Moved to learn: The effects of interactivity in a Kinect-based literacy game for beginning readers

Bruce D. Homer [a,*], Charles K. Kinzer [b], Jan L. Plass [c], Susan M. Letourneau [a,1], Dan Hoffman [b,2], Meagan Bromley [c], Elizabeth O. Hayward [c], Selen Turkay [b,3], Yolanta Kornak [a]

[a] The Graduate Center, CUNY, USA
[b] Teacher's College, Columbia University, USA
[c] CREATE Lab, New York University, USA

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ABSTRACT

Reading to young children has a number of benefits, including supporting the acquisition of vocabulary and literacy skills. Digital reading games, including ones with new modes of interface such as the Kinect for Xbox, may provide similar benefits in part by allowing dynamic in-game activities. However, these activities may also be distracting and detract from learning. Children (ages 5–7 years, $N = 39$) were randomly assigned to either i) jointly read a story with an adult, ii) have the story read by a character in a Kinect game, or iii) have the story read by a character in a Kinect game plus in-game activities. Both *Kinect-Activities* and *Book Reading* groups had significant gains for *High Frequency Words*, *Active Decoding*, and *Total Reading Score*, but only *Kinect-Activities* group had significant gain for *Sight* words ($p < .05$). Overall, these findings are encouraging for the next generation of digital literacy games.

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1. Introduction

Reading to children remains one of the most important activities for supporting literacy development and fostering language skills (Bus, van Ijzendoorn, & Pellegrini, 1995; Homer, 2009; Mol & Bus, 2011; Mol, Bus, DeJong, & Smeets, 2008; Sénéchal & LeFevre, 2003). Joint reading practices between adults and early readers can support this development in a number of ways, including guiding children's attention to relevant print features or concepts and encouraging metalinguistic awareness through engagement with the language and narratives of books (Justice, Pullen, & Pence, 2008; Zevenbergen & Whitehurst, 2003; Zucker, Ward, & Justice, 2009). Yet as digital technologies increasingly become a part of young children's lives, their relationships with the written word and their shared literacy experiences are changing. To ensure successful learning outcomes from interacting with digital materials intending to promote literacy, designers will need to integrate successful reading practices into effective experiences with new media. The current study investigates this issue by evaluating the potential of a digital storybook with embedded games, delivered via the Microsoft Kinect (a movement based physical gaming device) to promote children's literacy development without the assistance of an adult.

There is some evidence that children can benefit from reading interactive books in ways similar to reading traditional books, with subsequent gains in vocabulary and word recognition (de Jong & Bus, 2004; Korat, 2010). Other studies, however, have found that the interactive components of digital books, which are intended to keep children engaged and actively reading, can be distracting and actually result in less reading, poorer narrative comprehension, and limited language and literacy benefits (Chiong, Ree, Takeuchi, & Erickson, 2012; de Jong & Bus, 2002; Underwood & Underwood, 1998). In their recent review of research on children's digital reading experiences, Miller and Warschauer (2013) conclude that although there is great potential of digital media, we still know little about the specific mechanisms involved in

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* Corresponding author. PhD Program in Educational Psychology, 365 Fifth Ave, New York, NY 10016, USA.
  E-mail addresses: bhomer@gc.cuny.edu, bdhomer@mac.com (B.D. Homer).
[1] Present address: Museum of Science, Boston, USA.
[2] Present address: University of Illinois at Urbana-Champaign, USA.
[3] Present address: Harvard University, Boston, USA.

learning from them. They argue that one promising area for future work involves examining effects of specific features of digital reading materials. Such a focus on asking which design features of digital reading materials make them more effective, which parallels similar approaches in multimedia learning research in other subject areas (Homer & Plass, 2010; Plass et al., 2013; Plass, Homer, & Hayward, 2009), can make a significant contribution to the growing body of literature on early reading experiences with digital technologies by focusing this research on developing effective designs to promote good reading practices that take advantage of the affordances of new technologies.

The next generation of video game consoles and interfaces, such as the Xbox Kinect, provide great opportunities for developing digital reading games that can improve education through authentic interactive learning scenarios (DePriest & Barilovits, 2011; Hsu, 2011). The gesture- and movement-based interactions create a unique, responsive platform that affords designers new possibilities for embedding dynamic in-game activities that maintain young children's interest in reading and support deeper engagement with language and narrative. However, it is critical to ensure that the storybook interface and activities within the game are well designed and do not detract from the benefits of reading. Research is also needed to determine whether the experience of digital reading games are comparable to having a story read aloud by a caregiver.

To address these questions, we conducted a randomized controlled experiment comparing language and reading outcomes for children who had a story read to them by an adult, to those who had the same story read to them by a character in a prototype of a Kinect game, either with or without the addition of in-game activities. The Kinect versions of the story, *Children Make Terrible Pets* (Brown, 2010), included a number of interactive features that required the children to use gestures or movements to interact with the book/game. These features included a book selection menu navigated by a particular combinations of body movements, turning the pages of the on-screen book with the full body, and, for the *in-game activity* group, a series of activities related to a target vocabulary word and to a plot point in the story.

In the remainder of this section we will first briefly review research on joint reading strategies from traditional books, discuss how insights from this research can be used to design interactive digital storybooks, and then review results from research investigating the effectiveness of such digital storybooks for literacy learning.

1.1. Lessons from joint storybook reading strategies

Joint reading between an adult and a child has been shown to improve literacy development across many reading and language skills, including vocabulary acquisition, story comprehension and word reading (Mol et al., 2008; Mol & Bus, 2011; Whitehurst & Lonigan, 1998). In the design of our study, we orchestrated the interactions between a child and caregiver when reading a print book, and a child and on-screen character when playing on the Kinect, to include various co-reading strategies, giving us the ability to evaluate how a digital versus print experience may affect learning from the different reading activities. These interactions were informed by joint reading practices such as dialogic reading, in which an adult uses questions and comments to engage children in the reading experience (Zevenbergen & Whitehurst, 2003), but were also constrained by the capabilities of the Kinect system. These constraints meant that interactions needed to be scripted and had to focus on strategies that could be recreated by the Kinect system, including print referencing practices like pointing and tracking words, explaining concepts of print and vocabulary in context, and elaborative language uses for target words.

Print referencing strategies have been shown to enhance emergent reading skills as a part of joint reading experiences between adults and children (Ehri & Sweet, 1991; Justice, Kaderavek, Fan, Sofka, & Hunt, 2009). Print referencing occurs when an adult uses both verbal and non-verbal cues to guide an early reader's attention to elements in the storybook. These cues can be an implicit part of the experience, like pointing to and tracking words during reading, or can be explicit techniques such as making comments or providing explanations about concepts of print, and the use of elaborative questions (Justice & Ezell, 2004).

Many aspects of print referencing were directly mapped onto the design of the digital storybook on the Kinect platform. Pointing to and tracking words during joint reading has been shown to increase print concepts and develop internalizations of word features among early readers (Ehri & Sweet, 1991), and was therefore incorporated into the digital storybook in the current study. Other examples of these techniques used in our study include the narrator's explanation of how the word "MOM!" is written in all capital letters because it is meant to be read loudly, or the activity in which children enacted the word "together," which elaborates on the pronunciation and meaning of a word in the story. These kinds of contextualized reading interactions foster metalinguistic awareness and encourage exploration of concepts among early readers (Zucker, Ward, & Justice, 2009).

The implementation of strategies that were found to be effective in print books for the design of reading activities in digital books raises the question how we can ensure that these practices are effectively mapped onto reading experiences in digital media? We cannot assume that all implementation of such strategies will be effective. In fact, a number of studies have found that adding interactive elements to a digital learning environment can actually interfere with learning outcome (Moreno & Valdez, 2005; Tuovinen & Sweller, 1999). Although new research methods are necessary to more fully explore the potential of digital media for literacy learning (see Lemke, 1998; Leu & Kinzer, 2000; Unsworth, 2003), many of the findings from successful joint storybook reading strategies can be integrated into the design of technology for interactive reading experiences.

Our review of the literature has not revealed any empirical investigation of literacy learning and employable reading strategies on the Kinect platform. Since the commercial release of the Kinect in 2011, the majority of research on this technology has investigated learning concepts within science, technology, math and engineering (STEM) education (see Isbister, Karlesky, & Frye, 2012; Norris, Goza, & Shores, 2011; Underwood, Hung, Click, & Russell, 2012). Thus, to inform the present research we look to research that has been conducted on e-books, ranging from early investigations with CD–ROM technology and "Talking Books" to work with web-based platforms and, most currently, touch screen tablets.

1.2. Designing interactive storybooks for literacy learning

Interactive reading experiences, most generally referred to as e-books, have evolved in their design to include some general common features. Among these is the convention of "written text together with synchronized narration" (Korat, 2010, p. 30), often including an animated character reading the storybook in children's titles. As the words are read aloud, the text generally will become highlighted in real time, and pauses in the story will be made at the end of each page, prompting the reader to turn the page with forward and backward buttons or by swiping the screen.