad reading a picture book app, and the child that finds a hotspot first gets to tap it. This scenario also invites participation in conversations even though the children are very keen to explore the medium and to maximize their chances of touching the screen. Another option is to allow the children to take turns exploring and tapping on the hotspots. This calls for a stricter regime whereby the teacher is responsible for initiating and maintaining a dialog and for allowing the children to take turns in ways that they perceive to be fair. It is also possible for the teacher herself to interact with the screen, and let the children watch, or for no screen interaction to occur during a particular reading. In such cases, children will miss out on some affordances of the medium, but their participation in extended discourse may benefit from this.

Yesper and Noper can be read in different ways. The visual simplicity of the app and its use of contrasts, drama and humor with complex linguistic points might make it easier to find subjects for conversation once children have found where all of the hot spots are hidden. Eventually, it may also contribute to the 'liveness' of the reading experience to have Yesper and Noper answer "yes" or "no" at the exact point where it fits in the story. In this way, the children's interaction with the medium can create engagement and help move the story forward.

7 Conclusion

One of the main objectives of this study has been to present central dimensions of texts, media and situations that kindergarten teachers need to take into consideration for reading in the digital age. As the example analyzed above shows, a nuanced assessment of how a picture book app may be suited for dialog-based reading in kindergarten needs to cater to a variety of stories, literary forms and performative options through the reading situation. A few dimensions stand out across our example:

- A story told through words and images must be relevant to children's life experiences. This connection to lived experiences does not need to be realistic to spur recognition, but at some level, transferable features of characters and events are vital to inspire child readers' interest and engagement. The interest may also be connected to the aesthetic forms of words and images, where gaps and indeterminacies offer openings to be filled through the dialog around the reading.
- Picture book apps on touchscreen tablets create opportunities to take part in and perform text by activating semiotic resources (e.g. sound and movement). A central feature to assess concerns to what extent this activity is well integrated into the narration of the story, and whether it closes or opens reading experiences to further exploration and dialog. This is also a question of flexibility as related to options available through an app menu.
- Touchscreen tablets used in kindergartens enter an institutional practice where group reading, at least in Norway, is the only practical option, as opposed to use in private homes where tablets are normally used as media for single users. The teacher needs to assess whether the picture book app will work well in all its functions in an institutional setting. This involves assessing how well the app may work without activating interactive features, or how the reading situation may be designed for one child to engage in interactive options on behalf of the group, or for children to take turns. It is also essential to consider how the reading of a specific picture book app might differ through multiple readings, as children's attention may be drawn to different affordances of the text and medium as they are offered opportunities to explore, discuss and become acquainted with the app.

Acknowledgements We would like to thank our colleagues in the research group responsible for choosing and analysing the apps used in the VEBB project, Professor Terje Hillesund, Associate Professors Margrethe Jernes and Trine Solstad and PhD Candidate Marianne Larsen Undheim.

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Practical Strategies for e-Book Use in Early Childhood Classrooms (K-5)

Amelia K. Moody and Jeanne Swafford

Abstract This chapter examines current e-book research and practices and offers strategies for e-books use in early childhood settings (K-5). Results of a survey and in-depth interview data are provided and analyzed to offer a picture of why and how e-books are used in classrooms. Specifically, the chapter outlines which e-book features support early literacy development and assessment in classrooms. Benefits of e-books for both students and teachers are outlined. Finally, evidence provided by e-books users is examined. Findings indicate that patterns in how teachers are using e-books in the classroom are emerging in the research, however, some areas require further investigation.

Keywords e-Books · Reading · K-5 education · Classroom application · Scaffolding · Teacher benefits · Student benefits

Teachers often search for ways to keep their students engaged and excited about reading in order to build essential literacy skills. Universal Design for Learning (UDL) is a framework that offers guiding principles for educators about effective ways to enhance learning in classrooms. UDL promotes multiple means of representation (What is learned?), expression (How can knowledge be expressed?), and engagement (Why is it important to the student?) (Center for UDL 2018). Many electronic books (e-books) are designed with this framework in mind. For example, e-books may incorporate highlighting of the text and animations as multiple means of representation. They record oral readings and offer comprehension and vocabulary quizzes to provide multiple means of expression. Finally, e-books offer multiple means of engagement by offering reading incentives and reinforcers. These UDL principles also align with current research in reading including the use of reciprocal teaching, digital text comprehension, and engagement (Dalton and Proctor 2007).

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J. E. Kim, B. Hassinger-Das (eds.), *Reading in the Digital Age: Young Children's Experiences with E-books*, Literacy Studies 18,
https://doi.org/10.1007/978-3-030-20077-0_12

There are assertions that teachers can capitalize on children's motivation by teaching language and literacy skills, using electronic media (Brueck et al. this volume; de Jong and Bus 2002, 2003; Fisch et al. 2002; Jones and Brown 2011; Moody et al. 2010; Talley et al. 1997; Tønnessen and Hoel this volume; Verhallen et al. 2006). Current research contends that the use of electronic books will grow because e-book libraries are cost effective (Girmscheid and Genco 2015; Light Sail Education 2016). While there is growth of e-book use in schools, it is not happening at the expected rate. Teachers may not understand the benefits and challenges of including e-books in their classrooms to assist with instruction and assessment.

In this chapter we describe results of a recent study and integrate evidence from the literature that reveals the benefits of using e-books for students and teachers for supporting literacy development. Also discussed are the ways in which teachers use e-books and the challenges students and teachers may face. Finally, we review relevant information about how to select e-books that meet both teacher and student needs in the classroom and discuss the importance of research that bridges the gap between research and practice to address effective methods for using e-books in the classroom.

1 e-Book Use

In the Fall 2017, an electronic survey was conducted using a convenience sample of K-5 teachers ($N = 46$) in the United States to find out the extent to which teachers use e-books and what their use looks like in the classroom setting. The teachers who completed the online survey were enrolled in graduate programs at a local university or attended a local reading association meeting. Approximately 45% ($n = 21$) of the teachers had taught 12 years or more; 14% ($n = 6$) had taught 8–12 years, 22% ($n = 10$) taught 4–8 years, and 19% ($n = 9$) were beginning teachers (i.e., 1–3 years of experience). About 64% ($n = 30$) of the teachers taught grades K-3. The other teachers ($n = 16$) taught in grades 4–5. Seventy percent ($n = 32$) of the teachers who completed the survey reported that they used e-books. The findings are discussed throughout the chapter.

In addition to the survey, two in-depth interviews were conducted to gain details about effective tools and useful features of e-books. One of the teachers interviewed was a third grade teacher and the second was a kindergarten teacher. Specific themes emerged and those findings are integrated into the supporting research discussed in this chapter.

2 Picture of e-Book Research in Classrooms

Educators are working to integrate the use of technology into the classroom in an effort to better meet the individual needs of their students. e-Books offer scaffolding features that can be customized (Pisha and Coyne 2001). These include embedded

supports that can foster comprehension (Dalton et al. 2002; Herman and Ciampa this volume), print referencing (Moody 2010), vocabulary (Proctor et al. 2009), and progress monitoring (Hall and Murray 2009). This differentiation can benefit individuals who struggle with reading engagement and achievement.

Our survey data suggested that teachers used e-books in a variety of ways. The contexts in which teachers reported using e-books were for independent reading (78%), a learning center activity (68%), and for small group reading instruction (43%). One third of teachers reported using e-books for whole class instruction. When analyzing data from the survey and interviews and combining them with current evidence on e-books, some key themes emerged. These themes can be organized into two categories: student benefits and teacher benefits.

2.1 Student Benefits

Teachers reported a number of benefits when using e-books with diverse students in the classroom (see Table 1). These included increased reading engagement and scaffolding features. These tools can serve to promote repeated practice and greater exposure to books and reduce the cognitive demands of reading (see McKenna et al. 2003; McKenna and Zucker 2008; Zucker et al. 2009b). In the following sections, we discuss the ways e-books can benefit students' reading.

Reading Engagement Current research indicates that electronic media can motivate children to engage in literacy activities. Sometimes the features of e-books (e.g., dynamic visuals, auditory and visual supports, multiple means of representation) increase students' reading engagement (de Jong and Bus 2002, 2003; Fisch et al. 2002; Jones and Brown 2011; Moody et al. 2010; Talley et al. 1997; Verhallen et al. 2006). Huang and Liang (2015) indicated that many children who choose e-books possess the ability to use digital devices and prefer to read with them (Liang and Huang 2014). This literature corresponded with the view of the survey participants. Approximately 83% of teachers used e-books because they were engaging to their students.

The interview data offered additional perspectives about which features were most engaging for students. One teacher explained that many of the students he taught in rural North Carolina did not have access to electronic media at home, so

Table 1 e-Book benefits for students

Encourages engagement/motivation to read	Supports independent reading
Scaffolds comprehension	Promotes vocabulary development
Supports decoding and word recognition	Supports multiple means of representation
Offers access to leveled books	Provides access to varying genres
Supports reading at home	Helps alleviate roadblocks students may face
Fosters self-assessment	

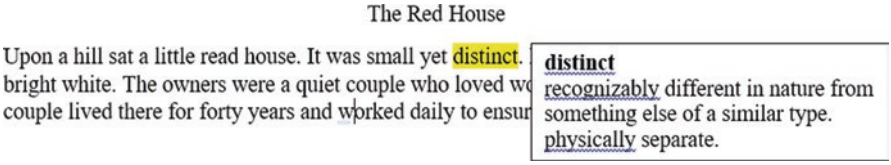

Fig. 1 Dictionary and highlighting functions

reading e-books at school was engaging for them. He also observed that many students were motivated by e-books' reinforcers (e.g., earning parts to build robots and rockets), which they received if they successfully completed the comprehension activities. In addition, when students had access to variety of e-books they were more likely to find books that interested them. Much research (e.g., Gambrell 1996; Ivey and Broaddus 2011) has shown that students read more when they choose books to read, rather than when teachers assign texts.

Different features offered in e-books can contribute to student engagement. For example, Moody (2010) found that hot spots can contribute to student engagement. Animations and extension activities are other examples of features that can get children excited about reading and promote independent reading.

Scaffolds That Support Independent Reading Literacy experts agree that e-books provide various scaffolds that support students' independent reading. These supports assist with a myriad of challenges that students face when trying to read (Herman and Ciampa 2017; Moody 2010). Interestingly, the respondents in our study also found e-books serve this purpose. More than 70% (n = 33) of teachers noted that scaffolding supports provided needed assistance to promote independent reading. About half of the teachers (n = 23) reported that dictionary and highlighting functions, for example, allowed their students to read independently (see Fig. 1). These features can also support students when reading at home.

The versatility of e-books also made them useful for teaching small and large groups of students. For example, interview data indicated that some teachers project e-books onto Smartboards, in place of using big books, because the text can be enlarged and words tracked using a pointer. Because all students can clearly see the print in e-books, they can be used for shared reading and print referencing. e-Books also provide students with opportunities to explore concepts about print, identify sight words, practice other beginning reading skills, and provide access to similar information on different reading levels. Discussed below are the kinds of support teachers reported e-books can provide for students: narration, decoding, vocabulary, and comprehension.

Narration Supports Narration supports are found to increase children's motivation to read (Liang and Huang 2014). Auditory supports, such as read aloud features and voice-overs paired with print text, provide children with the opportunity to follow along with the words on the page (Moody 2010), which can increase print understanding (Zucker et al. 2009a). The teachers we interviewed reported that

narration can be a helpful tool for struggling readers who are learning fundamental reading skills. Narration can also support the development of print concepts so students may explore texts more independently.

Decoding Supports Word pronunciation features can assist readers who are unable to decode text by providing modeling and pronunciation. Researchers investigated the use of text-to-speech features on young children's word recognition and found positive effects (Karemaker et al. 2010; Olson and Wise 1992). One of the teachers we interviewed revealed that he appreciated the immediate feedback his students received from the e-books. For example, if a child did not know how to pronounce a word, she could highlight it and listen to the pronunciation. Teacher interview data also revealed that word pronunciation features assisted emergent readers with decoding and could be especially helpful for English Language Learners (ELLs).

Vocabulary Supports Hot spots can also support language and vocabulary development (Smeets and Bus 2012, 2015; Verhallen et al. 2006). In some cases, students may recognize a word and its meaning when the word is read aloud to them, but they may not recognize the word when they are reading silently. As noted above, hot spots can provide the pronunciation of words, which may also support the development of a child's reading vocabulary. This feature can also be helpful for ELLs (Verhallen and Bus 2010) and beginning readers looking for word meaning (Verhallen et al. 2006). According to Kame'enui and Baumann (2012), vocabulary instruction can improve students' listening, speaking, reading, and writing vocabularies.

Comprehension Supports Not only does research indicate that e-books enhance students' vocabulary knowledge but e-books can also boost student comprehension (Doty et al. 2001; Greenlee-Moore and Smith 1996; Korat and Shamir 2004; Matthew 1996; McKenna et al. 1997; Roskos and Burnstein 2012; Shamir and Shlafer 2011; Segers and Verhoeven 2003). Findings suggest that hot spots used effectively can support students' comprehension of story content (e.g., the text says "the rabbit runs" and animation shows the rabbit running) (Korat et al. 2014; Underwood and Underwood 1998). One teacher we interviewed noted that the particular e-book system he used provided support for students in regard to comprehension. For example, if a student took a comprehension quiz, she received feedback when an answer was correct or incorrect. If an answer was incorrect, the e-book prompted her to revisit the text and answer the question again. This feature can support students as they learn to find evidence in a text, which is a valuable skill emphasized by CCSS and other state standards.

It is important to recognize that some of the scaffolds described above may not fully alleviate all the roadblocks students face, however, they can provide support students need as they practice reading independently. This finding leads to some of the teacher benefits reported by e-book users.

2.2 Teacher Benefits

Hutchison and Reinking (2011) conducted a survey of teachers' beliefs and practices related to the use of information communication technologies (ICT), of which e-books are a part. Although their findings were not specific to the use of e-books, they suggested that teachers were not integrating ICTs into reading and writing instruction. In contrast, global e-books sales, indicated that e-book use is on the rise (Rüdiger et al. 2016) and Lam et al. (2010) speculated that as e-books become more available, their use will increase. In our 2017 survey and interview findings, a large majority of teachers revealed they used e-books on iPads and computers. These data may suggest an emerging trend in e-book use as the prevalence of digital devices increases in schools.

In our research, teachers reported a number of ways e-books benefit them and foster their use of e-books. To learn more specifically about why teachers use e-books, we also referred to interview data. Benefits included the following: access to books, student independence, assessment tools, and streamlines literacy instructional time (see Table 2).

Access to Books When examining global e-books sales, data indicated that e-book use was on the rise and prices were decreasing (Rüdiger et al. 2016). Teachers often search for economical options to increase book access at school. Interview data indicated that some e-book subscription systems provide access to several copies of a single title, which decreased costs compared to purchasing several hard copies of books. These data are in agreement with findings that teachers are using e-books to provide students with access to various online resources (Lam et al. 2010).

Benefits reported by teachers focused on how e-books and e-book systems (e.g., Learning A–Z) facilitated classroom literacy instruction. When teachers have access to well-designed e-books, written at varying levels, they can better differentiate instruction. This increased access facilitated small group instruction, which 43% (n = 20) of survey respondents reported as a reason why they used e-books. Access to multiple copies of the same book can also expedite small group book clubs, which provide a different context for small group instruction, particularly for those students who can read more texts independently.

Table 2 Benefits of e-books reported by teachers

Economical alternative	Provides a variety of assessment tools
Provides access to appropriate reading materials that support differentiated instruction	Supplements face-to-face assessment administration (records, analyzes, organizes results)
Monitors individual progress in various aspects of reading	Offers flexible scaffolding to facilitate independent reading
Promotes independent reading	Encourages collaboration between the students
Streamlines management of literacy instruction	Supports independent student research

Fig. 2 Child reading an e-book of her choice at home from the Raz Kids collection. (Permission granted by Heidi Higgins)

Access to e-books that represent high interest topics, different genres, and culturally relevant texts provide teachers with a variety of titles to better match student interests and reading levels. Furthermore, when students have more access to a variety of books, they are more apt to read on their own, which is an important activity for literacy development. Some online systems provide student access to e-books wherever students have access to a digital device (see Fig. 2).

Fosters Student Independence Typically literacy instructional time involves not only teacher-led small group reading instruction but also incorporates independent tasks and/or student-facilitated instructional activities. For example, learning stations, that include such activities as independent writing, oral reading, independent reading, word work, and research, offer uninterrupted time for the teacher to work with small groups of students and/or to conference with individuals.

Teachers in our study reported that they provided varying amounts of time for students to read e-books independently. Of the teachers who completed our survey, approximately 43% (n = 20) set aside about 15 min each day for students to read e-books. In contrast, 68% (n = 31) of teachers reported they set aside more than 15 min each day to read traditional books in the classroom. One teacher reported he set aside approximately 20–25 min, 4 days a week, during the reading instructional block, for students to read e-books independently.

e-Books also provided teachers with more uninterrupted instructional time because many of the books provide flexible scaffolding for students as they read (see Sect. 2.1 and Table 1). For example, if students run across an unknown word, they can request pronunciation of the word or a definition to clarify meaning. Features such as these facilitate student independence.

Assessment Tools In order to plan appropriate, differentiated instruction for all students, teachers need up-to-date assessment data. Some e-book systems provide a variety of assessment tools that can help teachers better plan instruction.

Recent survey research on e-book use by teachers indicated that teachers benefit from using assessment features of e-books because data is stored in one place and offers immediate feedback. The teachers we interviewed noted the benefits of

having several available assessment options and the convenience of easily accessible results. For example, a read aloud recording feature can provide teachers a tool to check-in on a student's oral reading more often than she may be able to do in a face-to-face context. The teacher can simply assign students the option to independently record their oral reading. Then, at a later time, the teacher can listen to the recordings and make additional notes, if needed. In addition to the read aloud recording feature, some systems also analyze a students' oral reading and organizes data for the kinds of cues (i.e., visual, semantic, or syntactic) students used, word count, speed (WPM), error rate, self-correction rate, and text accuracy. These data provide teachers a summary of skills at a glance, which can facilitate appropriate reading instruction.

Some systems provide a variety of reading comprehension assessments and an analysis of comprehension skills that students use when reading orally or silently. They not only keep track of comprehension test scores but also alert the teacher if there is a pattern of the kinds of questions with which a student struggles, valuable information when planning differentiated instruction for each student.

Other assessment tools that can assist teachers with tailoring instruction for specific students include systems that keep track of words for which students requested electronic assistance (e.g., pronunciation, definition). Some systems also keep track of the books students read. This data can provide evidence that a student may need to read books outside a particular series or genre, for example.

Although many e-book systems provide important assessment data, researchers do not recommend that these tools be used exclusively or replace face-to-face assessments teachers conduct. However, the assessment tools and analyses can provide a way for teachers to check-in more frequently with students they are most concerned about. Thus, some kinds of e-book assessment tools can help teachers more efficiently collect data needed to develop appropriate, differentiated instruction.

Streamline Instruction Managing differentiated literacy instruction for 20–25 students is much like directing an orchestra. Musicians play different instruments, and they each have a distinct part to play. Individuals must practice independently but they must also practice in collaboration with their peers. When everyone plays their parts and the orchestra is directed efficiently and effectively, the orchestra produces a harmonious melody to which everyone has contributed.

Literacy instruction must be well-orchestrated, and teachers need ways to meet the instructional needs of each student. The use of e-books can streamline the management of literacy instruction. Because students in a single class will possess varying literacy skills, strategies, and interests, access to a variety of books and other instructional materials written appropriately for all readers is imperative. To plan for instruction and determine which texts to use for instruction, teachers must know each child's strengths, areas for improvement, and interests. Assessment data provided by each child, analyzed by the teacher, and then used to inform instruction is imperative. Effectively orchestrating literacy instruction is only possible when students can engage in literacy activities independently and alongside their peers.

e-Books, which provide scaffolding for students during reading, are essential so teachers can work with small groups or with individuals. e-Books may also allow readers to monitor their reading fluency, accuracy, and comprehension.

Examples of literacy instructional activities that must be orchestrated in an elementary school classroom are described below. One group of students may be working with the teacher and reading a common e-book. Although the teacher will have collected initial assessment data to form groups and plan instruction, she can also assess students' skills, on the spot, and provide needed instruction immediately. At the same time, with no direct teacher supervision students in another group may be working at a Listening Station, where they are engaged with an audio e-book, and still others may be reading different e-books on individual digital devices. During literacy-focused instructional time, typically students practice reading books considered to be on their reading level. However, allowing students to read books of their choice is also a worthwhile and engaging practice for promoting literacy development.

Other learning stations in which students may be engaged during literacy instruction time may include a Writing Station where students are provided with materials and opportunities to write and conference with peers and/or the teacher, an Interactive Station where students may play reading games, and a Research Station where students use iPads, books, and other materials to research topics that particularly interest them.

Teachers in our study reported they use websites, such as EPIC! Books for Kids and Ducksters, to support individual and small group research because they provide digital materials, in a wide variety of formats and topics about which students may be interested (see Fig. 3). For example, if a child wanted to learn about sharks, some websites suggest additional books about sharks that students could explore. Because the materials are accessible online, several students can collaborate by reading the

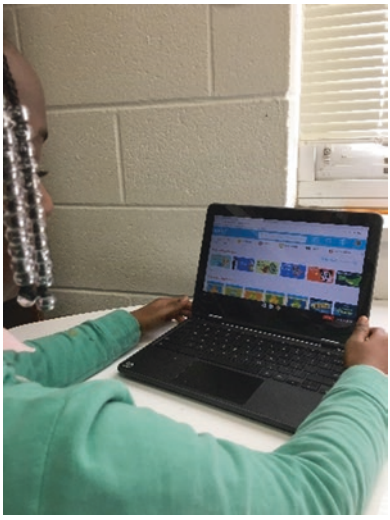

Fig. 3 Student peruses EPIC! for kids to select a book to read independently. (Permission granted by Chase Morgan)

same or different texts. The quality of electronic materials (e.g., books and videos) vary, but some e-book websites include high quality electronic materials, such as those published by the Smithsonian Institute.

Websites, such as EPIC! Books for Kids and Ducksters for Educators, offer free online libraries with an assortment of electronic texts, including graphic novels, books about pop culture icons, and audio chapter books. Although the books are not leveled in the same way as guided reading books, the website provides teachers and students with information about books' appropriate age ranges and lexiles.

3 Challenges for Students and Teachers

Although e-books benefit both students and teachers, they also create challenges. For one, children may lack expertise to use the features of e-books and other digital devices. This lack of knowledge can hinder students' ability to complete tasks effectively and efficiently (McAnulty et al. 2012) and reduces the potential benefits of e-books. Schugar et al. (2013) recommended that students should learn the basic operations of e-books (i.e., turning on the device, understanding and using features, and rules for use) to better support effective e-book use and to support independent reading.

Teachers may find e-book use challenging because of their own lack of knowledge about how to effectively use e-books, the cost of e-books, and how to obtain the technology necessary to support e-book use. Our survey found that 32% (n = 15) of teachers reported they did not use e-books because of a lack of necessary technology in their classrooms, lack of access to e-books, and lack of training about e-book use. Of those teachers who do not use e-books, 50% (n = 23) reported that the biggest challenge was the lack of technology**.** They also noted that the cost of e-books was a factor that contributed to their lack of use. Familiarizing teachers with outlets that make e-book purchases reasonable would benefit teachers. In addition to cost, some e-books are not available for sale but are licensed (Shannon and Leverkus 2014). Since some vendors' licensing regulations may limit access to one patron per book, multiple copies of popular books may not be available (Shannon and Leverkus 2014). This restriction may limit how e-books can be used in the classroom. Therefore, it is important that teachers make sure the e-book library subscriptions they purchase provide adequate access for students.

Approximately 28% (n = 13) of teachers in our survey reported they did not use e-books because of lack of teacher control or monitoring of students' in-progress reading. This finding seems to contradict what some teachers reported as a benefit of e-books. One reason for this may be because all e-books do not provide the same kinds of monitoring functions. It is also possible, as noted by some teachers in our research, that some teachers lack the experience and/or knowledge about how to use effectively the available monitoring features of individual e-books and e-book systems. For example, only one teacher in our study mentioned the use of the read aloud recording feature.

4 What Teachers Should Consider When Selecting e-Books

Digital books offer engagement opportunities, scaffolding supports, and extension features that can support meaningful reading activities. However, teachers need to give careful consideration to determine which e-books best support differentiated instructional goals for each student. Schugar et al. (2013) suggested that teachers judge whether e-books features are strategically placed, how and if the features support the text, and how effectively they extend book interactions. e-Books that allow for flexible use of features will probably be the most useful. Roskos et al. (2009) recommended that teachers need to consider a book's construction and ensure it can promote literacy development by providing vocabulary supports, decoding scaffolds, and plot comprehension supports. For example, English Language Learners (ELLs) might benefit from vocabulary supports, while another child, who lacks adequate decoding skills, may benefit from animations that support the storyline. Selecting e-books that provide the particular kinds of support individual students need is no different than carefully choosing appropriate traditional print texts. Thus, how teachers intend to differentiate instruction for particular students should influence e-book choice.

Similarly, teacher needs can influence e-book choices. If teachers need to assess a students' oral reading, they might utilize an assessment tool that records and analyzes oral reading. If a teacher is interested in progress monitoring a child's comprehension, another tool with built-in quizzes and an analysis of the results might be more appropriate.

e-Book architects also recommend that it is important to select e-books that purposefully embed auditory and visual features, which positively impact the overall message of the e-book (http://E-bookarchitects.com/learn-about-E-books/enhanced-E-books/). When selecting books with auditory features, such as voice reading of the text, it is important that the audio match the written word. Auditory features also increase accessibility for users who are unable to read the text independently or users with visual impairments. Furthermore, they can be paired with other accessibility programs (e.g., enlarging text).

Teachers also need to be aware that some features of e-books can actually divert readers rather than support them (Labbo and Kuhn 2000; Takas et al. 2015; Trushell et al. 2003). For example, hot spots and games that are not intricately related to a story may interfere with reading (see Takas et al. 2015).

5 What Populations Are Best Served by e-Books?

One item on our survey asked teachers what populations benefited the most from e-book use. Generally, they believed that all students benefit. Specifically, 80% (n = 37) of the teachers believed that e-books benefit typically developing students and those with learning differences, 60% (n = 28) believed highly advanced readers

Table 3 Ways e-books can be used with various student populations

Authors	Population	Features used	Reason
Coyne et al. (2012)	Intellectual disabilities	Scaffolding supports	To build word comprehension and phonological awareness
Schugar et al. (2013)	Typically developing students	Bookmarking, annotating, and highlighting	To summarize and retell stories, to monitor comprehension
Segers et al. (2006)	Autism spectrum disorders	Scaffolding supports	To build vocabulary
Shamir et al. (2010)	At-risk (i.e., low SES, immigrant status)	Animations and pictures	To build vocabulary and phonological awareness

benefit from the use of e-books, and 70% (n = 32) believed that e-books are beneficial for ELLs. One interviewee reiterated these findings by explaining that e-books benefit a diverse population of students. For example, some e-book systems provide leveled books for students who are still developing their reading skills. Access to these books is important so students can experience success, which builds reading confidence. Other systems provide a wide variety of high-interest fiction and nonfiction books, which provide students with different interests, access to texts that are engaging to them. Although all e-books are not categorized by specific reading levels, appropriate age ranges and lexiles often accompany the texts. It is important to note that children should not be restricted to only reading books on a particular level but should also be encouraged to explore books that interest them. Oftentimes, students can read more complex texts when they are passionate about a topic and have a well-developed schema for that topic.

A growing body of literature identifies how e-books benefit different populations of learners (e.g., typically developing students, those at-risk, and those diagnosed with disabilities), particularly in relation to scaffolding features often included in e-books (see Table 3).

Schugar et al. (2013) investigated e-book reading behaviors in typically developing students; results indicated they used bookmarking, annotating, and highlighting to assist them with tasks such as summarizing. Researchers often found that children at-risk for reading failure due to low socioeconomic or immigrant status also improved their literacy skills, despite language delays, through the use of e-books (Korat and Shamir 2007; Littleton et al. 2006; Moody et al. 2010; Shamir 2009; Verhallen et al. 2006). Shamir et al. (2010) used a randomized design to measure vocabulary, phonological awareness, and print knowledge in children ages 5–7 years old and at-risk for learning disabilities. Results indicated that children in the e-book condition performed significantly higher on vocabulary and phonological awareness measures than in the adult read aloud condition. Similar positive outcomes were highlighted by Korat et al. (2013) who found increases in word comprehension and phonological awareness in comparable populations when e-books were compared to traditional print text.

Research about the effectiveness of using e-books with students diagnosed with disabilities is more limited. Coyne et al. (2012) examined the effects of e-book scaffolds on 16 students with intellectual disabilities. Results showed significantly

greater gains in passage comprehension when an e-book was paired with letter and word recognition software and training on evidence-based literacy practices. A possible explanation for e-book effectiveness with these populations may be due to scaffolding features which meet the needs of students from diverse backgrounds (Pisha and Coyne 2001; Wehmeyer et al. 2004). When thoughtfully selected, e-books can provide the kinds of scaffolds individuals need.

Children diagnosed with Autism Spectrum Disorders (ASD) may also benefit from e-books since technology is highly engaging for many of them. Researchers (Williams et al. 2002) compared the effects of e-books and print books on engagement and word recognition; results indicated that e-books were significantly more motivating than print books and increased in-context word recognition. Thus, e-books may offer benefits for students with autism who are sometimes reluctant readers.

Segers et al. (2006) investigated the use of e-books for students with physical disabilities and results yielded positive results for teaching vocabulary. Observations indicated that children with learning disabilities may require alternative pedagogies in order to compensate for their information storage and retrieval issues (Swanson et al. 2013). As the use of e-books increases in schools, more evidence needs to be collected to determine how e-books and particular scaffolding features can benefit students with disabilities.

6 Conclusion

In this chapter, available evidences describe some unique and helpful e-book features that can benefit both teachers and students. Students benefit from e-books because they are engaging, thus providing more exposure to print. Scaffolding features like animations, hot spots, word pronunciation, embedded dictionaries, and read louds promote independence and support the development of literacy skills.

e-Books are beneficial resources for teachers too. They can be integrated easily into literacy stations or books clubs, in which students work independently, and allows time for teachers to offer direct instruction for small groups and individuals. Teachers also reported that assessment, data analysis, and reporting features provided by e-book systems, were beneficial to facilitate effective literacy instruction.

The findings of our 2017 study cannot be generalized because the survey reflected a relatively small number of teachers ($N = 46$) and the number of interviews were limited. However, many of our findings align with extant research, which indicate that e-books can benefit all readers. However, minimal research is available to reveal exactly how useful e-books are for students with disabilities.

It is evident that teachers are beginning to use e-book tools in meaningful ways that promote literacy development. More research is needed about e-book use in K-5 classrooms. By examining teachers' creative applications of these resources, researchers can learn more about where research efforts should be focused. Also worth investigating is how using e-book systems actually affects teachers' use of instructional time.

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Part IV
e-Books and Special Populations

Metacognitive Intervention with e-Books to Promote Vocabulary and Story Comprehension Among Children at Risk for Learning Disabilities

Adina Shamir and Gila Dushnitzky

Abstract The purpose of the current chapter is threefold. First, to describe the rationale underlying the use of e-books in literacy development among children at risk for Learning Disabilities (ALD). Several studies demonstrating the e-book's potential for promoting literacy among this population are also reviewed. The second and third parts of the chapter refer to two recent studies indicating that educational e-books designed specifically for young ALD children can enhance their Vocabulary and Story comprehension. The first study focuses on activity with two modes of educational e-books (with and without embedded metacognitive guidance) in the area of Story comprehension. The second investigates the effect of an intervention program, based on the metacognitive approach, aimed at promoting self-regulated leaning with e-books on Vocabulary and Story comprehension. In the concluding part of the chapter, we discuss the implications of current evidence regarding the e-book's use for creating inclusive learning environments.

Keywords Metacognitive intervention · Electronic books · Children at risk for learning disabilities · Vocabulary · Story comprehension

Among the special education population, children at risk for learning disabilities experience a wide variety of difficulties. One of the main ones many face is the acquisition of language and emergent literacy skills such as vocabulary and story comprehension, which are required for successful school learning and integration into modern, technological society (Hutinger et al. 2005; Milburn et al. 2017). Indications of learning disabilities develop before or during childhood and continue into adulthood. In light of this, educators and researchers are looking for new ways

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J. E. Kim, B. Hassinger-Das (eds.), *Reading in the Digital Age: Young Children's Experiences with E-books*, Literacy Studies 18,
https://doi.org/10.1007/978-3-030-20077-0_13

to reduce the gap between children at risk for learning disabilities and their typically developing peers, thus enabling them to start life on an equivalent level. In this spirit, the current chapter focuses on electronic books (e-books) that support vocabulary acquisition and story comprehension among children at risk for learning disabilities.

As they consider the variety of e-books on the market, educators and researchers evaluate the products' potential to enrich the development of literacy among children with diverse educational needs (Bus et al. this volume; Van Daal et al. this volume). The chapter will be divided into five parts: The first three will focus on the population at risk for learning disabilities, their academic difficulties, and the rationale behind using e-books to help them progress. The fourth part will present two studies: The first focuses on the impact of activity with the same educational e-book in two situations (with/without embedded metacognitive guidance) on promoting vocabulary and story comprehension. The second investigates the effect of an educational program to promote metacognition as preparation for activity with e-books and its effect on vocabulary and story comprehension. The last part of the chapter will discuss the findings of the studies and recommendations for the future.

1 Students at Risk for Learning Disabilities: Definitions and Characteristics

Learning disabilities are considered one of the most common types of disability with a lifetime prevalence of about 10% (Johnson 2017; Margalit 2014). Learning disabilities are characterized by language, memory, and phonological awareness difficulties that can already be detected at preschool age (Hebbeler and Spiker 2016; Pears et al. 2016). Young children with a delay in a cognitive, communicative, physical, or social-emotional domain (Margalit 2014) are defined as having a "developmental delay" or being "children at risk for learning disabilities." When such children are still young we must address indications of neuropsychological difficulties, some of which may develop into learning disabilities that will be manifest during the acquisition of literacy skills like vocabulary, phonological awareness, and concepts about print (CAP).

Literacy development is a central process in the life of a child. At a young age, children acquire the written and spoken language (Lonigan et al. 2000). The process of learning to read is a part of a developmental sequence that begins early in the child's life and continues into formal schooling (Whitehurst and Lonigan 1998). Studies have shown that differences in the emergent literacy skills of young children predict later differences in reading and writing acquisition, reading comprehension, and academic achievement in general (Haughbrook et al. 2017; Lonigan et al. 2011).

Students with learning disabilities have low awareness of cognitive processes and therefore have difficulties in monitoring and controlling their learning. They can have a diverse mix of difficulties in the areas of memory; attention span;

instruction following; visual or spatial perception; and performing metacognitive activities such as planning, regulation, information processing, and coding. Indeed, metacognitive difficulties affect achievement in areas like problem solving, language, reading, arithmetic, attention, and memory (Garrett et al. 2006). It is therefore important to improve the metacognitive abilities of these children.

2 Metacognition and Children with Learning Disabilities

The term metacognition refers to the ability of individuals to think about their thinking and their awareness of cognitive processes (Flavell 1979). The metacognitive system is in charge of cognitive mental processes and controls the regulation and monitoring of these processes through planning, monitoring, and evaluation (Pintrich 2002). Research findings indicate a link between metacognitive ability and achievements in various areas, including literacy (Chatzipanteli et al. 2014; Özsoya and Ataman 2009; Zepeda et al. 2015).

Scholarly literature relates to two types of metacognitive guidance, general and specific: (a) General metacognitive knowledge is usually acquired generically and not necessarily in relation to an individual task. It affects performance in a wide range of learning domains and it is assumed that this acquired knowledge can be transferred to new situations; and (b) specific, in contrast to general, metacognitive knowledge, is acquired in each content domain individually. This means that cognitive activity and implementation of thinking strategy must be carried out in a focused manner within the domain of the learning task (Veenman 2012; Veenman et al. 2006).

Research shows executive function deficits in students with learning disabilities (Moura et al. 2014; Toll et al. 2011; Varvara et al. 2014). There is a link between academic skills and executive functions (Toll et al. 2011; Varvara et al. 2014). Deficits in executive functions can manifest in difficulties in organizing, planning, and monitoring (Ward 2006). Studies have consistently shown that students with learning disabilities regulate poorly and benefit from strategy instruction that combines practice with self-regulation that includes metacognitive ability (Graham and Harris 2003; Wong et al. 2003).

Students with learning disabilities generally lack metacognitive skills and have difficulty performing effective metacognitive thinking processes, monitoring understanding, and adapting strategy to task (Antoniou and Souvignier 2007; Klassen 2010; Martini and Shore 2008). They do not use self-questioning to clarify the purpose of a task and how to achieve it while using regulation (Desoete and Roeyers 2002; Garrett et al. 2006). When students with learning disabilities have metacognitive deficits, they are limited in their ability to use strategies that may compensate for them (Mason et al. 2006; Wong 1986). Research findings suggest that improvement in metacognitive abilities promotes academic abilities in general (Andersen 2016; Boyle et al. 2016), in particular, literacy abilities (Bulgren et al. 2013; Lovett et al. 2014).

The computer as part of a technological learning environment can provide the learner support and improvement in self-regulation processes vis-à-vis cognition and metacognition (Azvedo 2007).

3 Promoting Literacy Among Children with LD: Multisensory Learning and e-Books

The unique characteristics of children with learning disabilities require multisensory learning (visual, auditory, and sensory) to provide a variety of input channels to compensate for deficits (Hetzroni 2004; Lipka et al. 2006; Shamir and Margalit 2011; Van Daal et al. this volume). This can be achieved by exposing the learner to various technological aids such as computers, iPads, tablets, smartphones, and more, which make use of multimedia platforms and the simultaneous use of different media formats (text, graphics, color, animation, images, sound, music, video, and games) that help simplify and streamline learning processes. Multimedia presentation consists of two channels, one verbal, such as printed or narrated text, and one non-verbal, like photos, pictures, animation, video, and games (Geva 2010).

Research findings indicate that young students at risk of failure in school can be helped by computer technology to develop various skills that affect learning achievement and processes: such technology promotes academic learning (Huffstetter et al. 2010; Kiru et al. 2017) and extends the attention span when carrying out a task (Vernadakis et al. 2005). In addition, computers help these learners advance their literacy in fields like alphabetic principles and reinforcement of phonological awareness (Torgesen et al. 2010), word recognition (Hitchcock and Noonan 2000), comprehension (Blok et al. 2002), development of metacognitive skills, and conceptual knowledge (Clements 2002).

According to the dual coding theory (Paivio 1986) and the working memory model (Baddeley 1986), humans process verbal and nonverbal information in separate channels. When information is received through the senses it is processed in both channels in combination and thus is learned more effectively than if it were processed only through one channel. According to the theory of synergy (Neuman 2009), young people, especially children at risk for reading difficulties, will read better when using a variety of computer, radio, television, and printed materials, such as books. These theories are supported by the cognitive theory of multimedia learning, which focuses on the integration of a symbolic system used in various media (Mayer 2003, 2005). In-depth learning occurs when information is presented verbally and nonverbally to the learner, as well as in snippets of information presented in close time proximity rather than individually. In this way, children are not required to hold the voice narration and the illustration in their working memory for a long period time in order to form the connection between them. Thus, the cognitive load on the learner is lighter and learning is easier.

One tool that combines multimedia resources that children of different ages are exposed to is the electronic book, also called e-book, CD-ROM storybook, and interactive story. The e-book is popular among adults and youngsters, including kindergarten children (Bus et al. 2015; Zucker et al. 2009). e-Books appear in various formats, such as for CD-ROM, tablets, iPads, and more, and are able to augment the written version with hypertext and multimedia (Anuradha and Usha 2006). The story in an e-book is presented through two channels – one verbal and one visual – as opposed to a one-channel presentation, thus improving the understanding and recall of unfamiliar words (Bus et al. 2015) and story comprehension (Zipke 2017). Much like set out in the dual coding theory, in which the verbal and nonverbal systems are combined, it can be assumed that children will remember and comprehend stories and difficult words better (Paivio 2007).

The quality of commercial e-books is not uniform and most cannot be considered to support literacy. This finding emerges from comprehensive surveys in Israel (Korat and Shamir 2004) and in Holland (de Jong and Bus 2003). The e-books examined did not include enough dynamic aids to support the story plot, like highlighting a word as it is being read, reading the book before options for play are presented, hotspots to support comprehension, and a dictionary option to enrich the child's vocabulary. It was also found that in commercial books special effects that do not support the plot may distract the child from the story content and cause cognitive overload (Sweller 2005). However, when nonverbal narration and animation are synchronized, e-books can advance story comprehension (Bus et al. 2015, this volume).

Because commercial e-books differ in terms of their educational value and ability to advance literacy, educational e-books and multimedia resources with the potential to benefit learning have been developed to promote literacy ability in young children, including vocabulary and phonological awareness (Brueck et al. this volume; Korat and Shamir 2008; Shamir and Korat 2007; Wood 2005). The text and illustrations in an educational e-book are similar to the print version, but e-books incorporate literacy support features and various multimedia tools (Labbo 2000, 2005; Pearman 2008; Roskos et al. 2011). Much like reading a book out loud is a means of promoting literacy, children can listen to a narrator read the digital text for them, see words highlighted as they are being read, see pictures, hear music, and operate hotspots that activate animation. Animations in an educational e-book expand the plot, prompt the reader to focus on storyline events, and support story comprehension and spoken and written language development (de Jong and Bus 2003; Korat and Shamir 2008; Labbo 2000; Lefever-Davis and Pearman 2005; Shamir and Korat 2007, 2015).

Some studies support the finding that activities using educational e-books with or without adult support have advanced various areas of literacy among typically developing children regarding vocabulary (de Jong and Bus 2004; Korat 2010), phonological awareness (Chera and Wood 2003; Shamir 2009; Shamir and Korat 2007), written word recognition (de Jong and Bus 2002; Lewin 2000; Wood 2005), and CAP (Shamir et al. 2008).

Studies comparing children reading an e-book independently with no intentional adult intervention to an adult reading the same book to them from a print version reported consistent improvement in spoken language, that is, vocabulary and story comprehension (de Jong and Bus 2004; Doty et al. 2001; Korat and Shamir 2007; Segers et al. 2004), and inconsistent improvement in literacy skills like word reading and phonological awareness (Chera and Wood 2003; Korat and Shamir 2007; Wood 2005). In other words, there is disagreement among scholars regarding to what extent e-books support various aspects of literacy, as well as which students would benefit most from the use of technology (Shamir and Korat 2015; Zucker et al. 2009).

It should be noted that most of the studies focused on a typically developing population or one characterized by low socioeconomic status (Ihmeideh 2014; Korat et al. 2011; Shamir and Korat 2015; Shamir et al. 2017). A meta-analysis of 43 studies about the impact of technology on the literacy development of children using e-books included studies about children with low socioeconomic status, children from immigrant families, and children with gaps in language and literacy. The results from these studies indicated that multimedia elements have a small but statistically significant positive effect on story comprehension and expressive vocabulary. Information obtained from nonverbal multimedia, like animation and background music, can help comprehension as long as it is synchronized with the story plot (Takacs et al. 2015).

Research among children at risk for LD is still in its infancy and there are many questions regarding the use of educational e-books to promote their emergent literacy. As to vocabulary and story comprehension, Shamir et al. (2011) investigated the effect of independent reading with an e-book without adult mediation on vocabulary and story comprehension among kindergarteners at risk for learning disabilities, as opposed to typically developing kindergarteners. Good progress in vocabulary was found in both groups, though it was higher among the typically developing kindergarteners. Another study by Shamir et al. (2012) investigated the effect of activity with an e-book without adult mediation compared to reading the same book in print version among kindergarteners at risk for learning disabilities. Vocabulary, phonological awareness, and CAP were examined. The findings were inconsistent. Activity with the e-book resulted in improved phonological awareness and vocabulary, but no improvement in CAP. These findings indicate the need to continue to examine the effectiveness of interventions with an educational e-book in promoting literacy among young children at risk for learning disabilities.

In the next section we present two studies that examined the effects of two different metacognitive approaches used in children's working with e-books. The first study focused on metacognitive guidance embedded in the software of an e-book; the second involved external (i.e., a metacognitive) intervention was carried out prior to the study as preparation for activity with the educational e-book.

4 Metacognitive Guidance to Promote Literacy Skills: Two Studies

The first study focused on the effect of activity with an educational e-book in two situations (with/without metacognitive guidance) on promoting vocabulary and story comprehension (Shamir and Lifshitz 2013). The second investigated the effect of metacognitive intervention with adult mediation prior to and in preparation for working with an e-book on vocabulary and story comprehension.

4.1 Study 1

Seventy-seven children aged 4.5–7 years (M = 5.88, SD = 67) participated in the study. All the children had been identified by the psychological services as having developmental delays placing them at risk for learning disabilities. They were native Hebrew speakers with typical cognitive abilities and no severe emotional, motoric, or language difficulties. The participants possessed normal or higher nonverbal cognitive abilities according to the Test of Nonverbal Intelligence (TONI) (TQ 85 or higher) and verbal abilities lower than their chronological age according to the Illinois Test of Psycholinguistic Abilities (ITPA) (Kirk et al. 1968), a gap expected because they were at risk for learning disabilities (APA 2013). Participants were selected only after taking and passing two screening tests that examined verbal and nonverbal cognitive abilities. They first took the TONI test (Brown et al. 1997) followed by the ITPA test.

The purpose of the TONI test is to examine nonverbal intelligence, abstract reasoning and problem-solving abilities. TONI's internal reliability as α = .89 to .97, and a correlation with the WISC-3 test of r = .63 among children with LDs. The ITPA test verbal level by having children retrieve a word using 'auditory association'. The test's target population is children of typical intelligence, aged 4–8. The test's reliability is r = .90 (Paraskevopoulos and Kirk 1969). Raw scores, ranging from 0 to 42, are used to determine the child's linguistic age. Children whose verbal abilities were below their chronological age were selected to participate in the study.

They were randomly assigned to three groups: (a) an experimental group using an educational e-book with metacognitive guidance embedded (EBM) (n = 26), (b) an experimental group using an educational e-book without metacognitive guidance embedded (EB) (n = 25), and (c) a control group that was exposed only to the regular kindergarten program (n = 26). The research question was, what is the effect of activity with an educational e-book embedded with metacognitive guidance as opposed to one not embedded with metacognitive guidance on vocabulary and story comprehension of kindergarteners at risk for learning disabilities.

Activity with the e-book took place once a week in five 20-min sessions. The metacognitive guidance embedded in the educational e-book was general and not aimed at a specific skill. It was based on the educational rationale that ascribes to

multimedia environments learning advantages that can develop a metacognitive environment through pre-planning and post-evaluation (Cooper 2005). The guidance focused on planning and monitoring of learning processes and simultaneously exposed the children to two sensory channels. The visual channel used the symbol of a stop sign and the auditory channel used the sound of a gong. The guidance included narration together with visual and auditory support. The following were the verbal components of the metacognitive guidance:

1. A planning-focused type of metacognitive guidance imparted prior to exposure to new information was aimed at focusing attention on auditory and visual stimuli before the child begins the activity. The narrator says, "Say to yourself: 'I am planning, listening, and observing.'"
2. A comprehension-monitoring type of metacognitive guidance was imparted post-exposure to new information: At the end of each page of the e-book, the narrator says, "Ask yourself: 'Did I understand? If I did, I can go on to the next page. If I did not? I will go back to listen to/read the page again.'" After each screen, the narrator directs the children to monitor comprehension of the new information they were exposed to.

All the children in the experimental groups took a "fitting the picture to the word" vocabulary test pre- and post-intervention. The test included 22 words, half from the e-book and half from the Peabody Picture Vocabulary Test (PPT-R new version, Dunn and Dunn 1981). Each word appeared with three pictures. The child was required to identify the picture that represented the word. Each correct answer earned a score of one, with possible raw scores ranging from 0 to 20.

After the intervention, three components of story comprehension were tested: word recall, quotation recall, and key concept recall. The score range for key concept recall was 0–48; for quotation recall, 0–109; and word recall, 0–356.

To examine differences between the groups pre-intervention and to examine if there was a difference if the words were taken from the book or not, an ANOVA 3 X 2 analysis was performed (experimental group X type of word) with words from the book and not from the book serving as the repeated-measures variable. No significant differences were found between the experimental groups ($F(2, 74) = .04$, $p > .05$). There was also no significant difference between words from the book and words not from the book ($F(1, 74) = .46$, $p > .05$) and no significant interaction of the experimental groups X type of words ($F(2, 74) = .67$, $p > .05$). These findings indicate there were no differences between the experimental groups regarding words from the book and not from the book as measured pre-intervention.

To investigate the research question, a MANOVA 3 X 2 analysis (experimental groups X time) was performed with time serving as the repeated-measures variable. A significant difference was found between the two measurements ($F(2, 73) = 31.02$, $p < .001$, $\eta^2 = .46$). To identify the source of the differences, separate variance analyses were performed on the words from the book and not from the book parameters.

The analyses indicated there were significant differences between pre- and post-measurements both for words from the book ($F(1, 74) = 42.57$, $p < .001$, $\eta^2 = .37$) and words not from the book ($F(1, 74) = 15.30$, $p < .001$, $\eta^2 = .17$).

A significant interaction of groups X time was found in the MANOVA analysis ($F(4, 146) = 3.19$, $p < .05$, $\eta^2 = .08$), that is, there were differences between the experimental groups regarding changes in pre- and post-measurements in variance analyses performed for each word type separately. A significant interaction of experimental groups X time was found only with respect to words from the book ($F(2, 74) = 3.95$, $p < .05$, $\eta^2 = .10$). Figure 1 shows the interaction of groups X time with respect to words from the book.

Simple effects analyses performed to compare the pre- and post-measurements for each of the experimental groups separately revealed a significant difference in the two time measurements among members of the EBM group ($F(1, 25) = 26.76$, $p < .001$, $\eta^2 = .52$) and among members of the EB group ($F(1, 24) = 35.19$, $p < .001$, $\eta^2 = .59$). However, no significant difference was found in the control group, ($F(1, 25) = 1.58$, $p < .05$).

A difference was found between achievements of the participants in the two experimental groups compared to the control group, but only with respect to vocabulary from the e-book. In addition, improvement among participants assigned to the EBM group was no greater than for the EB group.

After the intervention, story comprehension was examined through story recall, which was made up of three components: word recall, quotation recall, and key concept recall. Because the distribution of scores was abnormal, comparisons were made using Mann-Whitney non-parametric analyses, which showed no significant differences between the participants in the two experimental groups. However, it is possible to see that for the participants assigned to the EB group, the finding regarding the parameters measured during the story recall process ($M = 16.64$; SD = 8.11) using words from the story ($M = 37.92$; SD = 29.87) and quotations from the story ($M = 5.16$; SD = 5.86) was higher than the means among participants assigned to the EBM group in the story recall process ($M = 16.42$; SD = 8.33, $U = 317.50$, $p = .89$) using words from the story ($M = 24.65$; SD = 25.75, $U = 240.00$, $p = .10$) and quotation from the story ($M = 2.92$; SD = 6.04, U = 234.00, $p = .08$), although the differences were not significant.

In conclusion, the results showed that participants assigned to the experimental groups showed statistically significant improvement in vocabulary as compared to participants assigned to the control group. The improvement, however, was no higher among the EBM group than among those working with the same e-book without metacognitive guidance. In story comprehension as well, no advantage was found for activity with an e-book embedded with general metacognitive guidance.

The purpose of the study described below was to examine the impact of a metacognitive intervention program given prior to activity with an e-book for promoting vocabulary and story comprehension of young children at risk for learning disabilities.

4.2 Study 2

The intervention in the second study was based on the findings from the first one that indicated that young children at risk for learning disabilities did not benefit from general metacognitive guidance embedded in a computer program. The hypothesis of the present study was that in light of the young age of the participants and their literacy difficulties, there is a need for a preliminary metacognitive training program prior to activity with an educational e-book. In the present research, a specific type of training program was developed focusing on developing self-direction, regulation, and monitoring of learning and vocabulary acquisition while listening to/reading an e-book. The intervention was carried out by an adult mediator in preparation for activities with e-books.

Research Questions:

1. To what extent will there be differences in vocabulary and story comprehension skills between the group assigned to the experimental metacognitive intervention, the group assigned to the e-book alone, and the control group?
2. To what extent will the e-book alone group improve more in vocabulary and story comprehension skills than the control group?

Ninety first graders aged 6–7 years (M = 78.75, SD = 4.98 months) participated in the study. They had all been defined by the psychological services as having developmental delays that placed them at risk for learning disabilities. All were integrated into regular elementary school classes. In order to assess the cognitive level of the participants and their suitability for the study, two screening tests were conducted to test verbal and nonverbal cognition, as in the first study.

The specific intervention program consisted of illustrated fun cards suitable for young children. The intervention program is called **AAA**, the Triple A Model, which stands for "Aim, Action, Assessment": **A**im (to strive to understand the task, that is, "Which words on the page don't I know the meaning of?"), **A**ction (carrying out the task using an appropriate strategy, like "I look at the picture" or "I press on the on-screen explanation bubble), and **A**ssessment (quality assessment, reflexive questions about comprehension, like "Did I understand the meaning of the word?" or "What did I do to understand the meaning of the word?"). Each letter A in the Triple A model was colored in either the red, yellow, or green of a traffic light to remind the young children of the order their thinking needed to follow. The study was developed based on research literature about the metacognitive aspect of self-directed learning and the literature that underlines the deficits children with learning disabilities have vis-à-vis metacognitive skills like self-regulation and monitoring comprehension (Brown 1978; Flavell 1976; Wong 1987).

Each intervention session was divided into three parts: acquisition, implementation, and summary. They began with an adult imparting around 7 min of specific metacognitive content, that is, selecting a difficult word from a specific page in the educational e-book and activating the program according to the illustrated fun cards to improve understanding of the word. The learners then received clear instructions,

following which they engaged independently with the e-book for about 20 min. The e-book was presented to both experimental groups in a predetermined order: the first two times in the "read with dictionary" mode and then twice in the "read and play" mode. At the end of the activity, a 5-min summary was held with the adult in order to both reflect on the activity during the current session and provide a basis for the start of the next one.

The participants in the study were divided randomly into three equal groups: The first experimental group worked with an electronic book only (EB) (n = 30), the second experimental group worked with an e-book after a specific metacognitive intervention with an emphasis on understanding an unfamiliar word (EBSM) (n = 30), and the third was a control group that continued its regular activities in the school (n = 30). The children in the experimental groups engaged once a week with the e-book for an average of 20 min over 4 weeks according to the mode order outlined above. The children in the specific metacognitive intervention group received specific metacognitive intervention for about 7 min before engaging with the e-book. The participants were tested pre- and post-intervention in vocabulary and post-intervention only in story comprehension.

Vocabulary was measured in two tests: the first was fitting the picture to the word, in which a child was presented with several pictures and was required to point to the picture that best represented the word. There were ten words in the tests, the score range was 1–10. Reliability was found to be $\alpha = .77$. (The test was developed in line with Shamir et al. 2012). The second was "story word definition," in which the child was required to answer true or false regarding whether a sentence defined the word. The word appeared once with the correct definition and once with the incorrect one. There were 20 sentences in the test, the score range was 0–20. The test was developed in line with Coyne et al. (2007) and reliability was found to be $\alpha = .71$.

Story comprehension was measured post-activity in three tests: first, by a "joint story retell" test, in which the researcher stops reading the story at agreed-upon places and the child completes a word or phrase. The score range was 0–24. The test was developed in line with Skarakis-Doyle et al. (2008) and reliability was found to be $\alpha = .67$. The second test consisted of 12 true or false questions describing an occurrence from the story and testing information and analogy. The participants had to answer true or false for each sentence. The score range was 0–12. The test was developed in line with Korat and Shamir (2012) and reliability was found to be $\alpha = .61$. The third test was picture sequence, in which the participant was asked to arrange four pictures in the correct sequence of the story. The score range was 0–4, $r_{tt} = .60$.

Prior to intervention, no differences were found between the three groups in vocabulary as assessed by the fitting the picture to the word and the story word definition tests ($F(4, 174) = .07$, $p > .05$). However, statistically significant differences were found post-intervention, as indicated in the MANOVA 2 X 3 analysis (groups X time), with time serving as the repeated-measures variable ($F(2, 86) = 541.49$, $p < .001$, $\eta^2 = .93$). There was also a significant interaction of groups X time ($F(4, 172) = 63.96$, $p < .001$, $\eta^2 = .42$).

The analyses performed separately on the fitting the picture to the word test revealed significant differences between the three groups with respect to time ($F(1, 87) = 483.49$, $p < .001$, $\eta^2 = .85$). Indeed, for the control group, the post-intervention measurement was higher ($M = 3.80$, $SD = 1.19$) than the pre-intervention measurement ($M = 3.23$, $SD = 1.25$); for the EB group, the post-intervention measurement was higher ($M = 6.10$, $SD = 1.40$) than the pre-intervention measurement ($M = 3.10$, $SD = 1.27$); and for the EBSM group, the post-intervention measurement was higher ($M = 8.57$, $SD = .97$) than the pre-intervention measurement ($M = 3.10$, $SD = 1.47$). In addition, significant interaction between groups and time were found ($F(2, 87) = 106.70$, $p < .001$, $\eta^2 = .71$).

Further analyses performed separately on the story word definition test revealed significant differences for the three groups with respect to time, ($F(1, 87) = 775.35$, $p < .001$, $\eta^2 = .90$). Indeed, for the control group, the post-intervention measurement ($M = 10.90$, $SD = 1.18$) was higher than the pre-intervention measurement ($M = 9.83$, $SD = 1.60$); for the EB group, the post-intervention measurement ($M = 14.90$, $SD = 1.93$) was higher than the pre-intervention measurement ($M = 9.77$, $SD = 1.27$); and for the EBSM group, the post-intervention measurement was higher ($M = 18.37$, $SD = 1.35$) than the pre-intervention ($M = 9.70$, $SD = 1.91$). Thus, significant interactions between groups and time were found ($F(2, 87) = 152.22$, $p < .001$, $\eta^2 = .71$).

In addition, the test results showed that whereas for the control group improvement was minor, a significant improvement was found in both the EB and EBSM groups. In a simple effects analysis performed to examine the differences for each test separately pre- and post-intervention, the control group showed a significant difference in the fitting the picture to the word test ($F(1, 87) = 5.71$, $p < .05$, $\eta^2 = .0.6$). This was seen also in the EB group ($F(1, 87) = 159.98$, $p < .001$, $\eta^2 = .65$) and the EBSM group ($F(1, 87) = 531.20$, $p < .001$, $\eta^2 = .86$).

Similar results were found in the story word definition test, where significant differences were found in the control group ($F(1, 87) = 11.97$, $p < .001$, $\eta^2 = .12$), in the EB group ($F(1, 87) = 277.32$, $p < .001$, $\eta^2 = .76$), and in the EBSM group ($F(1, 87) = 790.48$, $p < .001$, $\eta^2 = .90$). According to the η^2 measure, improvement in the control group appeared to be very low, followed by a higher improvement in the EB group, with the highest improvement of all in the EBSM group.

A simple effects analysis was performed to compare the differences in change between the groups in pre- and post-measurements. The results indicated significant differences between the control group and the EB group ($F(1, 58) = 104.35$, $p < .001$, $\eta^2 = .64$) and between the control group and the EBSM group ($F(1, 58) = 195.53$, $p < .01$, $\eta^2 = .77$). There was also a significant difference between the EB group and the EBSM group ($F(1, 58) = 38.51$, $p < .001$, $\eta^2 = .40$).

The findings for the vocabulary tests showed significant differences between the EBSM and the control groups and between the EBSM and the EB groups.

Story comprehension tests on the e-book they read were administered only to the two groups that engaged with the e-book (the e-book alone or combined with the specific metacognitive program). Three parameters were derived from the responses received from the participants picture sequence, joint story retell, and true or false question tests. In order to examine whether there were differences between the two

experimental groups in these measures, one-way MANOVA analyses were performed. ($F(3, 56) = 38.75$, $p < .001$, $\eta^2 = .68$).

The analyses performed on each measure separately revealed significant differences between the two groups in all three measurements. For picture sequence, the difference was significant ($F(1, 58) = 7.58$, $p < .01$, $\eta^2 = .12$) between the EBSM group ($M = 3.43$, $SD = 1.10$) and the EB group ($M = 2.40$, $SD = 1.73$); for joint story retell, the difference was significant ($F(1, 58) = 68.50$, $p < .001$, $\eta^2 = .54$) between the EBSM group ($M = 12.57$, $SD = 2.34$) and the EB group ($M = 8.20$, $SD = 1.69$); and for the true or false question test, the difference was significant ($F(1, 58) = 53.94$, $p < .001$, $\eta^2 = .48$) between the EBSM group ($M = 11.10$, $SD = 1.96$) and the EB group ($M = 8.83$, $SD = 1.09$). That is, the average comprehension of participants who engaged with the e-book with specific metacognitive intervention was found to be better than among the participants in the e-book alone group for all parameters.

To summarize, the findings suggest that the specific metacognition intervention program was effective for children at risk for learning disabilities in respect both of vocabulary and story comprehension in comparison to those who engaged with the electronic book alone. In addition, the e-book group without metacognition intervention showed an improvement in these measures as compared to the control group.

5 Improving Vocabulary and Story Comprehension: Does Metacognition Matter?

Difficulties in acquiring language and developing emergent literacy skills may put young children at risk for LD (Kim et al. 2017; Stetter and Hughes 2010). These difficulties can impact future acquisition of reading and writing in school (Diamond and Powell 2016; Kuder 2017). In addition, such children have deficits in cognitive and metacognitive strategies, which explains their difficulties in reading comprehension. Children at risk for learning disabilities use fewer planning, monitoring, and regulation strategies than their peers without learning disabilities (Antoniou and Souvignier 2007; Berkeley et al. 2010). Therefore, scholars and educators stress the importance of finding ways to intervene in the field of emergent literacy and metacognition among children at risk for learning disabilities.

The two studies presented in this chapter focused on the impact of metacognitive intervention to promote vocabulary and story comprehension using an e-book. The results of the first study indicated that the participants in the two e-book groups significantly improved their vocabulary achievements as compared to children in the control group. However, no benefit was found for using the e-book with metacognitive guidance embedded in comparison to the same e-book without metacognitive guidance. No advantage was found in story comprehension for the group that worked with an e-book embedded with general metacognitive guidance.

In contrast, the findings of the second study suggested that the specific metacognition intervention program administered to children in preparation for e-book activity was effective in both the vocabulary and story comprehension parameters for children at risk for learning disabilities as compared to e-book activity alone. In addition, the group using the e-book without metacognition intervention showed an improvement in these skills as compared to the control group.

The lack of improvement in the metacognition group in the first study can perhaps be explained by cognitive overload generated during the young children's activity with the educational e-book that provided general metacognition guidance. Overload can occur when a learning task consumes more resources than are found in a student's working memory, cognitive load prevents the student from understanding and performing the given task (Chinnappan and Chandler 2010; Sweller 2016). The overload apparently stemmed from the complexity of the task and the objective abilities of the children due to their young age and skills. There may have been too much new information presented in a relatively short period of time and at too rapid a pace. In addition, it may be that the children's low level of activity during the learning process affected their achievements. It seems that due to their young age, cognitive characteristics, and undeveloped metacognitive abilities, prior separate exposure should be considered in order for the metacognitive guidance to have an effect on children. It seems that adult mediation over the course of the activity aiming to reduce the metacognitive overload generated by simultaneous exposure to guidance and learning activity is required.

Indeed, the second study, which applied the conclusions of the first one, used specific metacognitive intervention imparted by an adult as a prelude to activity with the e-book. Its findings present significant and strong results regarding the group that used the e-book with the specific metacognitive intervention. This can be explained by the type of intervention and the disability of the participants.

The findings of the present study indicate that this type of intervention helped promote vocabulary and story comprehension. The metacognitive intervention method used in the second study was probably more effective and did not cause an overload because it was given separately, before the activity with the e-book. In addition, the nature of the metacognitive intervention was specific (e.g., targeted at working with e-books). Thus, we may conclude that for young children at risk for learning disabilities it is important that cognitive activities and implementing thinking strategy are carried out in a focused manner targeted at the learning task, as reported by Veenman et al. for young children in general. Research literature reports that interventions for learning disabilities should include explicit methods that provide repetition, isolation of critical content, and a rationale for what is being taught (Archer and Hughes 2011). Swanson and Sachs-Lee (2000) published a meta-analysis covering 30 years of research with students with learning disabilities aged 6–18. They found that explicit instruction and strategy instruction were both effective approaches. Strategy instruction focuses on processes such as metacognition and self-regulation. Hughes et al. (2017) undertook a historical survey of the concept of explicit instruction that was part of regular and special education. It was identified as a key component of education initiatives and was named one of 22

teaching methods recommended for special education by the Council for Children with Special Needs. In all of the surveys, explicit instruction was identified as effective for teaching students with learning disabilities in content domains like reading, mathematics, and writing (Archer and Hughes 2011; Graham and Harris 2003; Kroesbergen and Van Luit 2003; Solis et al. 2012). According to Hessels-Schlatter et al. (2017) as well, many learners do not spontaneously develop metacognition, leading scholars to urge explicit instruction of metacognitive skills.

The findings of the present research join a growing body of knowledge about the possible benefit of e-books in promoting spoken language; that is, vocabulary and story comprehension for typically developing children (de Jong and Bus 2004; Korat and Shamir 2007; Segers et al. 2004) and for children at risk for learning disabilities (Shamir and Korat 2015; Shamir et al. 2011, 2012).

The unique contribution of the two studies presented here is in providing evidence that indicates that unlike integration of metacognitive guidance within an e-book activity, a prior specific metacognitive intervention can make a difference in improvement of vocabulary and story comprehension of first grade children at risk for learning disabilities. It is important to note that these children show lower vocabulary level than typically developing children. The results confirm the hypotheses and point to the potential for this population when this model is adopted as an effective teaching tool in schools with children with language development delays.

The findings of the current studies are promising for educational purposes. We recommend continuing research with a larger sample and examining other types of metacognitive interventions besides specific metacognitive intervention prior to activities with an educational e-book to promote additional literacy skills among young learners at risk for learning disabilities.

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A Meta-analysis of Multimedia Applications: How Effective Are Interventions with e-Books, Computer-Assisted Instruction and TV/Video on Literacy Learning?

Victor H. P. van Daal, Jenny Miglis Sandvik, and Herman J. Adèr

Abstract We examined how effectively multimedia applications (computer-assisted instruction, e-books, and TV/Video) benefit the literacy development of at-risk and not-at-risk children. Blok et al. (Rev Educ Res 72:101–130, 2002) analysed computer-assisted instruction studies undertaken in the 1990–2000 period and found an effect size of 0.254. Due to improvements in software and hardware over the 2000–2010 period, it was expected that the efficacy of multimedia applications had increased. Thirty-seven studies covering altogether 42 different treatments/experimental groups, in which in total 2525 children participated, were analysed. Eligibility criteria included quantitative research with participants up to 8 years old, which was published in English. An average effect size across all outcomes of .645 was found. Effects were larger when more time was spent on the task, and for preschoolers and kindergartners in comparison to first and second graders. Implications for the future development of smart phone and tablet applications are discussed.

Keywords Computer-assisted instruction · e-Books · TV/Video · Literacy · Meta-analysis

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J. E. Kim, B. Hassinger-Das (eds.), *Reading in the Digital Age: Young Children's Experiences with E-books*, Literacy Studies 18,
https://doi.org/10.1007/978-3-030-20077-0_14

In this meta-analysis the efficiency of multimedia applications on literacy skills in developing young children was examined. In particular, we looked at computer-assisted instruction (CAI), picture storybooks presented on a computer with audio and video animations (e-books), and conventional TV/Video applications. The review is restricted to the 2000–2010 period in order to compare the results with a study that covered 1990–2000, an equally long period (Blok et al. 2002). Studies on learning to read and write in alphabetic languages were eligible.

1 Becoming Literate

Initially, all written words with the exception of a few words recognised from environmental print are completely unfamiliar to beginning readers. At school, children first learn how letters are pronounced, and then learn to read words by consecutively translating each letter (grapheme) into a sound (phoneme) and blending the sounds into a whole-word sound, a process called phonological recoding. Alternatively, look and say methods or a mix of decoding and whole word strategies are used for words such as *yacht*, the sixteenth century Dutch spelling. Thus, two processes are involved in word recognition: (1) phonological recoding, and (2) visual-orthographic look-up, coined by Coltheart (1984) as the dual route model of reading. Share (1995) speaks to the developmental aspects of the dual route model. He proposes that phonological recoding serves as a self-teaching mechanism for visual-orthographic look-up, enabling the beginning reader to proceed from slow deciphering trough decoding to fast retrieval of word pronunciations through visual-orthographic look-up. The self-teaching hypothesis (Share 1995) contends that with every phonological recoding attempt, both the phonological (how the word is pronounced) and the orthographic (how the word is written) specifications will be strengthened in the lexicon.

The psychological process underpinning reading comprehension, the ultimate goal of reading, seems to be even more complicated. However, the assumption that reading comprehension builds on listening comprehension has proven to be a good starting point (Kintsch and Rawson 2005). According to these authors, comprehension largely depends on automatic processes that help us build up a representation of the text at hand. Automatic processes are processes that do not require conscious effort to execute them, such as listening comprehension (in one's native language). Another process that needs to be automatic is word recognition. Word identification processes need to be automatic in order to have resources available for understanding what the text is about. A text is represented at several levels, including a linguistic structure, a semantic representation, and a so-called situation model, that is, a mental model of what the text is about. Perfetti et al. (2005) suggest that the essential skills children should acquire include the following: (1) The parsing of meaning and form of sentences into a text representation; (2) Building up a situation model on the basis of the text representation; and (3) Drawing inferences, that is, making

the text coherent, because no text is completely explicit. Finally, the model developed by Perfetti and colleagues assumes that the real "bottleneck" in reading for meaning is decoding skill, that is, quick word recognition (see also Perfetti 1985).

2 Individual Differences in Reading Development

In the following section we describe where and how multimedia might benefit literacy learning, having first looked into developmental and behaviour-genetic studies of reading.

Longitudinal Studies of the Development of Reading Skills Stanovich (1986, 2000) conducted a series of studies to explain the 'fan-spread' effect on the variability of reading skill. He observed that students who start at a relatively high level of initial reading skill developed their skills much quicker than students who were less able when they started learning to read. He coined the term for this difference the 'Matthew-effect', from the biblical reference of the rich getting richer, the poor getting poorer. From recent research we know that the driving factor behind the increasing differences in reading skill is leisure time reading. More precisely, leisure-time reading activities were related to differences in the size of the vocabulary, and, in turn, vocabulary size promotes reading comprehension (Bast and Reitsma 1998).

Differences between students already exist when formal reading instruction starts, usually at the time they become 5, 6 or 7 years of age. It is clear that general cognitive skill is a powerful predictor of reading ability, as long as no specific skills for the effective processing of print are learnt, that is, when measured in kindergarten (Bowey 1995). Bowey (1995) and De Jong and Van der Leij (1999) explained with an assessment of vocabulary in kindergarten between 15% and 22% of the variance in reading in the first grade. Most probably, general cognitive ability contributes to reading success through efficient perceptual processes, such as being able to discriminate letters and sounds. Within normally developing children it is verbal ability at preschool age, rather than general cognitive ability, which determines later success at learning to read (Stanovich 2000). Subsequent studies have examined which specific aspects of verbal ability predict early reading achievement. Vocabulary predicts about 25% of the variance in end-of-first grade readers (Bowey 1995), whereas grammatical skills predict about 17% (Scarborough 1990). Phonological memory, commonly measured with a nonword repetition task (Baddeley and Gathercole 1992), predicts reading development in both deep (English) and relatively shallow orthographies, like Dutch (De Jong and Van der Leij 1999) and German (Naslund and Schneider 1996). Most of the research concentrating on speech perception and speech production has been carried out by Scarborough (1990) who found that errors in spontaneous speech in 30-month-old children predicted reading attainment in the second grade, and by Elbro et al. (1998)

who observed that the distinctness with which Danish children pronounced phonologically complex words predicted later reading success, even when effects of letter knowledge and other factors were controlled for.

Phonological sensitivity is perhaps the factor most researched. The initial finding that kindergartners' ability to count and manipulate phonemes and syllables in spoken words predicts later reading achievement (Mann and Liberman 1984) has led to an enormous amount of research not only in normally developing children, but also in children with dyslexia. The tasks typically require children to select a rhyming word with a given word, to say a word leaving out the last sound, or similar. Phonological skills play a relatively large role in learning to read in a deep orthography such as English, but are developmentally limited in shallow orthographies (Wimmer et al. 2000), that is, they are only relevant during a limited period (in the beginning of the year in which children start learning to read). Letter-name knowledge appears to be a very strong predictor of later reading achievement, explaining up to 36% of the variance in word identification at the end of the first year of reading instruction, especially when phonics reading programmes were used (Bowey 2005).

Finally, rapid automatised naming (RAN) has been a factor of much research interest. In RAN tasks a subject has to name as quickly as possible a continuous series of stimuli such as digits, common objects, colours, letters or words. There is still a debate over whether RAN is an independent contributor to early reading achievement over and above phonological skills. When assessed with digits and letters, it is likely that the effects are mediated through letter knowledge (Wagner et al. 1997).

Behaviour-Genetic Studies of Reading The power of behaviour-genetic studies in which monozygotic twins (MZ), who share 100% of their genes, are compared with dizygotic twins (DZ), who share about 50% of their genes, is that it facilitates an assessment of the genetic, shared environment, and non-shared environmental influences. An example of a shared environmental factor is, for example, the school, the teacher, and the reading method used. If one of the twins breaks a leg and misses school for some time is an example of a non-shared or unique environmental factor. If the correlation in DZ twins is more than half the MZ correlation, then there is an influence of the shared environment.[1] If the correlation is smaller, genetic factors play a relatively more important role. In short, behaviour-genetic studies can inform us of where teachers have the best chances to make a difference for their students and of where best to use technology, that is, where influences of the shared environment are relatively large. Behavioural genetics can also help us to find those components of reading skill that are only moderately or less heritable. These components depend much more on the environment and are sensitive to changes in the environment, for example, to teaching, training or intervention (with multimedia).

[1] Unique environment refers to the situation in which twins experience difference things, like attending different classes, one twin having an accident, etc. The unique environment term also comprises of measurement error, and is therefore hard to interpret.

Behavioural-Genetic Studies of Decoding Skill With a genetically sensitive design in three different countries (U.S., Australia, and Norway and Sweden together), Samuelsson et al. (2007) looked at the contributions of phonological awareness (PA), rapid automatized naming (RAN), verbal memory, vocabulary, knowledge of grammar and morphology, and, knowledge of and experience with print to reading and spelling at the end of kindergarten. PA, RAN, and verbal memory showed substantial heritability, whereas knowledge of and experience with print and vocabulary showed strong influences of shared environment. Oliver et al. (2005) found similar results in a study conducted with a larger sample of twins in the UK.

Behavioural-Genetic Studies of Reading Comprehension Byrne et al. (2009) replicated earlier findings that reading comprehension is substantially heritable and mostly determined by vocabulary, which has both substantial heritability and shared environment components in Grade 2. Keenan et al. (2006), working with older students in which the assessment of reading comprehension is less confounded with decoding skill, found that listening comprehension and word recognition (decoding) were the most important variables that independently drive reading comprehension.

3 Multimedia

Multimedia in the context of this meta-analysis refers to the integration of text, images, and sound presented electronically. Children, even very young children, are increasingly exposed to electronic media in the form of television, video, DVDs, computer programmes, electronic books, talking books, the internet, video games, tablet and smart phone applications, and interactive toys, to name a few.

As long as nearly 30 years ago, researchers called into question the efficacy of the prevailing teaching paradigm of one-dimensional, primarily verbal delivery of instruction (Clark and Paivio 1991) and recognised the potential for multimedia technologies to facilitate interactive learning opportunities. The National Association for the Education of Young People (NAEYC) issued a position statement acknowledging that "used appropriately, technology can enhance children's cognitive and social abilities" and recommended that "computers should be integrated into early childhood practice physically, functionally, and philosophically" (NAEYC 1996, p. 2). An update was published in collaboration with the Fred Rogers Centre in January 2012 (http://www.fredrogerscenter.org). However, while some recognise the potential for multimedia to enhance learning, others debate the desirability of technology in early childhood education settings (Buckingham 2000; Lankshear and Knobel 2003; Stephen and Plowman 2003). Some argue that the use of technology in early childhood may not be developmentally appropriate, particularly in terms of cognitive overload (Kirschner 2002). Conversely, proponents of dual-coding theory maintain that the combination of visual with auditory stimuli results

in enhanced comprehension (Sadoski and Paivio 2007). Some reference teacher resistance to incorporating technology into lessons (Turbill 2001), while others argue that the cost of integrating technologies into classrooms, particularly those of young children, costs much and produces little in measurable educational gains (Yelland 2005). Still others go so far as to contend that the use of technology undermines the very nature of childhood (Buckingham 2000). Whether or not young children *should* engage with multimedia has been long debated. Nonetheless, it is clear that children *are,* in fact, *doing so* on a daily basis (Etta, this volume; Rideout and Hamel 2006; Rideout 2014). Depending on which side of the debate one hails from, those who view technology as a powerful resource for early literacy enhancement, supporting 'children of the digital age' (Marsh 2005) or, alternatively, those who criticize technology as 'the death of childhood' (Buckingham 2000), a meta-analysis can tell us how effective multimedia applications are.

More importantly, it needs to be considered how technology and multimedia applications in particular might work, that is, how they actually might benefit literacy learning. Cheung and Slavin (2012) suggest that (new) technology might improve (1) the quality of instruction, because "content can be presented in a visual, varied, well-designed, and compelling way"; (2) the appropriate level of instruction because of the capacity to adapt the pace and level of the instruction to individual needs. Also, (3) the incentives to learn can be increased, as well as (4) the time on task and providing feedback.

Reviews of Multimedia Several literature reviews have attempted to provide an overview of the existing research on the topic (Courage this volume; Hisrich and Blanchard 2009; Kamil et al. 2000; Lankshear and Knobel 2003; Plowman and Stephen 2003; Bus et al. this volume; Yelland 2005; Zucker et al. 2009). See also recent reviews on the topic, Courage's chapter and Bus, Sari, and Takacs's chapter in this book. Kamil et al. (2000) undertook a comprehensive review of 350 articles including empirical studies and research reviews on the effects of multimedia on literacy. It was suggested that the use of multimedia facilitates children's comprehension through 'mental model building', hypothesized to be a result of information presented as animation. Similarly, Lankshear and Knobel (2003) provided a synthesis of the research on the use of technology in promoting early literacy, focusing on young children. They found only 22 published articles that were relevant for review. In their quantitative assessment of the literature it was found that the research literature was unevenly distributed, with most focusing on the conventional aspects of reading such as decoding, rather than comprehension, or generating texts. Most significantly, they concluded that the effects of technology on early literacy development were "radically under-researched". Likewise, Burnett's (2009) literature review on literacy and technology in primary classrooms also noted a lack of research on the topic. A review of 38 studies published between 2000 and 2006, 22 quantitative and 16 qualitative, was conducted. It was concluded that the studies reviewed were limited in scope, as technology was used to support literacy in the same ways as print literacy, "assimilating technology by grafting it onto existing practices", and therefore rendering the differential impact of multimedia on literacy development difficult to ascertain.

Recognising the need for research evidence on the topic, Zucker et al. (2009) provided a synthesis of studies published between 1997 and 2007 on the effects of electronic books (e-books) on the literacy outcomes of children from preschool through fifth grade. Seven randomized-trial studies and 20 quasi-experimental narrative studies met the selection criteria for their review. The aim of the study was to examine effects of e-books on children's comprehension and decoding-related skills, specifically in relation to emergent and beginning readers and children with reading disabilities or at risk of reading failure. Of the seven randomized-trial studies included, results of their meta-analysis showed small to medium effect sizes for comprehension. The effect on decoding was inconclusive, as only two studies that met the inclusion criteria examined it. The 20 studies included in the narrative review indicated mixed results. While it was found that e-books overall supported comprehension, they could, under some circumstances, actually undermine it (De Jong and Bus 2002). More recently, Cheung and Slavin (2012) found effect sizes of .37 for low-ability children, .27 for middle-ability children, and .08 for high-ability children, respectively, when reviewing 84 studies conducted in K12 over the period 1980–2010. Although these effects are small, it clearly indicates that those who need it most, benefit most: an indication that Matthew effects can be reversed!

4 Computer-Assisted Instruction

Since the late 60s computers have been used to assist in the teaching of reading and in the remediation of reading problems. Some computer programmes aim at practising a specific subskill of reading. Other programmes have been designed to combine the training of various subskills. An example of a combination of repeated reading, phonological awareness, and decoding is the WordBuild programme (McCandliss et al. 2003; Harm et al. 2003). The following two categories still seem to describe CAI for reading adequately: (1) computerised versions of basal reader programmes, and (2) tools that have especially been developed for (older) struggling readers.

Computerised Versions of Basal Reader Programmes These programmes come with a standard reading method and may differ from each other in several ways. In some reading methods the accompanying computer programme offers additional practice for struggling readers, in others all children go through the same programme, more or less in the same pace. The main characteristic is that these programmes contain several types of practice, usually from training phonological skills to text reading. More recently, reading and math programmes have been developed that keep motivation levels high by providing tasks that are not too easy nor too difficult for the individual learner (e.g., Klinkenberg et al. 2011).

Tools Especially Developed for Struggling Readers and Older Persons with Dyslexia These programmes serve the purpose of supporting the user in reading, by reading aloud texts, such as Kurzweil 3000 (http://www.kurzweiledu.com/). Kurzweil 3000 offers also the possibility of scanning books while keeping the

original layout, including pictures, drawings, and tables. The spoken text can be exported as a MP3 file and then can be listened to everywhere, without the need to take a computer with you.

Reviews of CAI The Stanford project, aimed at a complete replacement of the teacher by a computer, was the first project to be evaluated. It did, however, not live up to the expectations (Fletcher and Atkinson 1972). The main reason that these reading programmes never would have become cost-efficient is because they ran on very expensive mainframe computers. Slavin (1991) evaluated IBM's Writing to Read programme in a meta-analysis study by looking at 29 studies and concluded that the efficiency of the programme was very low, that is, the costs in comparison to the learning effects were too high, a conclusion that is in line with other reviews (Krendl and Williams 1990).

Seven reviews that evaluate the use of CAI and beginning reading were published since 1990 (as far as we are aware). Two used a meta-analytic techniques and found effect sizes of 0.25 ($SE = 0.07$) and 0.16 ($SE = 0.08$), Kulik and Kulik (1991) and Ouyang (1993), respectively. Qualitative reviews were conducted by Torgesen and Horen (1992), Van der Leij (1994), Wise and Olson (1998) and by the National Reading Panel (2000), which were generally positive. However, Torgesen and Horen (1992) pointed out that much work needed to be done on the integration of the computer with the existing curriculum that was highly teacher-driven. The qualitative studies conducted by Van der Leij (1994) and Wise and Olson (1998) both concerned the use of computers with reading-disabled children. Van der Leij (1994) found that studies that concentrated on a specific subskill were generally more effective than multi-component programmes. Wise and Olson (1998) concluded that talking computers combined with phonological awareness training had a positive effect on learning outcomes, especially in children with relatively stronger phonological skills. The National Institute for Literacy report (2008) also concluded that talking computers show promise.

Although most of the recent studies seem to be positive about effects of CAI, the two studies that analysed effect sizes within a meta-analytic approach do however not give much reason for optimism, as mean effects of about .20 with a standard error of around 0.07 are reported. In the terminology of Cohen's (1988) these are small effects. However, it is likely that due to improvements in computer hardware and software and the integration of the computer in classroom learning activities, CAI has become more effective. Therefore, Blok et al. (2002) analysed studies undertaken in the 1990–2000 period. They categorised the studies, which all were concerned with beginning reading, along a variety of criteria in order to be able to find out what the elements are that make computer programmes work. In particular, they looked in 45 studies that reported on 75 experimental conditions at effect sizes and characteristics such as year of publication, language of instruction, experimental design (with or without control group, with or without pretest), subject assignment

(blocking, randomisation, matching, within-subjects), size of control and experimental group, population (normally developing, reading-disabled), age of participants at the beginning of the study, type of programme (phonological awareness, speech feedback, flash words, reading while listening, or mixed), duration of the programme in weeks and in hours, type of the dependent variable (phonological skills, letter identification, word accuracy, word speed, text accuracy, text reading speed, mixed), type of posttest score (observed score, gain score, score adjusted for covariates). The combined effect size was 0.254 with a standard error of 0.056. Experimental subjects thus were on the average 0.254 standard deviations better off than students in the control condition or compared with a baseline score. The variance of the effect sizes was 0.083, which means that there were considerable differences in effect sizes between the studies. Thirty-four per cent of the variance could be explained by entering the effect size at pretest into the equation. Language of instruction explained another 27% of the variance; studies conducted with English as medium of instruction obtained effect sizes that were 0.319 *SD* larger than non-English studies. No other variable was related to effect size at the posttest. The conclusions were very straightforward: computer-assisted instruction has little effect. As said, another 10 years of further developments in hard and software has not produced any better results than in the decade before. The language effect comes, however, as a surprise. The authors explained it as an effect of the transparency of the language. If this explanation however were viable the same would be expected for the Danish studies (there were two Danish studies in the sample), because Danish is nearly as deep as English with respect to the orthography of the language (Seymour et al. 2003). The language effect may reflect that there is more room for improvement in deep orthographies, as reading development lags behind in deep orthographies compared with shallow orthographies.

5 Purpose of the Study

The aim of the current systematic review is to analyse the studies that were conducted after the Blok et al. (2002) review, that is, studies published between 2000 and 2010, an equally long period. The review was extended with e-books that became widely available during that period, together with TV/Video. Furthermore, defining characteristics of the studies associated with the effect sizes are examined. We expected that multimedia applications would be more effective than before, because of the following technological changes. Availability of the Internet in schools made it possible to have access to large databases of learning materials. Generally, also, video and audio animations improved, and, due to new programming methods, programming computers, tablets and smart phones became easier.

6 Method

6.1 Search Criteria

Specific key terms and phrases related to multimedia and early literacy were identified by reviewing the following reference books: *Handbook of Early Literacy Research* (Neuman and Dickinson 2001), *Handbook of Research on New Literacies* (Coiro et al. 2008), and *International Handbook of Literacy and Technology, Volume II* (McKenna et al. 2006). The first two authors independently devised key word search strings, and then cross-referenced these, resulting in the following list of primary search key words: *children, young children, children at risk, minority children, language minority children, cultural minority children, low SES children, disadvantaged children, children with reading disabilities, dyslexic children*. Secondary search key words were: *literacy, emergent and early literacy, reading, early and beginning reading, writing, early writing, beginning writing*. Finally, the following tertiary search key words were used: *media, multimedia, electronic media, digital media, technology, ICT, information technology, educational technology, interactive technology, digital books, on-line books, talking books, digital books, electronic books (e-books), CD-ROM, computers, computer-assisted learning, computer-based learning, CAI, internet, World Wide Web, television (educational television, children's television), Sesame Street, Between the Lions, DVD, mobile phones*.

6.2 Search Strategy

The Educational Resources Information Centre (ERIC) and PsychINFO were searched simultaneously using the aforementioned key word search strings. The broadest terms were input first and 'find all search terms', 'apply related words', and 'also search full text' were options selected in order to attain the highest number of hits. In PsychINFO, a selection was made to narrow the subject age range by selecting the age group 'childhood (birth – 12 years)'. These databases were then searched for peer-reviewed articles published in English between 2000 and 2010. In addition, the following key journals published in the same period were manually searched: *Journal of Early Childhood Literacy, Journal of Research in Reading, Journal of Early Childhood Literacy, Reading Research Quarterly, Early Childhood Research Quarterly, Journal of Literacy Research, Reading and Writing, Computers & Education,* and *Journal of Computer Assisted Learning*. Finally, the following special issues on technology and young children were searched: 'Technology in early childhood education' in *Early Education and Development* (Vol. 17, 1, 2006), 'Using technology as a teaching and learning tool' in *Young Children* (November 2003), 'Literacy and technology: Questions of relationship' in *Journal of Research*

in Reading (Vol. 32, 1, 2009), 'Technology special issue' in *Contemporary Issues in Early Childhood* (Vol. 3, 2, 2002), 'Technology and young children', downloaded from www.technologyandyoungchildren.org. References for several hundred potential studies were located. After reviewing the abstracts of each, 92 studies were acquired through the library or, if published in an E-journal, downloaded for further evaluation. The search and the review process were carried out by each of the first two authors independently and then cross-checked.

6.3 Selection of Relevant Studies

Studies were included in the meta-analysis by meeting the following criteria, based on the content of the article abstract, if it provided the necessary information, and full-text, if the abstract was not sufficient. (1) Quantitative research on literacy interventions published in peer-reviewed journals between 1 January 2000 and 1 May 2010. (2) Studies in which participants were classified as 'early childhood', that is, subjects 0–8 years old. (3) Studies that included children at risk for literacy failure (e.g., dyslexia, low SES and/or language/cultural minority children). (4) Studies that included mainstream children. (5) Studies that measured *at least one* of the following literacy outcome variables: phonological awareness, reading comprehension, spelling, accuracy of reading words, accuracy of reading nonwords, fluency of reading, learning about print concepts, vocabulary learning, letter learning, rapid automatized naming and listening comprehension. (National Institute for Literacy 2008). (6) Studies that were published in English**.**

6.4 Coding

The first two authors independently coded all studies as to the following study characteristics. (1) Age group of the participants. Categories included kindergarten, preschool and kindergarten, first graders, second graders, kindergarten through second graders, second and third graders. (2) Specificity of treatment. Studies were coded as either training one subskill or training more than one subskill. (3) Risk of reading failure: at-risk (low SES, second language learner, or reading failure) or not-at-risk students. (4) Language of instruction: English, Dutch, French or Hebrew. (5) Country in which the study was conducted: US, UK, Canada, Netherlands, France or Israel. (6) Media type: e-book, computer-assisted instruction, TV/Video. (7) Type of control group/treatment: traditional medium/curriculum, alternative reading treatment, alternative non-reading treatment (e.g., math), pretest used as baseline assessment or no-risk group used as control. (8) Grouping of participants for intervention/treatment: mixed groupings, individual, whole class, small groups.

(9) Type of test used to assess learning outcome: standardised test, experimental test. (10) Transfer of training: training to test, transfer of training/curriculum-based. (11) Duration of treatment in weeks. (12) Number of sessions over whole treatment period. (13) Average session duration in minutes. (14) Type of posttest score: raw observed, adjusted (e.g., for pretest score), transformed (e.g., standardised score). (15) Design – experimental: pretest-posttest untreated control group, posttest untreated control group (with gain-scores analysed), pretest-posttest control group with alternative reading treatment, posttest no control group, pretest-posttest no control group. (16) Design – statistical: between classes, within classes, between schools, within schools, counterbalancing within class. In addition, publication order was computed by using the year of publication (2000–2010) and the issue number (1–4 or 6) of the journals into a scale that ranged from 1 to 10. From 12 and 13 the total time-on-task in minutes was computed. For analysis purposes, this number was divided by 100 and centred around 10. See Table 1 for the coding of all studies.

Coding of Literacy Outcomes The selected studies were also coded for type of literacy outcome, according to generally accepted definitions (see Stanovich 2000). However, we have reported elsewhere about whether the various literacy outcomes are differentially affected by the use of multimedia applications (Van Daal and Sandvik 2013). The results are summarised in Appendix 2. In this paper the different literacy outcomes are amalgamated, see below.

Phonological awareness (PA) is defined as the ability to detect, manipulate, or analyse the auditory aspects of spoken language, including the ability to distinguish or segment words, syllables, or phonemes, independent of meaning. *Reading comprehension* is the ability to comprehend and recall a written story and to make inferences. Both conventional ('write the word or the sentence') and invented spelling tasks (for preschoolers) are used to tap *spelling ability*. The *accuracy of reading* is defined as the ability to correctly read real words, sentences or text. The *accuracy of reading nonwords* is defined as the ability to correctly read nonwords or low-frequency words. In some studies, lexical decision-making (decide whether a string of letters is a word or not) was used as a reading accuracy task. *Fluency of reading* is measured with timed reading of words, sentences or texts tasks. *Learning about print concepts* is defined as knowledge of print conventions (e.g., from left to right and from top to bottom of a page reading, and going through a book from front to back) and concepts such as book cover, author, and purpose of books. *Vocabulary learning* comprises of being able to use words actively and passively. *Letter learning* entails knowledge of the names and sounds associated with printed letters, including letter naming fluency, sound discrimination, and letter-sound relations. *Rapid automatized naming (RAN)* is defined as the ability to rapidly name a sequence of random letters, digits, colours, or objects. Finally, *listening comprehension* is the ability to comprehend and recall an oral story and to make inferences.

Table 1 Study coding

Study number	Treatment/ condition	Author(s)	Publication order[a]	Age group	Specificity of treatment	Risk of reading failure	Language of instruction	Country	Media type	Type of control	Grouping
1	Sound – meaning	Brabham et al.	6.2	1	2	2	1	1	1	2	1
2	CD-ROM – tape	Brabham et al.	6.2	1	2	2	1	1	1	2	1
3		Cassady and Smith	3.8	1	2	1	1	1	2	1	1
4		Chambers et al.	8.2	3	2	3	1	1	3	2	3
5		Chera and Wood	3.2	2	1	1	1	2	1	3	2
6	Analytic phonics	Comaskey et al.	9.2	1	2	3	1	3	2	2	4
7	Synthetic phonics	Comaskey et al.	9.2	1	2	3	1	3	2	2	4
8		De Jong and Bus	4.8	2	1	1	2	4	2	4	2
9		Doty et al.	1.4	4	1	1	1	1	2	4	2
10		Ecalle et al.	9.6	3	1	4	3	5	2	2	2
11		Hecht et al.	2.4	1	2	2	1	1	2	4	2
12		Howell et al.	0.6	3	2	4	1	1	2	4	4
13		Karemaker et al.	10.2	3	2	1	1	2	2	1	3

(continued)

Table 1 (continued)

Study number	Treatment/ condition	Author(s)	Publication order[a]	Age group	Specificity of treatment	Risk of reading failure	Language of instruction	Country	Media type	Type of control	Grouping
14		Karemaker et al.	10.2	3	2	4	1	2	2	1	4
15		Kegel et al.	9.8	1	1	4	2	4	1	1	2
16	Kindergarten	Korat	10.2	1	2	1	4	6	1	1	2
17	First graders	Korat	10.2	3	2	1	4	6	1	1	2
18		Korat and Shamir	7.4	1	2	2	4	6	1	1	2
19	At risk	Linebarger et al.	10.4	6	2	2	1	1	3	1	4
20	Not at risk	Linebarger et al.	10.4	6	2	1	1	1	3	1	4
21		Lonigan et al.	3.8	2	1	4	1	1	2	1	2
22		Macaruso and Walker	8.6	1	1	4	1	1	2	4	2
23		Macaruso et al.	6.4	3	1	4	1	1	2	4	2
24		Mathes et al.	1.4	3	1	4	1	1	2	4	4
25		McKenney and Voogt	9.2	1	1	1	2	4	2	1	2
26		Mioduser et al.	0.2	1	1	4	4	6	2	1	2
27		Mitchell and Fox	1.8	2	1	4	1	1	2	1	2

28		Regtvoort and Van der Leij	7.2	1	2	4	2	4	2	4	2
29	Synthetic phonics	Savage et al.	9.6	3	2	1	1	3	2	4	4
30	Analytic phonics	Savage et al.	9.6	3	2	1	1	3	2	4	4
31	Not at risk	Segers and Verhoeven	3.8	1	1	1	2	4	2	3	2
32	At risk	Segers and Verhoeven	3.8	1	1	3	2	4	2	3	2
33		Segers and Verhoeven	2.6	1	2	3	2	4	1	4	2
34		Segers et al.	4.4	1	2	3	2	4	1	1	2
35		Segers and Verhoeven	5.2	1	1	3	2	4	1	3	2
36		Shamir et al.	8.8	1	2	2	4	6	1	1	2
37		Silverman and Hines	9.4	5	1	3	1	1	3	1	3
38		Van Daal and Reitsma	0.4	1	2	1	2	4	2	1	2
39		Verhallen and Bus	10.2	1	1	3	2	4	1	3	2
40	Multimedia	Verhallen et al.	6.4	1	2	3	2	4	1	3	2
41	Static	Verhallen et al.	6.4	1	2	3	2	4	1	3	2
42		Wild	9.8	3	1	1	1	2	2	3	2

(continued)

Table 1 (continued)

Study number	Treatment/ condition	Author(s)	Publication order[a]	Age group	Specificity of treatment	Risk of reading failure	Language of instruction	Country	Media type	Type of control	Grouping
1	Sound – meaning	Brabham et al.	1	1	4	20			1	3	1
2	CD-ROM – tape	Brabham et al.	1	1	4	20			1	3	1
3		Cassady and Smith	1	1	40	80	20	1600	1	1	3
4		Chambers et al.	1	1	28		90		2	2	4
5		Chera and Wood	2		4	10	10	100	1	1	4
6	Analytic phonics	Comaskey et al.	1	1	13	39	15	585	1	3	2
7	Synthetic phonics	Comaskey et al.	1	1	13	39	15	585	1	3	2
8		De Jong and Bus	2			12	15	180	3	4	2
9		Doty et al.	2	1					1	1	1
10		Ecalle et al.	1	1	5	10	15	150	1	1	2
11		Hecht et al.	2	1	24		15		1	1	3
12		Howell et al.	1	1	16	74	30	2220	1	1	2

13		Karemaker et al.	1	1	1	5	60	300	1	4	2
14		Karemaker et al.	1	1	5	2	60	120	1	4	5
15		Kegel et al.	2	1	16	15	10	150	1	1	4
16	Kindergarten	Korat	2	2					1	1	2
17	First graders	Korat	2	2					1	1	2
18		Korat and Shamir	2	2	3	3	30	90	1	1	2
19	At risk	Linebarger et al.	2	2					1	4	2
20	Not at risk	Linebarger et al.	2	2					1	4	2
21		Lonigan et al.	1	1	8				1	1	2
22		Macaruso and Walker	1	1	24	48	20	960	1	4	4
23		Macaruso et al.	1	1	24	64	20	1280	1	1	4
24		Mathes et al.	1	1	8	32	25	800	1	2	2
25		McKenney and Voogt	1	1	5	4	20	80	1	1	2
26		Mioduser et al.	2	1					1	2	2
27		Mitchell and Fox	1	1	4	15	20	300	1	1	2

(continued)

Table 1 (continued)

Study number	Treatment/ condition	Author(s)	Publication order[a]	Age group	Specificity of treatment	Risk of reading failure	Language of instruction	Country	Media type	Type of control	Grouping
28		Regtvoort and Van der Leij	1	1	14	70	10	700	1	1	2
29	Synthetic phonics	Savage et al.	1	1	12	48	20	960	1	3	2
30	Analytic phonics	Savage et al.	1	1	12	48	20	960	1	3	2
31	Not at risk	Segers and Verhoeven	2	2	15	30	15	450	1	1	3
32	At risk	Segers and Verhoeven	2	2	15	30	15	450	1	1	3
33		Segers and Verhoeven	2	2		3	25	75	1	5	
34		Segers et al.	2	2		1			1	1	3
35		Segers and Verhoeven	1	1	40	40	15	600	1	1	3
36		Shamir et al.	1	1					1	1	2

37		Silverman and Hines	2	2	12	36	45	1620	1	1	2
38		Van Daal and Reitsma	1	1					1	1	2
39		Verhallen and Bus	2	2					1	1	2
40	Video	Verhallen et al.	2	2		1	6	6	1	3	2
41	Static	Verhallen et al.	2	2		1	6	6	1	3	2
42		Wild	1	1	10	20	20	400	1	4	2

[a]Publication order: 0–11 (rescaled conversion from publication year and volume number of journal. Age group: (1) kindergarten, (2) kindergarten and first graders, (3) first graders, (4) second graders, (5) kindergarten through second graders, (6) second and third graders. Specificity of treatment: (1) one subskill, (2) more than one subskill. Risk of reading failure: (1) not at risk (2) low SES, (3) second language learners, (4) reading failure. Language of instruction: (1) English, (2) Dutch, (3) French, (4) Hebrew. Country: (1) US, (2) UK, (3) Canada, (4) Netherlands, (5) France, (6) Israel. Media type: (1) e-book, (2) computer-assisted instruction, (3) TV/Video. Type of control: (1) traditional medium/curriculum, (2) alternative reading treatment, (3) alternative non-reading treatment, (4) pretest used as baseline assessment or no-risk group used as control. Grouping: (1) mixed groupings, (2) individual, (3) whole class, (4) small groups. Type of test: (1) standardised test, (2) experimental test. Transfer of training: (1) training to test, (2) transfer of training/curriculum-based. Duration of treatment: weeks. Number of sessions. Average session duration: minutes. Time-on-task: minutes. Type of posttest score: (1) raw observed, (2) adjusted, (3) transformed. Design – experimental: (1) pretest-posttest control group, (2) pretest-posttest experimental group only. Design – statistical: (1) between classes, (2) within classes, (3) between schools, (4) within schools, (5) counterbalancing within class. Empty cells: missing or n/a. See also text.

7 Results

7.1 Descriptive Statistics

After reviewing the abstracts or full-text of each article collected, 51 studies met the selection criteria.[2] If studies included more than one treatment or more than one experimental group, we treated them as separate studies. Nine studies were later excluded for missing relevant statistics (number of participants, means, standard deviations, or non-aggregated statistics; only five corresponding authors replied positively to our request to supply us with missing statistics). Twenty-eight articles reported on single studies, whereas seven contained multiple treatments/experimental groups. Of the remaining 42 studies, 26 studies included children at risk of reading failure. Of the studies of children at risk, 11 studies reported on interventions with second language learners, most stemming from cultural or language minority groups, six studies included children of low socio-economic status, and nine studies dealt with underachieving readers. Twelve studies on the effects of multimedia interventions in mainstream children were found. The 35 studies that were submitted to the meta-analysis are marked with an asterisk (∗) in the References.

The majority of studies were conducted in English-speaking countries, USA (15), UK (4), and Canada (4). Thirteen studies were conducted in The Netherlands (Dutch), one in France and five in Israel (Hebrew). Two studies dealt with embedded multimedia (TV/Video) in teachers' reading lessons, two with subtitled video, 14 with e-books, and 24 with Computer-Assisted Instruction. Most of the studies were published in the last 16 months of the period we examined (16), five in 2003 and five in 2006, whilst other publications were evenly spread over the other years. Thirty-eight studies were carried out with participants from preschool and kindergarten. About half of the studies trained a single subskill (18). Seventeen studies used the traditional medium/curriculum, six an alternative reading treatment, eight an alternative non-reading treatment and 11 a pretest baseline or a no-risk group as a control condition. Twenty-seven studies provided an individual treatment. Twenty-three studies used a standardised test to assess the learning outcomes, whereas 19 studies used experimental tests. Twenty-seven studies trained to the test, whereas 13 aimed at transfer or tested targets from the existing curriculum, whilst two studies were unclear about what sort of test was used. Duration of the treatment varied from 3 to 40 weeks, whereas the number of sessions varied from 1 to 74 with average session duration varying from 6 to 90 min. The intensity of the training in terms of total time-on-task varied between 6 and 2220 min. All but three studies analysed raw observed scores, whereas eight studies did not include a control group at all. Finally, three studies compared treatments between classes, 26 within classes,

[2] Our searches produced only one reference to a study on the Fast ForWord intervention programme. As this programme has extensively been evaluated by others without finding any effects, we decided not to include this study (which didn't find any effects either). See What Works Clearinghouse (2006, 2007) and Strong et al. (2010).

6 between schools, and 5 within schools. In one study treatments were counterbalanced within classes. In total 2525 children participated across all studies, 1201 as experimental subjects (on the average 28.6 per study) and 1324 as control subjects (on the average 31.5 per study).

7.2 Meta-analysis

For each treatment/experimental group/literacy outcome Hedge's *g*, to account for small sample sizes, was computed, that is, the difference between the means (of either the experimental group and the control group, or the posttest and the pretest in case there was no control group) was divided by the pooled standard deviations, as different units of measurement were used across studies (see Cornell and Mulrow 1999). Within each study, the effect sizes of multiple literacy outcomes were averaged. In Table 2 multiple and averaged effect sizes of all studies are presented, together with the numbers of participants of the studies.

However, it was first checked whether literacy outcomes could be averaged without losing information by running a principal component analysis on the results of two studies in our sample that contained the widest range of literacy outcomes. In the Savage et al. (2009) study in total 11 outcome measures were taken, of which the raw data were made available to us. We combined the two measures for PA (elision and blending) and the two for RAN (objects and letters). All nine remaining outcomes loaded between .466 and .878 on one factor that explained 58.3% of the variance. Steve Hecht ran a similar analysis on the primary data set of the Hecht and Close (2002) study and kindly shared the SPSS output with us. Six assessments explained 58.5 of the total variance and loaded between .631 and .870 on one single factor. Although there were differences between the studies as to instruments used, the age of the participants, and the types of computer programmes, the results of the principal component analyses, which both examined effects of analytic and synthetic phonics in both studies, definitely converge. It was therefore concluded that it is appropriate to average literacy outcomes within studies. Because the factor contains both outcomes that are close to reading (e.g., PA, reading fluency) and literacy (e.g., listening comprehension, vocabulary), we prefer to keep using the term 'literacy outcomes'. The results of both principal component analyses are presented in Appendix 1.

7.3 Multilevel Modelling

Multilevel modelling (MlwiN) was used to assess the effect that study characteristics have on the effect sizes reported in the studies (Rasbash et al. 2005). For this analysis, studies were regarded as nested under publication year. An average effect size of .645 (*SE* = .112) was found, whilst 19.53% (.126, *SE* = .085) of the total

Table 2 Aggregated effect sizes and effects sizes for different learning outcomes

Study number	Treatment/ condition	Author(s) (n exp-control)	d'[a]	PA	Comp	Spell	Word	Nword	Fluency	P-concepts	Voc	Letter	RAN	List comp
1	Sound – meaning	Brabham et al. (25–55)	−0.04	0.18			0.16				−0.09	−0.42		
2	CD-ROM – tape	Brabham et al. (42–30)	−0.26	−0.67			−0.14				−0.02	−0.22		
3		Cassady and Smith (26–62)	0.50	0.64						0.37				
4		Chambers et al. (43–56)	0.56		0.56		0.75	0.46				0.47		
5		Chera and Wood (15–15)	0.07	0.37			−0.23							
6	Analytic phonics	Comaskey et al. (27–27)	1.01	0.73			0.64	0.76				1.92		
7	Synthetic phonics	Comaskey et al. (26–26)	1.29	1.49			0.80	0.91				1.94		
8		De Jong and Bus (18–18)	2.25		2.25									
9		Doty et al. (20–19)	1.14		1.14									
10		Ecalle et al. (14–14)	1.26			1.22	1.29							
11		Hecht et al. (42–34)	0.76	1.14		1.20	1.11			0.23	0.24	0.14		
12		Howell et al. (35–35)	1.55	1.77		0.80	2.06							
13		Karemaker et al. (61–61)	0.21	0.18			0.23							
14		Karemaker et al. (17–17)	0.13	−0.03			0.43	−0.01						
15		Kegel et al. (45–45)	0.49	0.24		0.73								
16	Kindergarten	Korat (20–20)	1.13				0.62				1.64			
17	First graders	Korat (25–25)	1.16				0.97				1.35			
18		Korat and S. (25–14)	0.42	0.19			0.10				0.96			

19	At risk	Linebarger et al. (6–8)	1.15		1.92		1.65	1.01	0.02					
20	Not at risk	Linebarger et al. (16–14)	0.30		1.21		−1.01	1.29	−0.28					
21		Lonigan et al. (20–21)	0.42	0.42										
22		Macaruso and Walker (12–12)	1.23	1.21						0.66	1.80			0.49
23		Macaruso et al. (15–15)	0.43				0.31					0.55		
24		Mathes et al. (43–42)	−0.07	−0.28			−0.16	0.12		0.05				
25		McKenney and Voogt (19–18)	0.63				0.63							
26		Mioduser et al. (16–15)	0.67	1.65			0.05					0.30		
27		Mitchell and Fox (24–24)	0.70	0.70										
28		Regtvoort and v.d. Leij (31–16)	0.35	0.29								0.41	0.55	
29	Synthetic phonics	Savage et al. (43–57)	0.20	0.41	0.28			0.20	−0.06		0.18	0.20	−0.12	0.46
30	Analytic phonics	Savage et al. (44–57)	0.14	0.24	0.16			0.10	−0.20		0.13	0.37	−0.22	0.39
31	Not at risk	Segers and Verhoeven (67–97)	0.41								0.41			
32	At risk	Segers and Verhoeven (67–97)	0.04								0.04			
33		Segers and Verhoeven (25–25)	0.87								0.87			

(continued)

Table 2 (continued)

Study number	Treatment/ condition	Author(s) (n exp-control)	d'[a]	PA	Comp	Spell	Word	Nword	Fluency	P-concepts	Voc	Letter	RAN	List comp
34		Segers et al. (30–30)	−0.05		−0.27						0.17			
35		Segers and Verhoeven (26–36)	0.26	0.26								0.26		
36		Shamir et al. (27–27)	0.30	0.17			0.34			0.38				
37		Silverman and Hines (42–42)	0.37								0.37			
38		Van Daal and Reitsma (9–9)	0.53				0.51	0.40		0.31		0.89		
39		Verhallen and Bus (29–29)	0.97								0.97			
40	Video	Verhallen et al. (10–10)	1.87		1.55						2.19			
41	Static	Verhallen et al. (10–10)	0.80		0.64						0.96			
42		Wild (44–40)	0.16	0.30		0.02								

[a]*d'* aggregated effect size, *PA* phonological awareness, *Comp* reading comprehension, *Spell* spelling, *Word* word reading accuracy, *Nword* nonword reading accuracy, *Fluency* reading fluency, *P-concepts* print concepts, *Voc* vocabulary, *Letter* letter learning, *RAN* rapid automatized naming, *List Comp* listening comprehension. See also text

Table 3 Results of multilevel modelling for the effect of study characteristics on effect sizes

Variable	Parameter estimate	SE
Number of sessions (range: 1–74)	−.0354	.010
Time-on-task (divided by 100, centred at 10; max. = 22.2)	.153	.048
Age: Older than Kindergarten	−.740	.239
Control: Alternative reading treatment	1.139	.357
Control: Pretest as baseline or no-risk group	.758	.265
Design: Gain scores	−.881	.410

variation in effect sizes was explained by the year, in which the study was published and 31% (.200, *SE* = .064) was due to differences between studies. In Table 3 the parameter estimates and the standard errors of the estimates of the final model with only significant effects are presented.

Factors that positively affect effect size include total time-on-task (an increase of .153 with every 100 min more, *SE* = .051), which was slightly moderated by the number of sessions the participants engaged in (a decrease of −.035 with every additional session, *SE* = .010). Effects are .854 larger for preschoolers and kindergartners in comparison to first graders and older children (*SE* = .248). In comparison with studies in which the traditional medium or curriculum forms the control condition, effects sizes are larger if the control condition consists of an alternative reading intervention (1.139, *SE* = .357) and if there is a pretest as base-line or if a no-risk group is used as the control group (.758, *SE* = .266). A study design in which gain scores are analysed gave smaller effect sizes (−.882, *SE* = .410).

Effect sizes are not influenced if the control condition consists of a non-reading task. Publication year, specificity of the training, type of risk factor, language of instruction, media type, grouping of the participants, type of test used, type of scores analysed, and design (statistical comparison) all did not affect the effect sizes of the studies. Nor did any interaction between significant parameters in the final model.

Finally, we checked whether publication bias affects the current meta-analysis. Publication bias refers to a tendency to publish studies with significant results, thus with sizable effect sizes. The presence of publication bias is assessed by examining the correlation of the effect size of studies with a measure of precision, such as sample size, standard error, or the inverse of the standard error (Cornell and Mulrow 1999). This can be done by visually inspecting the scatterplot of the correlation and by statistically testing the correlation under the assumption that studies are symmetrically distributed in a funnel shape with precise studies having less variable and less precise studies having more variable effect sizes, if publication bias is absent. In Fig. 1 effect sizes of the primary studies are plotted against the sample sizes. Visual inspection shows that there are relative few studies with many (over 80) participants. A funnel-like shape can be recognised in the studies with less than 80 participants. For these 30 studies the Kendall rank correlation is −.130 (p = .317). Given the relative high p-value, it is unlikely, even given a relatively small number

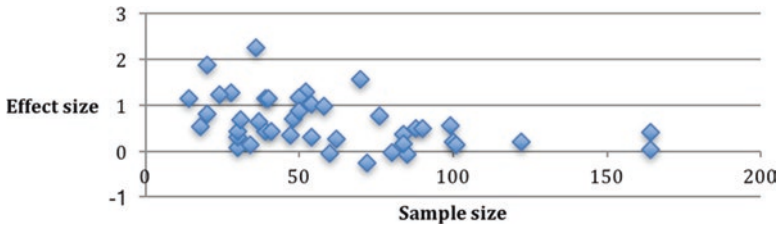

Fig. 1 Standardised effect sizes plotted against sample sizes

of primary studies, that publication bias forms a threat to the validity of this meta-analysis. However, the studies with large numbers of participants show clearly no funnel shape. This may well be due to the fact that very few large-scale studies can be conducted at all, due to financial constraints.

8 Discussion

This systematic review sought to assess how effective multimedia applications were in the 2000–2010 period, in which major developments in hard- and software took place. In addition, this study examined which characteristics of the primary studies are positively related to the effect sizes obtained. The hypothesis that multimedia applications would be more effective than before, is supported, as a medium overall effect of .65 was obtained, which is substantially larger than reported by Blok et al. (2002) in their review of CAI and by Zucker et al. (2009), who reviewed the efficiency of e-books. Moreover, this study shows that effects can and have been replicated in non-English speaking countries, though on a small scale. It also complements a previous report (Van Daal and Sandvik 2013), in which the effect of multimedia applications on specific literacy outcomes was evaluated.

Nineteen percent of variation in effect sizes in the current study can be ascribed to the year in which the study was published, whilst 31% reflected overall differences in effect size between the primary studies. Note that effect sizes vary between studies according to year of publication, but there is no significant association between effect size and year of publication. Time-on-task and being a preschooler or kindergartner were positively related to effect size obtained in the primary study. Three aspects of the design affected the effect size of studies. Larger effect sizes were obtained in studies that compared interventions/treatments with a traditional medium or curriculum. Also, effect sizes were larger for studies that used a pretest-posttest design without a control condition or took a no-risk group for comparison. Smaller effects were obtained, if gain scores were analysed.

The largest effect size, 2.25 on a comprehension measure, was obtained in a study by De Jong and Bus (2004), which compared effects of electronic books and being read aloud by parents with a counterbalanced design. In 10 other studies aggregated effect sizes were greater than 1. In most studies with multiple literacy

outcomes a considerable variation in effect sizes across literacy outcomes was found. This is probably due to different contents and different forms of practice. For example, in the Comaskey et al. (2009) study both the analytic and the synthetic phonics training was very effective for letter learning and PA but less so for word and nonword reading, whilst in the Hecht and Close (2002) study a *combination* of analytic and synthetic phonics training was more effective for word reading and PA but not for letter learning.

In contrast to these two studies, experimental groups were often compared with a control group that did 'nothing', which may produce inflated effect sizes. A more telling comparison would be to look at the so-called 'added value' of multimedia applications. Several of the studies included in this review offer such a possibility in addition to the aforementioned studies that compared multimedia interventions with regular classroom instruction. For example, in the study by Chambers et al. (2008) computer-assisted tutoring was compared with embedded multimedia. Effect sizes were larger for embedded multimedia than for computer-assisted tutoring with respect to comprehension (.56), word reading (.75), nonword reading (.46), and letter learning (.47). Another way to learn more about how multimedia may work is to include different kinds of experimental groups, as Verhallen et al. (2006) did. The effect size for the experimental group that was presented video pictures was larger than the effect size of the experimental group that was presented static pictures. In addition, the current study clearly showed that larger effect sizes were obtained in studies that compared the experimental group with an alternative reading treatment group, or using the pretest as a baseline, if there is no control group, or using a no-risk group as a control group. The latter should be positively interpreted: if at-risk children can catch up with their not-at-risk peers with help of multimedia, Matthew effects can be turned around (Stanovich 2000), which is also supported by the finding that effects were larger in preschoolers and kindergartners compared to older children. In other words, the earlier you intervene, the greater the chances of a positive response to intervention. In addition, population (at-risk, not at-risk) did not matter; it can thus be inferred that multimedia applications were equally effective in both populations: at-risk children did not get further behind their peers.

Over the years the methodological quality of the primary studies has definitely increased. Whereas Blok et al. (2002) observed that only 25 of 75 had a rigorous design, that is, included a control group and did not lack essential statistics, the current study includes 35 (out of 42 studies) with a control group. In most studies possible differences at pretest between experimental and control groups were accounted for. Also, the use of standardised tests has increased, and unreliable assessments, such as the use of gain or difference scores have become rare. Nevertheless, three studies that analysed gain scores were included in the current meta-analysis and yielded significantly smaller effect sizes. This is due to a relative large error variance of such compound scores and a reduction of the true variance, which leads to an underestimation of the effect size (see for a discussion of the use of compound scores Adèr et al. 2008, p. 261).

We were able to demonstrate that time-on-task between studies makes a difference. This has also been a topic of investigation within studies. For example, Hecht and Close (2002) found that time spent on using the Waterford Early Reading Programme uniquely contributed to effects four out of six literacy outcomes. A similar result was obtained by Segers and Verhoeven (2005), who found that the more time spent on playing a computer game that promoted phonological skills in native Dutch and immigrant children, the more was learnt. The moderating effect that was found for the number of sessions across primary studies in our meta-analysis could be due to regression to the mean, that is, with very many sessions an asymptote of the effectiveness is reached.

Consistent with Blok et al. (2002) no influence of study characteristics such as year of publication, design (statistical), population (being at risk or not at risk), and specificity of training (one or more subskills trained) was found. Cheung and Slavin (2012) found no effect of year of publication either. It is remarkable that year of publication did not affect the effect sizes, as one would expect that researchers gain insights from previous studies and build more effective multimedia. On the other hand, effect sizes are based on *mean* differences and variances. This means that some children profit more from interventions with multimedia than others. It could well be that multimedia interventions across different years of publication are beneficial for different subgroups of children without showing an overall increase of effect size. Design-statistical characteristics of the study (between classes, within classes, between schools, within schools, and counterbalancing within class) most probably did not affect the effect sizes, because when weaker designs such as the between comparisons were used, it was usually checked whether still valid conclusions could be drawn, for example, differences between groups at pretest could be excluded as a possible confounder.

Study characteristics, which Blok et al. (2002) did not examine, but made no difference in our review, include media type (e-book, CAI, TV/Video), country, language, grouping of students (mixed, individual, whole class, small groups), transfer of training (train to test, transfer of training/curriculum-based), and type of scores analysed (raw observed, adjusted, transformed). Unfortunately, if these effects existed at all, the design of the current study would not have had sufficient power to detect them.

8.1 Comparisons with Other Meta-analyses: CAI

It seems useful to compare our results with the results from other meta-analyses. As far as we know, two recent studies are relevant here, Hattie (2008), who conducted over 800 meta-analyses of existing meta-analyses, which encompassed 52,637 original studies and Cheung and Slavin (2012), who focussed on the impact of technology in literacy learning, synthesizing 84 studies. Hattie (2008) synthesized meta-analyses of CAI, of which only three original studies focussed on literacy

learning, including the aforementioned study by Blok et al. (2002) and two others with respective effect sizes of .19, .27 (published in 2000) and .31 (published in 1995). Cheung and Slavin (2012) using very stringent inclusion criteria, that is, only studies with print-related outcomes, – no phonological awareness or listening comprehension were included – found a 95% confidence interval for the effect size that ranged from .12 to .21. Cheung and Slavin (2012) also reported a relatively larger effect size for comprehensive models of instruction, that is, using CAI along with other non-computer activities supported by teachers.

Where does the difference between the current study's results and the results obtained by Blok et al. (2002) and Cheung and Slavin (2012) come from? We think that, whereas our inclusion criteria were similar to the ones used by Blok et al. (2002), there are disparities with the ones used by Cheung and Slavin (2012). Firstly, Cheung and Slavin (2012) selected 84 studies from the 1980s onwards, of which 47 were published in the 2000–2010 period, including not only journal articles as we did (they selected 15), but also unpublished doctoral theses (11), web publications (4), and reports (17). All studies they included were American, of which 4 were included in our meta-analysis. On the other hand, we included 11 more American studies and 21 studies conducted outside the US. In addition, the selection of studies by Cheung and Slavin (2012) was narrower with respect to literacy outcomes as they selected only print-related outcomes, but much wider with respect to the context in which the multimedia applications were used and the age of the participants. Thus, it could well be that selecting studies from the 1980s onwards, conducted in a wider educational context and with older participants in the original studies has led to finding relatively lower effect sizes of multimedia applications. Please note that we found that older participants profit relatively less from multimedia applications.

8.2 Implementation Variables in CAI

In intervention research, pilot and efficacy studies are first run in the lab and under controlled circumstances in schools. Then, a manualised intervention is implemented in real-world settings and it is evaluated whether intervention outcomes which are generalizable across various settings and participants (Kaderavek and Justice 2010). Pilot studies and efficacy research are carried out in a controlled setting to assess the causal relation between an intervention and an outcome, for example, whether a phonics programme influences phonological awareness. Maximum control is usually achieved by random allocation of participants to the experimental group, which receives the treatment, or to a comparison group, which receives an alternative treatment and/or a control group, which engages in 'business as usual', combined with pre- and post-testing. Efficacy research results in identification of the 'active ingredients' of an intervention; it answers the questions of why the intervention produces positive outcomes, of how and why an intervention is effective

and of why it works better than other interventions (Longabaugh et al. 2005). In addition, efficacy research informs the effectiveness of the intervention (characteristics) in terms of effect sizes.

Finally, through effectiveness research it is examined how effective an intervention is *as implemented* (Hulleman and Cordray 2009), that is, how treatment effectiveness reduction can be countered when moving from the lab to the field. The reduction in treatment effectiveness is examined by studying treatment fidelity. Treatment fidelity is defined as the degree to which field implementation of an intervention corresponds to the prototype implementation (Hulleman and Cordray 2009). There are two sources of treatment infidelity which decrease treatment strength: (1) in the experimental condition the treatment may not be implemented as prescribed (the teacher does not follow the manual or missed professional development training sessions), so that the intervention becomes less effective, and (2) in the control condition a teacher may add components from the experimental treatment or an alternative treatment, so that the control becomes more effective than it otherwise would have been. In sum, evidence-based practice (EBP) is based on results of both efficacy and effectiveness research.

Thus, in order for multimedia to be successful in the classroom situation or at home we already mentioned that the use of computers should be integrated with other teaching/learning activities (Cheung and Slavin 2012). Archer et al. (2014) examined therefore the moderating effects of (1) the quality of training and support teachers received for implementing a CAI intervention, and (2) the degree of implementation fidelity by combining three comparable meta-analyses. These meta-analyses comprised of original US studies conducted between 1990 and 2007. The overall effect size was .18, whereas there was an added effect size of .58 for training and support, a result that corroborates the finding of relatively larger effect sizes for comprehensive models of instruction (Cheung and Slavin 2012). However, no effect of treatment fidelity was found.

8.3 Comparisons with Other Meta-analyses: e-Books

For a very comprehensive systematic review of storybooks, see Bus et al. (2015). As far as we know, there is one meta-analysis specifically on the effectiveness of multimedia and interactive features in storybooks (Takacs et al. 2015). They analysed 57 effects on 5 outcomes from publications between 1980 and 2014 with 2147 participants, aged between 3 and 10 years of age. Effects were .17 (p = .04), .20 (p = .04), −.08 (n.s.), .16 (n.s.) and .26 (n.s.) for story comprehension, expressive vocabulary, receptive vocabulary, code-related literacy skills and engagement and child-initiated communication during reading, respectively. In addition, Takacs et al. (2015) found that animated pictures, music and sound effects were beneficial, whereas hotspots, games, and dictionaries were distracting. It seems difficult to compare effect sizes from this study with ours, as Takacs et al. (2015) also included TV, video and more, whereas we seem to have included interventions based on the very first lab studies, which had been tested in the field by researchers.

8.4 Limitations

As with all research, this study has its limitations. We discuss one of them that pertain to meta-analyses in general: whether causal conclusions can be drawn.[3] For example, it would seem sensible to conclude from this study that especially young children should expand the time they spend on learning with multimedia applications, because it was found that effect sizes were relatively larger for younger children in comparison to older children and for studies, in which children spend more time on using the multimedia applications in comparison to studies, in which less time was spent. This is however not necessarily true, because we don't know *how exactly* the multimedia are used. We suggest an examination of how multimedia applications on are actually used. Generally, smart phones and tablets offer opportunities for more interactivity through touch screens that can be used by even very young children. However, evaluating apps is a challenging task for the following reasons. (1) There are very many apps available,[4] which makes it difficult to choose from, not only by teachers and parents, but also by researchers. (2) It is unlikely that any commercially available app is fully adaptive with respect to instruction and testing a (literacy) learner, because a sizable item bank is usually lacking. It is therefore unlikely that many primary studies with adaptive interventions can be run, let alone conduct a systematic review. A future methodology that exploits advantages of smart phones and tablets (Dufau et al. 2011) could entail to design an app based on a proven adaptive learning system available to very many children and to tag the devices over the Internet in order to collect data.

9 Conclusion

Multimedia applications evaluated over the 2000–2010 period have proven to be effective, especially when delivered to preschoolers and kindergartners, and if they are used intensively.

We expect that CAI will continue to be used in schools and homes. However, it seems unlikely that tablets and smart phones equipped with touch screen technology will soon be replaced. However, as we indicated, it will be hard to conduct evaluation studies for these hand-held systems. Nevertheless, this should be done.

An interesting topic for future research is, in our opinion, to look at when children are ready to use educational apps and games on smart phones and tablets. Looking at school readiness, Duncan et al. (2007) found that school-entry maths, reading and attention predicted later achievement best. Others, for example, Diamond (2012) and Nicolson (2016) have suggested that children are ready for

[3] There exist many more limitations. Statistical issues are discussed by Bergeron and Rivard (2017).

[4] As of June 2015, over 80,000 educational apps were found on the Apple App Store.

learning maths and reading if their attentional skills are well developed. Moreover, Diamond (2013) found that attentional skills could be trained. Going back to educational apps and games, it would therefore be worthwhile to research how children can best be trained to use educational apps, thereby avoiding distraction by 'bells and whistles' (Bus et al. 2015; Takacs et al. 2015).

Appendices

Appendix 1: Principal Component Analysis of Literacy Outcomes in Two Primary Studies

Literacy outcome	Hecht and Close (2002)	Savage et al. (2009)
PA	.870	.803
Letter knowledge	.706	.578
Word reading	.791	.864
Spelling	.849	.880
Vocabulary	.631	.878
Print concepts	.715	–
Listening comprehension	–	.466
Reading comprehension	–	.837
Nonword reading	–	.863

Appendix 2: Effect Sizes for Separate Literacy Outcomes (Van Daal and Sandvik 2013)

Literacy outcome[a]	ES	95% confidence interval	Number of studies
Comprehension	.52	.27–1.31	12
Letter learning	.89	.66–1.13	6
Nonword reading	.53	.39–.67	13
PA	.75	.68–.83	51
Print concepts	.86	.61–1.11	6
RAN	.21	.05–.38	3
Spelling	1.11	.90–1.32	5
Vocabulary	.68	.57–.80	28
Word reading	.60	.52–.68	44

[a]Literacy outcomes were slightly differently grouped, e.g., listening and reading comprehension were taken together

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