

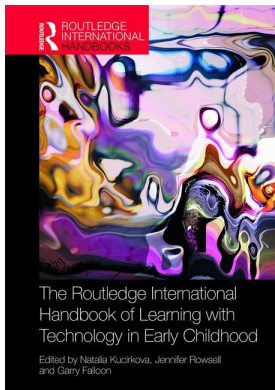
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READING IN THE DIGITAL AGE

Lessons learned and future opportunities

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Roberta Michnick Golinkoff and Kathy Hirsh-Pasek*

Technology is ubiquitous. It now pervades early childhood in ways that were unimaginable even five years ago. From the roughly two hours a day children under the age of eight spend using screen media (Common Sense Media, 2017), to the recent report that most children have their own devices by the age of four (Kabali et al., 2015), children's first-hand experience with technology has changed dramatically over the last decade. Indeed, even parent-child interaction has undergone a remarkable transformation with one observational study finding that 40 out of 55 caregivers used a mobile device during a family meal at a fast food restaurant (Radesky et al., 2014). These devices are changing the landscape of childhood.

One specific area in this "digital landscape" of particular importance is the use of e-books. When we refer to e-books, we include a variety of formats in which books are consumed digitally, including those that are read on computers, consoles, and tablets. The term "e-books" is an umbrella term inclusive of all of these formats. Similarly, the term e-book includes both interactive and non-interactive reading experiences. This wide variability may account for some of the divergent findings in this literature. However, to be comprehensive we include all of these formats in our review.

By 2014, 62% of two- to ten-year-olds had access to either a tablet or a dedicated e-reader for electronic reading at home, and parents reported that half of those children regularly engaged in electronic reading (Rideout, 2014). Even pre-literate children use this technology: two- to four-year-olds clock in at rates similar to those of older children (Rideout, 2014). E-book reading is common for children of all SES backgrounds: Parents of four-year-olds in a low-income sample, for example, report that 46% of children read or looked at e-books at home at least once per week (Pasnik et al., 2015).

As e-books proliferate, researchers rush to keep up with the rapidly evolving technology. Admittedly, research in this area is still in its infancy. However, scientists have already provided valuable insights into the role of e-book technology in children's learning. In this chapter, we highlight a number of important "lessons learned" over the past decade. These lessons reflect both current challenges and future opportunities.

**Lesson 1: it is vital for research to keep up with
rapidly changing technology**

One unique challenge in studying e-book reading is the rapidly changing technology in the way e-books work. For example, early e-book research used CD-ROM storybooks that children

interacted with through a desktop computer (de Jong & Bus, 2002; Kim & Anderson, 2008; Korat & Shamir, 2007; Lauricella et al., 2014; Moody et al., 2010). Since the advent of smartphones and tablets, computer-based e-books have taken a nosedive. Similarly, one study conducted in our labs (Parish-Morris et al., 2013) used a console-based e-book which allowed users to insert a paper book along with a matching cartridge that resulted in touch-activated pictures, sound effects, and games. These talking book consoles were popular when the study was originally designed and conducted, but by the time it was published, iPads were common and e-books on tablets commanded the marketplace. By the time results are published, the technology used in the study has often given way to newer developments.

Children's engagement and learning may also differ across formats, and these differences may be important for interpreting research using now-outdated technologies. For example, different levels of materiality – or the ability to touch and physically interact with the book – across formats play a role in engagement and pleasure during reading (Kucirkova, 2017). In short, the pace of scientific discovery does not compete well with the pace of technological delivery.

Changes in technology can also affect the research itself. A recent study in our labs, for example, set out to test features of e-books and traditional books that might affect parent-child interaction and child story comprehension (Hassinger-Das, 2017). The study used an app downloaded from the web called *Storia* by Scholastic, and was showing interesting preliminary results: book format did not seem to have a large impact on children's story comprehension. However, a particular aspect of parent talk – connecting the story to the child's life – predicted comprehension across platforms. Partway through data collection, however, the *Storia* app was discontinued and because the app was no longer functional, additional participants could not be tested using the e-book versions of the story. Although the research team presented the preliminary results at several conferences, these presentations do not contribute to the field in the same way that a peer-reviewed publication would. As this example shows, even ongoing data collection can lag behind the rapidly changing digital world.

Diverging timelines of research and technology call for innovation in making our work timely and relevant. It may be valuable for the field to consider alternative models of collecting data, such as rapid cycle studies in which teams develop and share materials for studies that are run by a network of multiple research labs simultaneously (Hassinger-Das, 2017). By distributing data collection responsibilities across sites, timely studies can be conducted quickly, resulting in knowledge dissemination while the data are relevant and useful. One should also be in front of rather than behind the curve by using the newest technology as soon as it is available, rather than designing studies based on last year's models. It is not always clear what new fad will dominate the marketplace and which will wilt, but researchers can attempt to keep up with tech news. The field may also benefit from considering funding and publishing practices that move more quickly so that the pace of research closely matches the pace of technology. Another alternate and promising approach is to encourage collaborations between researchers and designers so that designers are familiar with the latest research and scientists are doing relevant research on next generation products.

Lesson 2: balancing the wide variety of e-book features and creating generalizable findings is a challenge

Another challenge is that “e-books” are not all created equal. Our cumulative knowledge is based on studies using a variety of e-book types, yet, different types of e-books have unique effects on how children interact with and learn from them. Some of the mixed findings in this

literature may result from the different forms (computer, console, tablet) being lumped together under the umbrella of “e-book.”

Even tablet-based e-books vary drastically in the amount and type of their interactivity. Some are simply picture books mapped into an electronic format, whereas others include “bells and whistles,” like hotspots, sound effects, and games. Some studies suggest that interactive features can inhibit parent-child interactions as well as children’s learning (Parish-Morris et al., 2013; Reich et al., 2016), whereas others indicate that high-quality multimedia or interactive features closely related to the story content may improve learning (Moody et al., 2010; Smeets & Bus, 2014; Takacs et al., 2014; Walker et al., 2017; Zucker et al., 2009). Still others show no influence of interactive or animated features on story comprehension compared to non-interactive e-books or print books (Karemaker et al., 2017; Rvachew et al., 2017; Zipke, 2017). When researchers study e-book reading, they have to make principled decisions, depending on their research question, about which e-book type to use. A recent study in our lab (Dore et al., 2018) favored a simple e-book based on the research suggesting that “bells and whistles” can be distracting (Hirsh-Pasek et al., 2015). Many e-books include these interactive features, so when researchers draw conclusions based on simpler books, they may not generalize to the types of e-books that are likely more prevalent. Gathering survey data would be beneficial to give researchers more accurate information about the types of e-books being used in homes and how different features are used and evaluated by parents. Further, the differences in format and in results make it imperative that researchers fully identify which kind of formats they are using and hypothesize about how they think the features of that format should or will impact the outcome of interest.

Once a researcher decides whether to include interactive features, like hotspots and games, the content of the e-book needs to be considered. First, researchers must decide whether to use a commercially available e-book or one they create. Ultimately, this decision needs to be based on what research question the researchers are attempting to study. If a researcher is interested in “real world” experiences, they are more likely to turn to commercially available books given that they increase ecological validity and reflect what families actually have access to in everyday life (Kelley & Kinney, 2017; Korat & Or, 2010; Lauricella et al., 2014; Parish-Morris et al., 2013; Richter & Courage, 2017; Ross et al., 2016; Yuill & Martin, 2016). However, when researchers want to closely control aspects of e-book reading, they might need to use experimenter-created materials. For example, Strouse and Ganea (2016) used an e-book created to teach preschoolers about camouflage, and Strouse and Ganea (2017) created an e-book with photographs of novel objects (i.e. a citrus reamer) to test toddlers’ learning of new labels. This approach allows researchers to provide specific information and to manipulate different features. Indeed, Etta et al. (2017) manipulated both electronic versus print format and interactive versus non-interactive features using an experimenter-created book. Studies using both types of materials are valuable and future research might consider ways to use these approaches together when possible to provide stronger conclusions.

Lesson 3: context and previous experience matter

When studying e-book reading in the laboratory setting, researchers are implicitly providing a certain context for the reading activity. Most often, researchers tell parents to read with their child as they would at home. In one recent study in our lab we told parents, “I have an eBook for you to read to your child! Just read how you normally would at home” (Dore et al., 2018). Likewise, a previous study in our lab told parents to “Do what you normally do with

books” (Parish-Morris et al., 2013). Other lab-based experimental studies have used similar instructions (e.g., Korat & Or, 2010; Krcmar & Cingel, 2014; Yuill & Martin, 2016). The goal of these instructions is to make reading in the lab as similar as possible to the book-reading experience in children’s everyday lives. However, to our knowledge, no one has tested whether these instructions are necessary or whether different instructions would skew results in a different direction. Although directives to behave normally have strong face validity, it would be useful for future research to vary instructions to assess whether more sparse instructions (e.g., “Please read this book with your child”) or more direct instructions (e.g., “Please read this book to help your child learn the names of the animals in the book”) would result in behaviors that may be more reflective of everyday home experiences. This is an area ripe for future investigation.

A second way to facilitate ecologically valid reading experience is through the physical environment. Some studies that use experimental methods are conducted in the child’s home. For example, Korat and Or (2010) had mother-child dyads choose a place in the home for reading (i.e., the living room, the child’s room, or the kitchen), and both Lauricella et al. (2014) and Yuill and Martin (2016) had participants read in their living room. Indeed, some findings from the clinical literature suggest that observations of parent-child interaction made in lab settings may result in different behaviors than those conducted in more natural home environments, suggesting that testing families in their homes may be ideal when possible (Gardner, 2000) even if this lessens the control of alternate variables such as distraction. However, in studies that must take place in the lab, researchers typically attempt to design a home-like naturalistic setting. In a recent study in our lab, parents and children sat next to each other in child-sized chairs (Dore et al., 2018). However, few reports describe how the physical set-up of the room and families’ comfort level with the physical space may affect findings.

The placement of a camera for recording the testing session is also essential. In one of our labs, webcams are placed unobtrusively in a corner of the testing room near the ceiling so that an obvious camera will not distract children and parents. When such a set-up is not possible, researchers try to avoid drawing parent and children’s attention to cameras by preparing equipment ahead of time and placing it as inconspicuously as possible. Although this is true to some extent for all child development research, adults’ behavior may be more influenced by camera presence than children, especially in a situation in which they may think their parenting is being evaluated. Balancing informed consent of videotaping while concurrently trying to make the experience as unobtrusive as possible is a challenge, but not one that should be overlooked. One way to help ameliorate parent concerns about evaluation is for the researcher to emphasize that the goal is to understand how families in general interact, rather than focusing on an individual parent’s teaching practices.

Researchers should also consider families’ experience with e-books outside of the laboratory setting as it may influence children’s responses to e-books during studies. Given the increasing popularity of e-books, it will be valuable for future research to more consistently obtain survey data about children’s experience with e-books at home. For example, in the console e-book study (Parish-Morris et al., 2013), questionnaire data revealed that the majority of the families in the study reported having electric console books in the home and so were familiar with the format (Parish-Morris et al., 2013). The precise questions asked have varied across studies. Krcmar and Cingel (2014), for instance, focused on *duration*, asking parents how long children spent reading on an iPad, whereas Yuill and Martin (2016) queried mothers and children about their *access* to tablets at home and whether children used a tablet device for reading either at home or at school. Ross et al. (2016) similarly asked about the availability of e-books in the home, but also

about frequency, or how often children read e-books. Notably, even when such data is collected, results are often not reported or reported only descriptively, and researchers do not use the data to address questions such as whether children with more home e-book experience learn more from e-books in laboratory settings.

Given children's varied experience with e-books, measures of prior experience may explain differences in dependent variables both within and between studies. For example, e-books may be distracting when families are unfamiliar with the technology, but not when families are comfortable with it. This might explain why some early studies found differences between e-books and traditional books in parent-child interaction and learning (Krcmar & Cingel, 2014; Parish-Morris et al., 2013), whereas more recent studies have not always indicated such a stark contrast (e.g., Hassinger-Das, 2017) or have even shown advantages for e-books (Courage et al., 2017; Etta et al., 2017; Strouse & Ganea, 2017). Perhaps using technology increases cognitive load when it is new but as this technology becomes more familiar, parents are better able to effectively scaffold the interaction and children are better able to learn.

Information about children's overall screen experience may also be relevant. Strouse and Ganea (2017) found that toddlers who watch passive video (e.g., TV, movies, YouTube) more than they use screen interactive media (e.g., Skype, digital games, etc.) were less likely to transfer learning from an e-book to real-world objects. The authors suggest that because these children are used to passive video that has no clear relevance for the real world, they do not see the touch-screen as a contingent, learning activity (see also Sheehan & Uttal, 2016). Future research would do well to include measures, ideally measures that researchers could create and standardize so they can be compared across studies, to assess parents' and children's experience with e-books, as well as with other types of screen media. For example, standardized measures about past use, duration of past and current use, types of experiences, co-viewing practices, frequency, availability, and even attitudes towards e-books versus traditional books would help provide insight into today's families. When these measures are included, researchers may uncover explanations for divergent findings across studies, as well as individual differences within studies. Additionally, the ability to examine large sets of data that account for factors like previous technology use may help give the field a more nuanced and representative understanding of technology's impact on reading practices. However, researchers should carefully consider which variables they hypothesize should relate to outcomes in their particular study, rather than indiscriminately including as many measures as possible.

In addition to familiarity and experience with e-books as a format, researchers should also be cognizant of families' familiarity with the particular book used in the study. Lauricella et al. (2014), for example, used books that were relatively novel. Parents reported that they were either "not at all" or "a little bit" familiar with the books. Similarly, Krcmar and Cingel (2014) reported that only 2 out of their 70 participants had previously read the book used in their study and Ross et al. (2016) chose storybooks that were not best sellers and found that, as expected, none of the children in their study had previously read them. It is often desirable for families to be unfamiliar with the e-books used in the study because parental interactions and children's story comprehension may differ for books that they know. However, a drawback to this approach is that using unfamiliar books in lab studies for experimental control may lead to lower ecological validity, because although children may struggle to understand an e-book after a first reading, comprehension may improve with repeated reading. In home settings, children often request to read the same books repeatedly, so lab studies with unfamiliar books may not be reflective of most of children's everyday experiences. Future studies might test whether parent-child interaction differs around familiar versus novel e-books.

Lesson 4: there is a need for innovative methods for quantifying language, behavioral/emotional engagement, and caregiver-child interaction

Researchers studying parent-child interaction around e-books in the lab have to decide how to best capture that experience in quantifiable data (e.g., determining what speech and behavior is critical to code). Parish-Morris et al. (2013) coded for behavior-related utterances such as “Can you push the button?” versus story-related utterances such as “Look at what Clifford did!” Other studies used similar categories to distinguish between comments about book format or technology and those that focus on story content (e.g., Krcmar & Cingel, 2014; Lauricella, Barr, & Calvert, 2014; Moody et al., 2010). Researchers often also code for the types of verbalizations such as whether each verbalization was a question or a comment (e.g., Parish-Morris et al., 2013), or a directive, corrective, affirmation, or an answer to a child’s question (Krcmar & Cingel, 2014). Some researchers have coded for dialogic reading strategies, like distancing prompts, which connect the story to the child’s life (Parish-Morris et al., 2013; Hassinger-Das et al., 2017) and talk that expands on the book’s meaning (Korat & Or, 2010). These different approaches provide unique insights into the parent-child reading interaction. It will also be valuable for researchers to innovate and develop categorizations that consider more complex dyadic interactions like the sophisticated scaffolding that parents might provide to support children’s comprehension.

Although coding for specific types of extra-textual talk is more common, some research has also focused on measures of attention or engagement during e-book reading. Attention and engagement in e-books may promote learning and increase children’s interest in reading in general. Some studies have coded children’s visual attention to the e-book (Lauricella et al., 2014), or to the e-book versus the adult or elsewhere in the room (Richter & Courage, 2017). Others have attempted to quantify children’s engagement more broadly: Moody et al. (2010), for instance, used a modified version of the Minnesota Teaching Task to code children’s persistence, enthusiasm, and compliance, each on a seven-point scale, while engaged with a book. Persistence was based on indicators like points to the book, turning pages, positive commenting, and asking questions. Enthusiasm was coded when the child smiled or laughed, turned pages, commented positively, and showed excitement, whereas compliance was demonstrated by the child staying seated, following direction, and responding to questions. Similarly, Yuill and Martin (2016) used a coder’s rating of overall child engagement, based on visual attention, gesture, expression, and verbalization, for each minute of reading on a scale from one to five. Despite the focus on e-books for education and learning, researchers should also consider children’s reading for pleasure and how e-books can foster different facets of reader engagement (Kucirkova et al., 2017).

In addition to the cognitive benefits of joint reading, children and parents may gain emotional benefits, such as joy and intimacy, from reading together. Several recent studies have begun to investigate child and parent emotional engagement during e-book reading. Ross et al. (2016), for instance, coded for both mother and child’s positive, neutral, and negative emotion during reading. Positive emotion was coded when smiling, laughter, or surprise was exhibited, whereas negative emotion was coded when dyads exhibited boredom, frustration, confusion, anger or anxiety, and neutral emotion was coded when participants were calm and attentive. Relatedly, Yuill and Martin (2016) used a coder’s rating of interaction warmth adapted from a validated measure (Parent-Child Interaction System; Deater-Deckard et al., 1997) to code for positive affect on a scale from one to five for each minute of the reading activity. Although inter-observer reliability for these codes was high, to support replication and expansion of findings, it would be helpful if detailed instructions for these coding schemes were documented and made available to other researchers. Technology will also increasingly make it possible to

automate this kind of emotion coding. Indeed, researchers are working to create programs that can classify emotional facial expressions in still images (Baker et al., 2017), a tool that could soon be extended to dynamic videos. It will also be valuable for researchers to consider other avenues for assessing emotional engagement, such as physiological measures. In ongoing work in our lab, for example, we are investigating the use of heart rate and galvanic skin response as potential measures of the effect of e-book reading on parent and child emotion. Finally, qualitative and multimodal measures of emotion and reading engagement may also prove useful in understanding children's interactions with e-books (Kucirkova et al., 2013; Laidlaw & O'Mara, 2015; Rvachew et al., 2017).

Lesson 5: using multiple measures helps capture multiple facets of learning

The ultimate goal of measuring parent-child interaction during e-book reading is typically to assess how these exchanges affect children's story comprehension and learning. Story comprehension focuses on children's understanding of and memory for the content of the e-book. Learning measures typically assess whether children learned novel, generalizable information. Both types of outcomes can be measured in a variety of ways.

Story comprehension is often measured through specific questions designed to assess whether children understood important aspects of the e-book content. In our lab, we have asked preschoolers forced-choice questions about the story with two response options (Dore et al., 2018; Parish-Morris et al., 2013). For example, one question was "How did the beaver get better at saying 'I'm sorry?'" A) He read a book about it. B) He practiced in the mirror." In a similar study, Lauricella et al. (2014) used a procedure based on Calvert et al. (2007) to choose three-option multiple-choice questions by generating questions and having adults rate them for their centrality to the plot and retaining only questions with at least 70% centrality rating. A more systematic approach like this one using adult raters may ensure that the assessment of children's comprehensions aligns with the central themes of the story.

Forced-choice questions are commonly used with preschoolers for several reasons. First, open-ended questions may be difficult for children with limited verbal abilities. Second, open-ended questions are more time-intensive to code, and judging whether the response is correct or incorrect can be subjective. However, creating and using multiple-choice questions has its own complications. First, it is vital to ensure that response options are clear and that even the youngest participants can comprehend them and make a meaningful choice. Part of this issue is related to inconsistencies in limiting the number of options children have to choose from. In our lab, we have had success with two choices (Dore et al., 2018), whereas others have used three (Lauricella et al., 2014) or even four (Richter & Courage, 2017). When using several response options, it can be useful to pilot with simple, non-story-related questions to ensure that children understand the procedure. Few publications report methods for validating these procedures, making null results difficult to interpret.

Another potential issue is that younger children's lower working memory and inhibition skills may lead them to choose the most recent of multiple response options. If options are given in a fixed order, some answers may be chosen more often than chance simply because of their placement. To avoid this confound, researchers often counterbalance the order of response options across children (e.g., Dore et al., 2018). In this way, we can identify how easy or difficult the questions are independent of the order of response options.

Other researchers have asked questions beyond simple multiple-choice questions to assess comprehension. Richter and Courage (2017), for instance, used a funneling procedure with

preschoolers by starting with open-ended questions and then providing four multiple-choice response options if children did not recall the answer independently. Responses were scored according to strict versus lenient criteria and analyzed separately. In addition to multiple-choice questions, Parish-Morris et al. (2013) used a chronology task in which preschoolers had to temporally order four pictures by the sequence in which they occurred in the story. With older children (six- and seven-year-olds), Ross et al. (2016) used several different types of questions including picture-based, short-answer, true/false, and fill-in-the-blank, along with typical multiple-choice questions (see also Korat, 2010). Research comparing different types of questions and assessing their appropriateness for different age groups will be valuable moving forward.

Multiple-choice questions and similar measures assess children's understanding of specific aspects of the e-book content, but another common assessment is to have children retell the story. We have used a page-by-page retell measure in which the researcher shows children the pictures from the book and asks them to retell what happened on each page (Dore et al., 2018). The experimenter provided an initial prompt (i.e., "I'll get you started. . . . There once was a . . .") and additional generic prompts (e.g., "What happened here?") if needed to encourage children's storytelling throughout the task, but did not include any specific information or give any feedback. Responses were coded by counting how many of a predetermined set of possible elements children recalled from the story. Elements were determined by breaking down the story text into fundamental discrete ideas. For example, for the part of the story when the main character makes a vase for his friend Bear, children could receive one point for "made/gave," one point for "Bear," and one point for "vase." Synonyms and closely related words were also accepted (e.g., flower pot for vase). This procedure attempts to give children credit for as much of the storyline as they can recall without penalizing them for not remembering precise wording or order. Incorrect inclusions (providing incorrect details) were not coded. Notably, we also used a free recall task without the support of pictures and found that it was too difficult for the four- and five-year-olds in our sample, resulting in floor effects.

Although story retell measures typically have more variability than multiple-choice questions, they are time-intensive to code and require careful calibration to achieve high reliability. However, story retell assessments result in rich datasets that can be analyzed in a variety of ways. Yuill and Martin (2016) had coders read children's free recall responses and rate them for richness of descriptive detail and narrative coherence, both on three-point scales. McCabe and Peterson (1984) showed that children's narratives can be analyzed using scoring systems that focus on story grammar or structure. To our knowledge, these approaches have yet to be used with children's retelling of e-book stories. Other tools, like the online program Coh-Metrix (Graesser et al., 2011) allow for computer-based analysis of text and provides measures of basic features like parts of speech and sentence structure, as well as more holistic measures based on linguistic analysis, like narrativity, or the extent to which the text conveys a story, and cohesion, or the extent to which the text forms a coherent whole. Although these tools have been used more commonly with authored works like textbooks, they have strong potential for use with spontaneous storytelling transcriptions.

Although much e-book research focuses on story comprehension, some studies also assess children's learning of novel information, such as new vocabulary. For example, Korat and colleagues asked children multiple-choice questions about word meanings, using either oral definitions or picture options (Korat & Shamir, 2007; Korat, 2010; Shamir et al., 2012, see also Kucirkova et al., 2014). In a study with toddlers, Strouse and Ganea (2017) tested children's learning of labels for novel objects named in an e-book they were read. Children were tested with both images of the exact objects they had seen in the e-book and with images of objects

similar in shape but different in color to determine whether children generalized the label to other objects in the same category. Some studies also use vocabulary measures that go beyond receptive language. Kelley and Kinney (2017) used two measures of expressive vocabulary knowledge: one in which children had to provide a definition (“What does ‘daft’ mean?”), which was coded as incorrect, partial, or complete, and a measure adapted from Beck and McKeown (2007) in which children had to answer four yes/no questions related to word meaning (e.g., “If you wore shoes on your hand, would that be daft?”). These different types of measures all provide valuable information, potentially assessing different aspects of children’s word learning from e-books.

Other studies assess how children learn new facts from e-books. Strouse and Ganea (2016), for example, used an e-book that teaches preschoolers about camouflage and then asked multiple-choice questions to assess children’s understanding. They also asked for justifications and coded for whether children used camouflage reasoning to explain their answers. Few studies have assessed children’s learning of facts from e-books, but it would be useful for future research to adapt measures from studies of traditional books (Geerds, 2015; Walker et al., 2015; Waxman et al., 2014) to assess how well children learn this kind of information from e-books. It will also be valuable to consider whether children are simply repeating information from the e-book or whether they transfer those novel facts to the real world. For instance, studies by Richert and colleagues (Richert et al., 2009; Richert & Smith, 2011) using traditional books ask children to transfer a problem solution from a book to a real-world situation, showing that factors like fantasy content influence level of transfer. Researchers studying e-books may want to consider using measures that assess this kind of application as well as recall of facts. Future studies would also do well to test children again after a delay to assess long-term learning.

More broadly, it would be useful for the field to both be more specific about what we mean by the terms we use, such as “comprehension” and “learning,” and to combine different types of measures into one study. Many of the studies assessing fact learning, for example, used experimenter-created e-books whereas most studies of comprehension used commercially available e-books, making it difficult to determine the role these different factors play in their results. It will be valuable for future research to use comparable materials and methods across different studies, as divergent findings in this literature may depend on the type of materials and assessments used.

Conclusion

Just as childhood has undergone a dramatic shift in the digital age, so too, must our approach to studying the technology and its impact on children. We described five of the key lessons we learned over the last decade about conducting experimental research on e-book reading during childhood. Although this is not an exhaustive list of methodological issues, we highlighted some of the most salient issues we have encountered and seen addressed in the literature in this area. There are many significant challenges, but also exciting opportunities for future research.

Our first lesson noted that research needs to keep up with the rapid pace of technology. As technology is changing, so must the methods we use and the publishing process. We recommend that researchers move towards rapid cycle studies and investigate opportunities for making research findings available to scholars and the broader public more quickly. Measures to assess interaction and learning must also change with advancing technology. For example, we recommend moving towards using automated tools for coding emotional expressions (Baker et al., 2017) and for analyzing children’s story retell responses (Graesser et al., 2011). These new

directions represent exciting opportunities for moving this field forward and making important advancements in our knowledge base.

Second, we highlighted the challenge of creating generalizable findings, given the many types of e-book features available. It is vital for the field to consider the balance between experimental control and ecological validity. This is a recurring issue in the existing research, for example, with researchers studying reading using experimentally controlled materials and procedures but asking parents to read as they would at home. However, there are many opportunities to further balance these needs across different types of studies in future research. For instance, we recommend that researchers try to forge partnerships with e-book publishers to create high-quality, professional e-books that can meet researchers' needs for experimental design. Such partnerships would allow researchers to answer significant empirical questions while also creating benefit for the publishers by providing valuable evidence-based claims about the efficacy of their products (Hirsh-Pasek et al., 2015; Kucirkova et al., 2017). This approach would help researchers keep up with the newest technology and open up opportunities to conduct increasingly meaningful and useful research for families and society. Furthermore, when research aligns with current technology, it can feed into public engagement and allow parents and teachers to learn from and contribute to translational efforts (e.g., Kucirkova & Cremin, 2017).

Our third lesson speaks to the context for the reading interaction, including what happens before the child steps into the lab. We recommend that the field move towards considering families' prior experience with e-book technology and screen media generally. Incorporating these data into our analyses in meaningful ways may at least partially explain divergent findings, as well as individual differences between children within studies. These types of analyses will be vital to distinguishing between effects due to technological novelty and issues that are more fundamental to particular devices. Notably, e-book technology cannot be examined in a vacuum: broader patterns of children's media may influence children's interactions with e-books in complex ways. By using a wide-angle lens on families' experiences, we will better understand e-books in the larger context of today's digital childhood. Taking the context into account will allow us to answer more complex questions and advance our knowledge about potential moderating effects of individual differences among families and children.

Lessons 4 and 5 focused on the methods and measures we use to assess the experience of e-book reading and children's learning. As in any area of research, measurement matters. Different types of interaction and learning measures may result in substantially different outcomes. We recommend that researchers combine different types of methods and measures to best understand the complex phenomenon of e-book reading. Given the discrepant findings in this area and the ever-changing landscape of e-book technology, being transparent about our methodology and using multiple measures in each study will be important to move the field forward. Extending the methods we use and collaborating across labs will give researchers the opportunity to understand e-book reading from a variety of perspectives.

Although we have described the formidable challenges in lab-based e-book studies, we also note the valuable insights gleaned from the existing literature and highlight exciting opportunities for future research. Given the wealth of evidence supporting the value of traditional book-reading for children's learning both at home and in school settings, it is clear that e-books have great potential for education in today's tech-focused childhood. Researchers studying these issues have the opportunity to collaborate to create generalizable and useful knowledge about how parents and children interact with and learn from e-books. Further, we would do well to be flexible and creative in our thinking and innovate new models of research to keep pace with how today's digital-native children experience and learn from technology.

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