

Screens, Apps, and Digital Books for Young Children: The Promise of Multimedia

Adriana G. Bus

University of Stavanger

ELTE Eötvös Loránd University

Susan B. Neuman

New York University

Kathleen Roskos

John Carroll University

Just beginning to understand the potentials new technologies might bring to the learning environments of young children, we invited authors to submit articles that investigate multimedia sources and their effect on learning settings. Two main themes emerged—how digitization changes the learning environment and adult-child interaction in particular and which digital affordances enrich digital materials and how these changes affect learning. We finish with “alerts” to further explore more the hidden potentials of new technologies and how routines such as book reading might change and become more effective in some respects.

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Introduction

Thirty years into the digital era, it is now quite clear that apps, digital books, and video streaming services are game changers in the young child’s learning environment. Traditionally built games, books, and educational television programs are rapidly giving way to digital content on electronic devices, often handheld and mobile in the near environment. We are only beginning to understand what this digital shift might mean for young children’s language and early literacy development and what potentials these new technologies might bring to the learning environments of young children. In this special topic, we survey this emerging field of research in early childhood to gauge what digital resources seem to afford young children in their environments and to what effect.

We invited authors to submit articles that explore to what extent digital resources can enrich young children’s learning environment. The special topic contains an eclectic set of articles that investigate a range of multimedia sources (games, books, programs) and learning settings (home, school). Collectively, the articles focus on a relatively large sample of young children in the 4- to 6-year age range

(~1,500), thus providing a rich set of observational data for examining child-screen interactions. Our reading of the set of articles leads us to a twofold set of descriptive observations relevant to the young child’s learning environment: (a) changes in the learning environment and the consequences these have for participatory interaction and (b) changes in design of learning materials as a result of digitization—that is, the affordances of the digital material. From each set, we learn more about the digital resource in the learning environment—that is, what it brings to the child’s language and early literacy experience. And we also gain insight into what is still unknown about enhanced apps, books, and programs and their potentials for improving and enriching the language learning environment of the young child. Below we briefly highlight key findings related to changes in the learning environment and digital design, recognizing that these represent but a “slice” of the rapidly growing research in this field. Based on the findings, we then summarize what we consider as “alerts” to our colleagues in the field. By this, we mean a greater attentiveness to the design quality of digital resources and their usage in the immediate learning environment to children’s benefit.



Changes in Young Children's Learning Environment and Consequences for the Adult Role

One of the more striking features in the articles in this special topic is the shift to digital book reading. No longer only hardbound, children's books are increasingly available in a digital format and, thus, include new affordances, which predictably have consequences for book reading routines. Not because of the medium, however. Reich et al.'s findings confirm that it does not matter to children whether a story is in print or digital: Children are equally emotionally engaged with a story whether it is read by an adult or a voice-over and comprehend comparable amounts of the story. Outcomes do differ when it concerns books including all kinds of app book affordances. There is growing evidence that sharing these digital books with young children differs from sharing print books. For instance, parents use more talk about the book format and environment than they are used to do in the traditional book condition, where both parents and children are more focused on the story content (e.g., Krcmar & Cingel, 2014).

The consequences of digitization for book reading routines and parental involvement in book reading and other screen-based activities are highlighted in a few studies in this special topic. A study conducted by Samudra and colleagues, for instance, examined co-viewing in a video streaming medium—namely, how parental guidance might contribute to children's vocabulary learning from a streaming video scenario. Prior research shows that interactive activities such as shared book reading and even child talk and conversational interactions more generally are beneficial for vocabulary and language growth (e.g., Marulis & Neuman, 2010). Building on this research, Samudra et al.'s study tests the role of co-viewing that included additional repetition of the word labels, examples, and definitions of words being taught in the educational media clips. Parents additionally promoted attention to the appropriate portions of the screen when providing word labels or naming pictured examples.

In a peer setting, Wang et al. target how buddy reading stimulates learning from digital books. In various ways, the potential support of another child may improve children's transactional behaviors with text: They may draw a buddy's attention to specific information in the book, ask questions, or debate and negotiate meaning. Yet effects of buddy reading on reading strategies as shown for print books are not typical for digital books. There is no evidence that buddy reading highlights the affordances of digital books, for instance, because a buddy makes children activate hotspots that align with or extend the story.

Hoel and Tønnesson's findings are an interesting addition to the literature showing that teachers sharing an enhanced digital book struggle to define their role. In the institutional setting of Norwegian kindergartens (this concerns early years' education and care institutions for children of age 1–5

years), reading is generally carried out as shared reading in small groups of five to six children, led by one adult reader—a pattern that they quickly abandon with digital books. Hoel and Tønnesson's findings confirm that when sharing a digital book that enables hands-on exploration (tapping hotspots initiates sounds, simple animations, and dialogue/sounds from the characters), children may be occupied by the interactive elements in the book while the story is ignored. Even in sessions with more teacher control, taking turns tapping hot spots constantly interrupted the reading, as a result of which it lacked coherence.

With such outcomes of sharing digital books in mind, it is not surprising that Strouse et al. find that parents do not welcome the shift from print to digital books and prefer to use print for children's learning, relaxation, entertainment, and parent-child bonding. They emphasize that "print is more educational and entertaining than digital media." Even though the parents' position is understandable they may have a hard time continuing with print books since children, by contrast, are welcoming the digital format. Strouse et al. presented children with the same choice between two color photographs of *The Monster at the End of This Book*, one in print format and one in digital format, side by side in random order, and found that children prefer the digital format when asked, "If you could read only one of these books, which book would you choose to read?" Given the magnetism of digital devices, we may expect that emergent reading and other learning experiences will increasingly take place on these devices.

Changes as the Result of Digital Affordances

A new generation of digital resources shifted the design focus to digital additions with potential for supporting young children's understanding of stories and their early literacy skills using the growing literature about multimedia learning principles. Several studies in this special topic contribute to this emerging body of research providing new information on key design features and child-screen interactions.

Gamification

Gamification, the application of game-design elements and game principles in nongame contexts, is an innovative way to promote learning enabled by digital materials. The core design technique is to deliver concrete challenges well-tailored to a player's skill level that increase in difficulty as the player's skill improves—a basic assumption of play theory (Csikszentmihalyi, 2008). Fundamentally, digital games have goals, interactive elements, rewards and incentives, and increasing levels of challenge, which are key to enjoyment and satisfaction (Ronimus et al., 2014).

Elimelech and Aram designed a digital game to help preschool children develop early word spelling skills without adult assistance. The investigation tests the effect

of hints that are analogous to the help parents offer to their children when they try to write text: (a) auditory support (hearing the words segmented into CV/Cs [consonant vowel/consonants]) and (b) auditory + visual support (each letter or letter combination is highlighted while the sound of it is pronounced). They contrast a condition in which children do not receive hints for completing a task with conditions in which children receive auditory hints: a voice-over, splitting words in consonants and consonant-vowel combinations, or auditory and visual hints similar to how parents may support young emergent writers when they try to spell words. Elimelech and Aram argue that orthographic-specific games allow children to practice spelling independently with feedback and can add to teachers' activities and guidance, especially in classrooms where teachers have limited time to attend to children individually. The digital game tested in this study is a basic design; its potential can be expanded by applying principles of gamification—that is, tailoring tasks to the player's skill level, increasing the difficulty as the writing skill improves, and adding gamelike elements, such as rewarding children's attempts.

Experimenting with a K–2 reading intervention, Kim et al. conclude that augmenting and intensifying follow-up with gamification of a story comprehension app improved comprehension outcomes. Gamification was tested in a subsample that had not accessed an app provided by the researcher to guide the students' reading activities. The app included a variety of text-dependent questions (i.e., questions about the books) and discussion questions (i.e., questions to stimulate parent-child conversations about the book). Gamification features were added to the app to motivate the nonresponders. It was designed as a set of stepping-stones on a path toward creating your own virtual zoo. Each completed set of activities meant a child could choose a new animal for their zoo—an external motivator that went beyond merely seeing a list of activities to complete. Results showed, however, that despite text messages sent to parents of nonresponding students, only 26% of students accessed the app with gamification, which underscores the difficult problem of implementation when using apps as a mechanism for augmenting reading engagement toward the goal of improving specific early literacy skills.

Hotspots

Some articles target hotspots in digital picture books, added to enhance children's engagement and meaning making. Reviewing the literature, Christ et al. conclude that most previous investigations of digital books focus on hotspots, which are activated by a user's touch to generate animations, sound effects or music, or orally read words. In first-generation digital books, these interactions

often had little or no relevance to the story, except that they allowed the children to interact with the illustration (Zhao & Unsworth, 2017). The design goal was to include interactive functions that invite the child to explore these mechanisms as objects in the book, risking that these actions go at the expense of exploring narrative meanings. The content analysis by Christ et al. reveals that the second-generation digital books include hotspots that are more congruent—that is, they elaborate or extend the story line.

Christ et al. analyzed app books, all including hotspots, selected from the commercial market. All books were suggested by online app book reviews for young children in the age range of preschool and kindergarten. Christ et al. report a small positive effect of the minimum number of hotspots per page on story retelling, thus suggesting that the hotspots are stimulating—an unexpected result in the context of previous investigations of digital books. Most prior experiments with digital books testing hotspots versus no hotspots reveal negative effects of hotspots (e.g., Krcmar & Cingel, 2014), which suggests that young children's story comprehension may seriously suffer from task switching between hotspots and hearing a story. This makes sense, taking into account that the human information processing system has a limited capacity; sharing resources among various tasks (e.g., memorizing and integrating story events in between activating hotspots) may come at a cost for performance (Kahneman, 1973). According to the 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.

How can we explain this discrepancy in findings? Christ et al.'s findings may make sense when we consider that they are based on a set of books that mainly includes considerate hotspots that are central to the narrative. In line with Fisch (2000), we may assume that the *distance* between the interactive functions (here the hotspots) and narrative content makes a difference. When the distance is small because the narrative and the interactive functions complement one another rather than compete for resources, there may be sufficient working memory resources to be devoted to story comprehension. In other words, complementary interactions may support understanding the narrative. Further experimental research seems warranted to disentangle effects of various kinds of interactivity built into digital books. Consider, for instance, Sargeant's (2015) book app *How Far Is Up?*, in which users can move a toy rocket around a scene by tilting the hardware device or by dragging a finger across the screen. Such interactive functions affording the experience of perceiving the world from the perspective of the story character

may support comprehension of the story line (Mangen et al., 2018). However, we do not know yet what kind of interactive functions are complementary to the narrative and which ones cause competition for resources.

Filmlike Picture Book Formats

In one study (Sun et al.), the focus is on filmlike formats of picture books involving motion pictures and background sounds and music; Christ et al. also talk about auto illustration animations and auto panning and zooming. This app book affordance is grounded in the multimedia learning theory framework explaining how pictures do support children in making meaning of a narrative (Mayer, 2009). Pictures providing nonverbal representations of the narrative thread and the plot line help overcome difficulties in understanding narratives in storybooks due to sophisticated words and complex grammar, rare in daily life conversations (Takacs & Bus, 2018). To facilitate comprehension of stories, app developers have added technology to enhance the effect of pictures. Particularly the multimedia learning principle, *temporal contiguity*, assuming that synchronizing pictures and words facilitates meaning making, seems relevant for this purpose. Instead of presenting the complete event(s) on a single page, a virtual camera, panning and zooming through the illustration, guides children's visual attention, thus facilitating that narration and illustration are synchronized. Likewise, putting details of illustrations into motion may have a similar effect by attracting a longer and steadier focus on details in the illustration in sync with the narration (Takacs & Bus, 2016). For the same reason, environmental sounds and music are added, though the current findings are inconclusive concerning the effects of sound probably because it might disrupt the perception of speech in line with Mayer's (2009) *modality principle*, predicting negative effects when information sources (e.g., narration and music) use the same modality.

Sun and fellow researchers test the efficacy of filmlike digital books on Chinese language development and acquisition in a sample of 4- and 5-year-old kindergarten children in Singapore. These children are learning Mandarin in addition to English, the language of interethnic communication of education, government, and commerce. For ethnic identity and heritage maintenance, the Mother Tongue language is promoted, and in this sample Mandarin alongside English. Sun et al.'s experiment replicated previous experiments with children speaking Dutch, Turkish, and English with Mandarin-speaking children. Filmlike illustrations, by adding motion, are hypothesized to enhance the congruity of the auditory reading of the story and the visual illustrations. Their findings confirm that a filmlike book design enhances visual attention for relevant information (longer total fixation duration across the repetitive readings than peers in the static groups), meaning making (more

complete story retelling although only one of the three books reveals significant differences), and learning new Mandarin vocabulary.

Tracking Animation in Print

In the digitally enhanced books used in a study conducted by Yow et al., a voice-over reads the narrative simultaneously with a tracking animation added to the print, thus attracting children's visual attention to print and the possibility of promoting an understanding of how print relates to oral language. As previous studies by Evans and Saint-Aubin (2013) and Justice et al. (2005) show, children are not inclined to pay attention to print while they listen to stories. Yow et al. investigated whether multimedia features in digital books (i.e., audio narration and tracking animation) direct preschool-age children's attention to print in the target language. Despite the effects found in this study—children paying more visual attention to print—there may be a pitfall to such digital enhancements. Paying attention to print and how print relates to oral language may go at the expense of paying attention to the story line and comprehending the story—the main aim of book reading. While it is the case that Yow et al.'s study does not show negative effects on comprehension (the first experiment even reveals a positive effect), it should be noted that the target books—*Spot* stories—are not age appropriate for 4- to 6-year-olds (the target group). Due to the simplicity of the stories, children's story comprehension may not suffer from paying attention to print while normally such additions may interfere with meaning making.

Our Alerts

Most studies are limited to designs on the commercial market, and the resulting research tests the digital features that are available in these materials, which may or may not be grounded in multimedia learning theory and principles. This situation gives rise to our first alert: While all the studies involve multimedia materials, few plumb the hidden potentials of new technologies and how these technological advances might expand the possibilities of the learning environment to children's benefit. Sorely needed are digital book formats grounded in multimedia learning theory that are tested for effectiveness and ease of implementation, creating better language and literacy learning environments for children. It is not possible, however, to test the promising digital affordances of design utilizing commercially produced apps and digital books that are largely developed without input from educator expertise, children's television programming with video streaming perhaps the exception. A collaborative process can integrate the expertise of app developers, computer specialists, literacy educators, and specialists in digital learning to create and author high-quality materials for further

experimentation. Collaboration, in fact, is indispensable in developing materials that integrate the best of literary features and digital affordances.

In this special topic as well as in the wider literature, we observe the tendency to focus on adult-child interactivity as the driver for innovative designs in materials and settings, which, we think, is a slippery slope. A classic example is providing questions/prompts for adult use during digital book reading or co-viewing—a well-worn paper book concept applied to digital resources. See, for instance, the prototype developed by Rvachew et al. (2017). This “old print-centric applied to new digital contexts” approach leads us to a second alert: Prefab questions do not take into account that adults have their personal style attuned to their child’s knowledge to make digital content accessible. Observing hundreds of parents/teachers reading similar digital books to 3- and 4-year-olds, we observe a variety of styles and strategies, the number of repetitions being substantial and probably the most typical feature. It seems, therefore, unlikely that all parents/teachers will be happy with the same questions and prompts or satisfied, which may explain the disappointing outcomes of this line of research thus far (Rvachew et al., 2017).

As a case in point applicable to other digital resources, reading digital books may be an activity that is very different from sharing paper book stories with an adult. In a recent study, we gave parents of 3-year-old children access to a platform including filmlike digital books with a voice-over; we asked parents to encourage their child to read stories daily (Bus, unpublished data). Using analytics that register which days children are logged in and which books are read each session, it struck us that children are inclined to read many books in one session and repeat the same books more often than ever during regular book reading sessions. For the 4-week period, the children in this study had six different books available. On average, they read each book 9 times whereby the repetitions per book strongly varied ranging from just once to almost 50 times. More research is needed to further explore *new* routines that develop when families have access to a set of well-designed digital picture books. The adult role may move away from direct support while using the materials to a more distal role, including selection and encouragement.

Final Comments

We deeply appreciate the observations and findings that the authors of this collection contribute to a field in its infancy. The research work is substantive and thoughtful, giving impetus for further investigations in varied directions. Indeed, the number of studies targeting multimedia resources (books, games, video streaming) geared to children in the 2- to 6-year age range has increased substantially over the past 5 years. Still, the question as to which

technology affordances grounded in multimedia learning theory have the most promise for enriching children’s language and literacy environment to good effect has yet to receive the imaginative attention it deserves. We invite the field to build bold, new designs that advance what we know about the role of digital materials in early literacy development, not simply to revisit (or recycle) familiar print-centric routines with digital materials that are capable of so much more.

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Authors

ADRIANA G. BUS is an emeritus professor of Leiden University, Netherlands; professor at University of Stavanger, Norway; and honorary professor at ELTE Eötvös Loránd University, Budapest, Hungary. She has carried out experimental studies and meta-analyses

of both paper book reading and digital book reading in early childhood. She aims at designing new digital book formats that benefit not only children's meaning-making of narratives but also their enjoyment of literature.

SUSAN B. NEUMAN is professor of childhood education and literacy development in the Steinhardt School, New York University, New York. Her work focuses on developing interventions both in and out-of-school to enhance young children's vocabulary and conceptual development.

KATHLEEN ROSKOS studies the design and use of digital books as teaching and learning resources that support early literacy development and promote early literacy skills. She is a professor emerita of the Department of Education and School Psychology at John Carroll University, Cleveland, Ohio.