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EVALUATING THE EFFICACY OF USING A DIGITAL READING ENVIRONMENT TO IMPROVE READING COMPREHENSION WITHIN A READING CLINIC

EVAN ORTLIEB
Faculty of Education, Monash University, Melbourne, Australia

STEPHAN SARGENT and MEAGAN MORELAND
Curriculum & Instruction, Northeastern State University/Broken Arrow Campus, Broken Arrow, Oklahoma

This study examined the effectiveness of using the online digital reading environment to increase elementary students' comprehension within a reading clinic. Preservice teachers at a four-year university in the Midwest worked one-on-one with 58 fourth-grade students from three schools who were assigned to one of three conditions: print-based text instruction, hybrid instruction consisting of equal time with print and online digital reading environment, and digital-based text instruction. Students participated in 12 tutoring sessions lasting 75 minutes each, consisting of instructional activities targeting their areas in need of improvement. Multiple pre- and post-intervention measures of reading comprehension were collected. One-way analysis of variance results indicated that after controlling for initial reading achievement, there was a main effect for condition on comprehension.

As technology continues to expand our definitions of what constitutes reading and literacy, interest in reading digital texts has skyrocketed, evidenced by retailers selling more e-books than printed books (Miller & Bosman, 2011). Few investigations, though, have measured the effectiveness of integrating technology on reading comprehension. Theoretical frameworks of reading comprehension have not progressed as rapidly as technological advances in digital media and texts (Leu, Kinzer, Coiro, & Cammack, 2004) and as a result, the usefulness of digital reading environments to advance student reading comprehension remains in question.

Schools adopt computer-based reading programs to supplement their reading curriculums. These multimodal digital

Address correspondence to Evan Ortlieb, Course Leader/Senior Lecturer, Faculty of Education, Monash University, McMahons Road, Frankston, VIC 3199, Australia. E-mail: evan.ortlieb@monash.edu

environments are programmed to allow students opportunities to refine their reading skills; yet limited research efforts have been aimed at investigating their viability to improve student reading comprehension proficiencies and fulfill federal efforts to reduce the achievement gap between majority and minority factions (U.S. Department of Education, 2001). Students use the Internet and other technologies to seek, learn, and transmit information as part of their everyday lives; therefore, educators must bridge the gap between childhood literacy practices in and out of school (Lenhart, Purcell, Smith, & Zickuhr, 2010). Best practices of reading instruction must extend beyond print and into digital reading environments if students are to flourish in second decade of the 21st century.

Digital reading environments provide multimodal learning experiences not available in printed mediums (Dalton & Proctor, 2007, 2008; Dalton, Proctor, Uccelli, Mo, & Snow, 2011; Proctor, Uccelli, Dalton, & Snow, 2009). Their application was explored in this study within a university-affiliated reading clinic, where substantial breakthroughs in reading research and instruction have occurred for the last century (Morris, 2003). Investigators tested the effectiveness of using a digital reading environment to develop struggling elementary students' reading comprehension skills. The primary purpose of this study was to examine what effect, if any, a digital reading environment had on struggling fourth-grade students' reading comprehension.

Theoretical Framework

This research investigation is grounded in theories of literacy as a social practice (Gee, 1996; Street, 1995) and that literacies have been shaped by digital technologies (Kress, 2003; Lankshear & Knobel, 2003; Lewis & Fabos, 2005). Using multiple theoretical frameworks for this study allows for a precise understanding of literacy. The complexities and ever-changing nature of literacies in the digital age are far too multifarious to understand via a single lens (Coiro, Knobel, Lankshear, & Leu, 2008).

Social literacies (Gee, 1996; Street, 1995) are rooted in sociological contexts, a stark shift from the purely cognitive models found in psychology (Crawford, 1995). As students read, respond, and recommend books in a digital reading environment, they

engage in social literary experiences. The need to successfully engage in textual reading and interaction in digital environments is becoming increasingly apparent in a technology-rich society (Goodfellow, 2004). These socially created, communicative cultures are at the foundation of new literacies (New London Group, 1996).

Literacies shaped by digital technologies, also known as new or digital literacies, offer multimodal environments for students to visualize, listen, and interact with text (Kress, 1997; Jewitt, 2009; Walsh, 2009). Crossing boundaries of home and school, these new literacies are entrenched within daily activities of both work and pleasure (Coiro et al., 2008). Moreover, digital literacies require participatory function and are collaborative by design (Wilber, 2010). If educators are to understand the utility of digital technologies, including digital reading environments, additional research is essential.

Using Multimedia Context toward Reading Comprehension

Multimedia can be defined as multiple forms of media (text, graphics, images, animation, audio, and video) that work together. The advent of computer technology ushered in an explosion in the availability of visual ways of presenting material. Multimedia learning is founded on the premise that instructional messages should be aligned with verbal and visual types of information processing. Words and pictures are complementary as understanding occurs when one mentally amalgamates verbal and visual representations. Learners create a deeper understanding from connecting words with pictures (Mayer, 2001).

Reading comprehension results from the retrieval of previously acquired schema to assist the processing and understanding of new unfamiliar information (Anderson & Pearson, 1984). Lin and Chen (2007) reported that "insufficient background knowledge hinders top-down processing of the new information, and limited language competence…makes the decoding process even more difficult" (p. 83). Students often encounter difficulties in reading comprehension when they have gaps or inadequate levels of content knowledge. For students with low levels of prior knowledge, explicit instructional

strategies should be integrated into the lesson. Multimedia resources facilitate learners' information processing and positively affect cognitive encoding and processing (Lin & Chen, 2007).

Multiple studies indicate that technology and digital reading environments can positively affect reading comprehension in fifth (Dalton et al., 2011) and sixth graders (Moran, Ferdig, Pearson, Wardrop, & Blomeyer, 2008). Significant learning occurs when students engage in active processing by selecting, organizing, and integrating relevant words and pictures into mental models embedded in working memory (Mayer, 2001). The use of multiple modes of learning is not new, particularly in the area of instruction, where effective communication is highly essential (Kalaitzakis, Dafoulas, & Macaulay, 2003). Empirical evidence suggests that imagery can be a valuable supplemental aid in learning a wide range of topics, including language skills (Bean, 1990; Higbee, 1988; Macaulay, 2002; Paivio, 1971; Parker, Brownston, & Ruiz, 1993; Royer & Cable, 1976; Svantesson, 1998). In other words, enhanced learning occurs when information is encoded through multiple channels or senses. This theory could explain why digital reading environments have been effective towards student learning.

In addition to anecdotal evidence of the effectiveness of multimedia learning (Bosco, 1986; Fletcher, 1989; Hofstetter, 1994; Holliday, Brunner & Donais, 1977; Rigney & Lutz, 1976; Samuels, Biesbrock, & Terry, 1974; Sewell & Moore, 1980), there is quantitative data that suggests multimedia can enhance reading comprehension. A review by various researchers (Bosco, 1986; Fletcher, 1989; Khalili & Shashaani, 1994; Kulik, Kulik, & Cohen, 1980; Kulik, Bangert, & Williams, 1983; Kulik, Kulik, & Bangert-Drowns, 1985; Schmidt, Weinstein, Niemic, & Walberg, 1985) of hundreds of studies that has investigated the effectiveness of multimedia in learning information purported that those who received computer-based multimedia instruction performed better on reading comprehension tests than those who received traditional classroom lectures. Other studies (Dimitriadi, 2001; Heimann, Nelson, Tjus, & Gillberg, 1995; Hetzroni, Rubin, & Konkol, 2002; Tjus, Heimann, & Nelson, 2001) have suggested that multimedia can improve learning in children with learning disabilities.

Digital texts are infused with pictures, sometimes interactive, to facilitate learning. Struggling readers can utilize auditory and visual cues to effectively absorb the information. Puchalski, Morra, and von Wandruszka (1992) reported that the combination of audio and visual signals results in a greater depth of understanding than either alone, which is particularly salient for struggling readers who tend to over-rely upon pictures to aid in decoding words and comprehending the text (Kozma, 1991).

According to Collins (1991), technology-rich classrooms offer many incentives: (a) active engagement, (b) differentiated learning, and (c) combined visual and verbal learning. Lebow (1993) described constructivist principles related to technology-based learning: (a) provide a context for learning that supports both autonomy and relatedness, (b) embed the reasons for learning into the learning activity, (c) support self-regulation through the promotion of skills and attitudes, and (d) strengthen the learner's motivation. Bailey (1996) further argues that new technology, such as the use of digital reading environments, can afford rich opportunities for constructivist approaches in the field of education.

Using Digital Texts to Reach Struggling Readers

Countless children who struggle to read are highly competent and frequent users of digital technology even at early elementary grades (Levy, 2008); yet schools have not capitalized on students' use of multimedia to promote reading skills, interest, and confidence in young readers. Existing research, notes Levy, "has been grounded in the assumption that the term 'reading' relates almost solely to an ability to decode printed text within the context of paper-based media" (p. 75). It is becoming increasingly recognizable that the nature of literacy is changing (Bearne, 2003; Kress, 1997). Digital texts are becoming increasingly popular (Facer, Furlong, Furlong, & Sutherland, 2003; Holloway & Valentine, 2003) and through recent research, numerous advantages in using electronic-text technology applications over paper-based text have been identified (Reinking, Labbo, McKenna, & Kiefer, 1998). The myON digital reading environment recommends digital texts to scaffold struggling readers through multisensory learning experiences guided by their interest and

comprehension level (Anderson-Inman & Horney, 1997). Electronic texts offer augmented accessibility and accommodations not found in traditional printed texts.

Yeh and Lehman (2001) found that struggling readers benefitted from interactive hypermedia lessons and, in turn, became more effective learners. Digital reading environments enable students to build vocabulary, achieve reading fluency, improve comprehension, access curriculum content, and strengthen their home-school connections (Heinze, 2004). Numerous studies have reported correlations between the number of digital texts read and the amount of language and literacy acquired (Dupuy, Tse, & Cook, 1996; Elley, 1991; Krashen, 1993).

Since the 1990s, digital reading applications have provided learning experiences that peaked students' interest to read within a new medium (Smith & Meyen, 2003). Today, digital reading environments like myON extend books beyond just words on a computer monitor and into educational opportunities that bolster student connections to the story, preview upcoming vocabulary, and use pictures, video, and other media to predict story events. As children read the story, they can select hyperlinked vocabulary for audio pronunciation assistance to help with word recognition and, ultimately, vocabulary acquisition. Embedded comprehension questions encourage the reader to reflect on textual content; graphical elements and illustrations aid in creating a visual context for each literature selection (Edyburn, 2001; Wissick & Gardner, 2002). After-reading activities target comprehension strategy development as well as targeted reading skills related to the specific stories (e.g., word part analysis: tri-).

Explicit Comprehension Strategies

Effective reading programs are composed not only of teaching techniques but also strategies for students to improve their comprehension of text. Strategies that good readers use must be explicitly taught regardless of the grade level. These strategies must be aimed at transfer effect; that is, students can use them across curriculum areas and grade levels, as their importance is significant to understanding fiction and non-fiction topics. Investigators of this study chose to focus on strategies for the

improvement of text comprehension derived from Duke and Pearson's (2002) book chapter "Effective Practices for Developing Reading Comprehension" within Farstrup and Samuels' *What Research Has to Say about Reading Instruction.*

Good readers apply a host of strategies to read and interpret the meaning of text (Pressley, 2000; Wade, 1990). Explicit instruction of *prediction* leads students to predict and constantly adjust those predictions throughout their active reading experiences (Allbritton, 2004; Radcliffe, Caverly, Hand, & Franke, 2008; Eilers & Pinkley, 2006). Effects of using strategies like prediction include increased levels of metacognition, especially in struggling readers (Klingner, Urbach, Golos, Brownell, & Menon, 2010). *Think alouds*, or the reader's verbal thoughts, depict what reading strategies are being used and create a focused reading environment around the task at hand (Smith, 2006). Understanding content, though, begins with identifying and analyzing the arrangement of ideas or *text structure* (Armbruster, 2004). Then, readers can use *visual representations of text* and/or *summarizations* to concisely explain their understanding of the text resulting in increased levels of comprehension (Haystead & Marzano, 2009). Having the ability to delete unnecessary information, select a topic sentence, and maintain sequence of events is of primary focus when summarizing (Boulware-Gooden, Carreker, Thornhill, & Joshi, 2007). *Questions/questioning* strategies promote critical thinking skills that focus on the construction of meaning and interaction with the text (Parker & Hurry, 2007; Trinkle, 2007). These six strategies were selected to aid students' comprehension in this quasi-experimental study by equipping fourth grade students with skills necessary to be thoughtful, independent, and literate consumers of information.

The Present Study

Given that reading scores have remained stagnant for the past two decades (National Center for Education Statistics, 2009), investigators designed a study to investigate digital reading environments to determine what role they have in the quest for improved literacy levels in the elementary grades. Project researchers focused on reading comprehension skills necessary to be thoughtful toward the overall goal of reading instruction

(Beck, McKeown, Sandora, & Worthy, 1996; Blachowicz & Ogle, 2001; Pressley, 2000). While studies have shown benefits of using technology (McKenzie, 2010) and digital reading environments (Dalton et al., 2011), this study aimed to investigate the following research question—What is the effect of treatment condition (myON digital reading environment vs. hybrid vs. traditional printed text) on fourth-grade students' comprehension learning? Investigators hypothesized that the hybrid condition would be most helpful to fourth-grade students' reading comprehension. Using print and digital environments with which to read and interact seemed to best replicate students' daily experiences in and out of school. In addition, it was thought that the combination approach would provide diversified approaches to learning, which are typically preferable to students of any age.

Methods

Participants and Setting

Fourth grade students from three elementary schools in school districts located in a Midwest metropolitan area, characterized with a high transient population, participated in this study. Each school had multiracial compositions without any one race having majority representation, with the largest number of students being Hispanic and Caucasian. Schools' statewide achievement scores ranged between 52–69% on the standardized testing measures while maintaining student-to-teacher ratios of 15:1 to 18:1. All schools had between 68–97% of their student population eligible for free or reduced lunch.

One class per school was selected to participate in this study, consisting of 58 students in all. The average class size of 19.3 can be attributed to several students who did not participate in the study for its duration. Students were individually administered two pretest measures of reading comprehension: (a) Basic Reading Inventory and (b) the Lexile Framework for Reading embedded within the myON program. Scores in reading comprehension were collected and analyzed. Analysis of variance for pretest scores indicated that there were no significant differences between each class of students at the three schools, $F(2, 58)=1.88$, $p=0.158$ (see Table 1). Therefore, each class of students began the

TABLE 1 Pretest Reading Comprehension Scores of Fourth Grade Participants

	Basic Reading Inventory		Lexile (Independent Level)	
Framework	M	SD	M	SD
Print-based treatment group ($n = 23$)	4.71	1.568	570.21	151.92
Hybrid treatment group ($n = 16$)	4.25	1.844	571.375	173.728
myON treatment group ($n = 19$)	5.21	1.7897	577.37	143.676

study with comparable levels of reading comprehension. In turn, classes were randomly assigned to one of the following treatment conditions:

1. Print based intervention: Students use traditional, printed texts on their instructional level while learning comprehension strategies to foster reading improvement.
2. myON digital reading environment intervention: Students read and interact with digital texts based on their interest and reading comprehension level via an online reading environment.
3. Hybird intervention: Students use both traditional printed texts and the myON digital reading environment within one-on-one tutoring sessions. Students split their time equally between both instructional formats while using comprehension strategies.

INSTRUCTIONAL CONDITIONS/SETTING OF THE INSTRUCTION

The reading clinic is situated within the College of Education building, having 28 individual tutoring rooms. Each room is equipped with recording devices so the tutor may record a lesson to later reflect on the teaching and the professor may observe without intruding on the lesson. Four of the tutoring rooms also offer a viewing area so the parents may see their children from behind the glass but the session remains uninterrupted. The central area of the reading clinic houses a classroom for professors to facilitate the class after tutoring sessions. This room is designed with

tables to foster collaboration among students and is equipped with a SMART board, SMART table, and a computer with an overhead projector.

Materials

PRINT-BASED

Materials included as part of traditional means of instruction were authentic literature selections on individual reading levels and of high interest. Texts were both non-fiction and fiction; essentially, books were selected to support the learning of targeted comprehension skills including prediction, think aloud, text structure, visual representations of text, summarization, and questions/questioning (Duke & Pearson, 2002).

MYON DIGITAL READING ENVIRONMENT

The employed digital reading environment is a personalized reading program for students in grades PreK–8. Students in the treatment group digital reading environment read digital books from the computer-generated recommended list. Students read, reviewed, rated, and shared their opinions via an embedded social network (see Figures 1 and 2). Following the reading of texts, students were automatically issued a comprehension test to assess student understanding of content (see Figure 3). As students finished reading five texts on their level of comprehension, they took a test to determine if they had sufficiently progressed to the next level of comprehension according to the Lexile Framework for Reading. Students and tutors carefully kept track of progress each week using charts embedded within the portal (see Figure 4). myON was crafted to specifically enhance reading fluency, comprehension, and overall reading achievement by including features such as text-to-speech capabilities, dictionary function, anaphoric reference highlighting, and embedded graphics illustrating the texts.

Procedure

During one semester, researchers administered pretests to students. All 58 fourth grade students were members of three classes, as convenience sampling was utilized for selection of participants.

FIGURE 1 Screen shot of graphic novel in the myON digital reading environment.

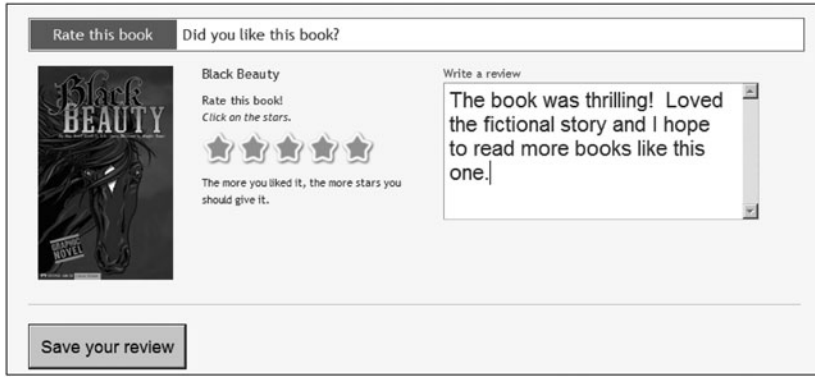

FIGURE 2 Screen shot of rate and review form of the myON digital reading environment.

FIGURE 3 Screen shot of comprehension quiz of read text in the myON digital reading environment.

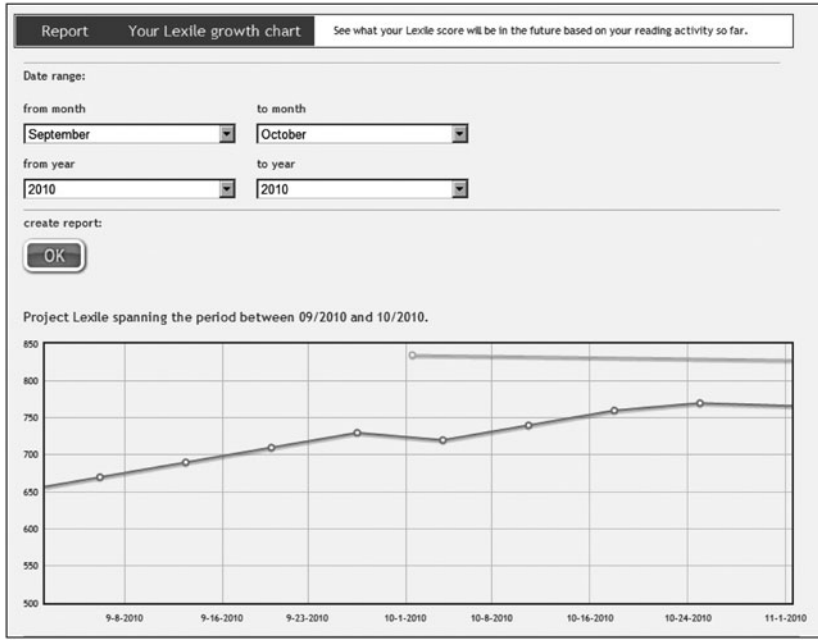

FIGURE 4 Screen shot of progress monitoring using Lexile Framework for Reading embedded in the myON digital reading environment.

Tutoring proceedings occurred after school hours in an effort not to interfere with their usual 90-minute reading block. Students partook in a total of 12 sessions with a duration of 75-minutes each. Students were randomly assigned to one of three conditions: print-based text instruction, hybrid instruction consisting of equal time with print and online digital reading environment (myON), and digital-based text instruction using only the myON program.

Curriculum design revolved around six comprehension skills (prediction, think aloud, questions/questioning, visual representations of text, summarization, and text structure). Strategies like teacher read alouds, shared reading, guided reading, partner reading, and independent reading were utilized around a framework of gradual release of responsibility (Pearson & Gallagher, 1983). Word learning strategies revolved around explicit instruction, context clues, word parts, and word consciousness. Practitioners (preservice teachers) were given the opportunity to individualize their daily lessons within the structure described. All lesson plans were approved by the instructor prior to each tutoring session. Weekly meetings with each preservice tutor ensued for the duration of the study in individual and small group formats.

INSTRUCTION

The reading clinic used a diagnostic approach to first assess the tutee (child) so that the assessment results could be used to design the literacy instruction that meets the needs of the child. Assessments included an informal reading inventory, sight word assessment, interest inventory, attitude survey, spelling/phonics assessment, perception survey, and writing assessment. After the assessments were examined, the students were individually tutored based on their specific literacy needs. The tutoring consisted first of a familiar text at the child's independent reading level to build confidence. Next, guided reading at the child's instructional reading level utilized a before/during/after reading strategy, used whole pieces of text, and was focused on comprehension. The next component was a working with words activity such as sorting and finding word patterns. A skill instruction activity followed, targeting a specific need as reflected by the assessments such as a fluency activity (e.g., repeated reading, choral reading). Finally, a teacher read aloud was used to encourage engagement and motivation as the child listened for pleasure.

Professional Development and Supplemental Assistance

All practitioners took four courses related to reading development, children's literature, language arts, and content area reading prior to this diagnosis and remediation of reading problems senior-level course; therefore, they were sufficiently equipped with content and pedagogical knowledge to plan and deliver appropriate reading instruction. All participatory teachers received two weeks of professional development to prepare them for issuing assessments, creating an instructional plan, providing successful individualized instruction, and progress monitoring their students' reading proficiencies.

The myON digital online reading environment was introduced to all 75 practitioners over the course of the second week of professional development in graduated modules. To minimize difficulties associated with the implementation, a professor of record was always available to provide assistance as needed. Following each tutoring session, these 75 practitioners were involved in debriefing sessions to review their instruction, reflect, ask questions for clarification, and continue to plan their methodical approach to reading remediation. Twenty-five practitioners (in the print-based treatment group) were introduced to the myON program so their students could take pre- and post-tests encompassing the Lexile Framework for Reading.

Assessments

LEXILE FRAMEWORK FOR READING

The myON reader has integrated assessment tests and reports student reading ability as a Lexile measure. Lexile measures are based on two strong predictors of how difficult a text is to comprehend: word frequency and sentence length. Williamson, Koons, Sandvik, & Sanford-Moore (2012) reported: "The idea behind The Lexile Framework for Reading is simple: if we know how well a student can read and how hard a specific book is to comprehend, we can predict how well that student will likely understand the book." When used together, Lexile measures aid in the selection of books that are at an appropriate level of difficulty for preservation of comprehension. These measures were used to

record and monitor a reader's growth in reading ability for the duration of one semester from pretest to posttest.

BASIC READING INVENTORY (10TH ED.)

This informal reading inventory includes both graded word lists and comprehension passages. Students read through the lists of words in isolation while the teacher records misread words as applicable. When students read six incorrect words, they have reached their frustration level. Using instructional level from the word lists, the comprehension passage is selected. Before the student begins reading the first passage, the proctor must tap into a student's background knowledge. Exposing the title, the teacher asks the student what the story will be about based on the title alone. The student will then orally read the passage. While the student is reading, the teacher records any miscues. Following the reading, the student answers comprehension questions and retells the story. The teacher records how well the student can recall facts and restate the story based on the rubric provided. Students are not allowed to look back to the story for this part of the examination. Teachers record the number correct, comparing the number with the comprehension scoring guide at the bottom of the page. This provides the student's independent, instructional, and frustration levels. Teachers completed these steps for both pretest and posttest proceedings to measure the students' comprehension level of reading ability.

Instructional Observations and Fidelity of Treatment

Principal investigators observed each practitioner intermittently throughout duration of the study to verify an acceptable level of fidelity, providing both written and oral directives for improvement and refinement of instructional practices. In addition, audio- and videotapes were recorded to provide a clear depiction of transpired elements of the session so as to provide a basis for teacher comments and suggestions for improvement. Fourth graders' electronic progress monitoring logs were also frequently checked to confirm students were continually reading and responding to the texts. The investigative team discussed teacher implementation of each of the three conditions, reviewing field notes and observational sheets.

Analysis and Results

One collegiate course was assigned to each condition (print-based, hybrid, or digital reading environment), although individual student learning outcomes were analyzed. These 58 students were nested within fourth grade classes, thus prompting researchers to test for initial reading achievement of the three distinct condition groups. Of the three conditions, there were no significant pretest differences of reading comprehension on both measures (see Table 1).

We computed one-way analyses of variance (ANOVAs) comparing the mean gain scores of participants' reading achievement differences using multiple measures—the Lexile Framework for Reading within the myON program, and Basic Reading Inventory. All participants received one of the three treatments. A significant difference was found among the interventions as measured by the Basic Reading Inventory, yielding a large effect size $F(2, 55) = 34.76$, $p = 0.000$; $\eta^2 = 0.558$. Tukey's HSD was used to determine the nature of the differences between the interventions. This analysis revealed that students who had the hybrid intervention ($M = 1.81$, $SD = 1.45$) or the traditional intervention scored higher ($M = 1.54$, $SD = 0.92$) than students who had the myON intervention ($M = -.89$, $SD = .95$). Students who had the hybrid intervention scores were not significantly different from those in the traditional intervention group.

On the Lexile Framework for Reading in the myON program, a one-way ANOVA was also utilized to compare mean gains across the three treatment groups. A significant difference was found among the interventions alongside a large effect size $F(2, 55) = 5.46$, $p = 0.007$; $\eta^2 = 0.166$. An analysis of Tukey's HSD indicated that students who had the myON intervention ($M = 42.11$, $SD = 37.15$) significantly outperformed those in the traditional intervention group ($M = 15.78$, $SD = 11.60$). Hybrid intervention group scores were not significantly different from either of the other two groups.

Discussion

This study investigated the effects of using a digital reading environment within a reading clinic setting to facilitate improvements

in reading comprehension of fourth grade struggling readers. The results provide further evidence that digital reading environments like the myON program can assist students in their reading comprehension of digital texts when assessed in a similar computer-based environment. The skills learned in reading and navigating through e-books, often times of high interest, promote reading comprehension.

Increasing comprehension levels was the overall aim of this study. Findings demonstrate that reading comprehension can be increased in reading clinics via multiple formats of instruction, whether print based or digital-text based. The explicit instruction of comprehension strategies (prediction, think aloud, text structure, visual representations of text, summarization, and questions/questioning) led students towards significant increases in comprehension levels for all three treatment groups over the semester in a carefully scaffolded one-on-one tutoring program. Hybrid group participants spent their time in print-based tutoring and the personalized digital reading environment; students receiving this intervention procured comprehension gains on both measures: IRI and Lexile Framework for Reading.

Although the myON treatment group improved its reading comprehension within the digital reading environment, other treatment groups (print based and hybrid) significantly outperformed the group on the print-based informal reading inventory. Evidence suggests that students required to perform tasks on paper-based assessments were more accustomed to working in a pencil and paper environment, whereas those students who spent all 75 minutes each session in the digital reading environment were comfortable and better prepared with digital literacy skills to competently display their knowledge on computer-based measures of reading comprehension in the myON computer-based program.

Investigators found the digital reading environment salient to classroom teachers who prioritize programs that quickly and effectively differentiate, accommodate, and remediate reading skills. Although these findings are consistent with previous research showing the potentiality of digital reading environments, its use and application in reading clinics provides additional insight into effective options for reading remediation. The myON

framework supports learners through a best practices approach by determining what the student is interested in, assessing the student's comprehension abilities, screening its extensive book collection, and then providing suggestions for e-books that the student would be interested in reading at a target level of difficulty. Approaches that foster these competencies in digital environments supplement a teacher's ability to foster reading success for all.

Limitations

The participant population in this study was fourth-grade students in three schools in a metropolitan district in the Midwest. Treatment assignments were randomized with each school receiving an alternate comprehension intervention within a university-affiliated reading clinic. Although researchers used pretest scores from multiple measures to control for variability in initial reading competencies, the effects of small sample sizes for each treatment group cannot be ignored. Replicating this study on a larger scale using numerous reading clinics throughout the nation would render results with increased generalizability.

Comprehension gains in this investigation were measured through both an authenticated measure of reading ability (Lexile Framework) and an informal reading inventory (Basic Reading Inventory). It should be noted that results varied between reading achievement tests. The intervention program lasted one semester in duration and results may have varied if additional time was provided for students to gain mastery of all the comprehension skills explicitly used to guide each tutoring session.

The amount and level of tutoring support is a caveat of any reading clinic. Although each tutor received the same number of reading courses prior to conducting tutoring sessions, the pedagogical proficiencies of preservice teachers vary. These unique qualities were recognized by the investigators and, in turn, individual and small group guidance was provided throughout the inquiry. Standardized lesson plan formats allowed for large-scale uniformity of comprehension skills to be targeted, but each tutor was given authority to craft lesson plans to their fourth graders' unique reading abilities, interests, and levels.

Conclusion

Digital reading environments like myON are significant additions to a core reading program led by a well-informed and critical-thinking classroom teacher. We do not suggest that digital texts or reading environments replace authentic literature experiences or teacher-led activities. Instead, results indicate that the use of the myON program as a supplementary instructional tool should be considered to optimize students' comprehension in their reading of print and digital texts.

The results of this study provide additional evidence that print- and digital-based learning environments can bolster comprehension levels of elementary students in reading clinics. Although evidence of the effectiveness of a digital reading environment towards gains in reading comprehension (Dalton et al., 2011) has been established, this investigation adds relevant information pertaining to its implementation in an elementary reading clinic. Results align with emergent theories of reading that indicate readers take strategic control of their reading experiences (Stahl, Kuhn, & Pickle, 1999) by reading, visualizing, listening, and interacting with text (Jewitt, 2009; Kress, 1997; Walsh, 2009).

Findings suggest that digital reading environments can serve a supplementary role in leading students towards comprehension development. Individualized instruction, whether in a print-based or digital environment, should remain the focus of every successful reading program. This preliminary investigation adds to existing research evidence of the role digital texts can play in student learning. Continued research on alignment between instructional and assessment practices is warranted to scrutinize the effects of testing format on individual student performance. Alongside the adoption of digital reading environments, research findings will advance our theoretical understanding of the relationship between print and digital literacies, defining which skills are media-specific and those that are universal.

References

Allbritton, D. (2004, November). Strategic production of predictive inferences during comprehension. *Discourse Processes, 38*(3), 309–322.

Anderson, R. C., & Pearson, P. D. (1984). A schema- theoretic view of basic processes in reading comprehension. In P. D. Pearson (Ed.), *Handbook of reading research* (pp. 255–291). New York, NY: Longman.

Anderson-Inman, L., & Horney, M. (1997). Electronic books for secondary students. *Journal of Adolescent & Adult Literacy*, *40*(6), 486–491.

Armbruster, B. B. (2004). Considerate texts. In D. Lapp, J. Flood, & N. Farnan (Eds.), *Content area reading and learning: Instructional strategies* (pp. 47–57). Mahwah, NJ: Lawrence Erlbaum.

Bailey, D. H. (1996). Constructivism and multimedia: Theory and application; innovation and transformation. *International Journal of Instructional Media*, *23*(2), 161–165.

Bean, T. W. (1990). Learning concepts from biology text through pictorial analogies and an analogical study guide. *Journal of Educational Research*, *83*, 233–237.

Bearne, E. (2003). Rethinking literacy: Communication, representation and text. *Reading Literacy and Language*, *37*(3), 98–103.

Beck, I. L., McKeown, M. G., Sandora, C., & Worthy, J. (1996). Questioning the author: A year long classroom implementation to engage students with text. *The Elementary School Journal*, *96*, 385–414.

Blachowicz, C., & Ogle, D. (2001). *Reading comprehension: Strategies for independent learners.* New York, NY: Guilford.

Bosco, J. (1986). An analysis of evaluations of interactive video. *Educational Technology*, *25*, 7–16.

Boulware-Gooden, R., Carreker, S., Thornhill, A., & Joshi, R. M. (2007). Instruction of metacognitive strategies enhances reading comprehension and vocabulary achievement of third-grade students. *LD Online.* Retrieved from http://www.ldonline.org/article/Instruction_of_Metacognitive_Strategies_Enhances_Reading_Comprehension_and_Vocabulary_Achievement_of_Third-Grade_Students?theme=print

Coiro, J., Knobel, M., Lankshear, C. & Leu, D. (2008). Central issues in new literacies and new literacies research. In J. Coiro, M. Knobel, C. Lankshear, & D. Leu (Eds.), *Handbook of research on new literacies* (pp. 1–21). Mahwah, NJ: Lawrence Erlbaum Publishers.

Collins, A. (1991, September). The role of computer technology in restructuring schools. *Phi Delta Kappan*, *73*, 28–36.

Crawford, P. (1995). Early literacy: Emerging perspectives. *Journal of Research in Childhood Education*, *10*(1), 71–86.

Dalton, B., & Proctor, C. P. (2007). Reading as thinking: Integrating strategy instruction in a universally designed digital literacy environment. In D. S. McNamara (Ed.), *Reading comprehension strategies: Theories, interventions, and technologies* (pp. 423–442). Mahwah, NJ: Lawrence Erlbaum.

Dalton, B., & Proctor, C. P. (2008). The changing landscape of text and comprehension in the age of new literacies. In J. Coiro, M. Knoble, C. Lankshear, & D. Leu (Eds.), *Handbook of research on new literacies* (pp. 297–324). Mahwah, NJ: Lawrence Erlbaum.

Dalton, B., Proctor, C. P., Uccelli, P., Mo. E., & Snow, C. E. (2011). Designing for diversity: The role of reading strategies and interactive vocabulary in a

digital reading environment for fifth-grade monolingual English and bilingual students. *Journal of Literacy Research, 43*(1), 68–100.

Dimitriadi, Y. (2001). Evaluating the use of multimedia authoring with dyslexia learners: A case study. *British Journal of Educational Technology, 32*(3), 265–275.

Duke, N. K., & Pearson, D. (2002). Effective practices for developing reading comprehension. In A. E. Farstrup & S. J. Samuels (Eds.), *What research has to say about reading instruction (*3rd ed., pp. 205–242). Newark, DE: International Reading Association.

Dupuy, B., Tse, L., & Cook, T. (1996). Bringing books into the classroom: First steps in turning college-level ESL students into readers. *TESOL Journal, 5*(4), 10–15.

Edyburn, D. L. (2001). Models, theories, and frameworks: Contributions to understanding special education technology. *Special Education Technology Practice, 4*(2), 16–24.

Eilers, L., & Pinkley, C. (2006). Metacognitive strategies help students to comprehend all text. *Reading Improvement, 43*(1), 13–29.

Elley, W. B. (1991). Acquiring literacy in a second language: The effect of book-based programs. *Language Learning, 41*(3), 375–411.

Facer, K., Furlong, J., Furlong, R., & Sutherland, R. (2003). *ScreenPlay: Children and computing in the home.* London, UK: RoutledgeFalmer.

Fletcher, D. (1989). The effectiveness and cost of interactive videodisc instruction. *Machine-Mediated Learning, 3*, 361–385.

Gee, J. P. (1996). *Social linguistics and literacies: Ideology in discourses (*2nd ed.). London, UK: Taylor & Francis.

Goodfellow, R. (2004). The literacies of online learning: A linguistic-ethnographic approach to research on virtual learning communities. *Proceedings from the Networked Learning Conference.* Retrieved from http://www.networkedlearningconference.org.uk/past/nlc2004/proceedings/symposia/symposium7/goodfellow.htm

Haystead, M. W., & Marzano, R. J. (2009). *Meta-analytic synthesis of studies conducted at Marzano Research Laboratory on instructional strategies.* Englewood, CO: Marzano Research Laboratory.

Heimann, M., Nelson, K. E., Tjus, T., & Gillberg, C. (1995). Increasing reading and communication skills in children with autism through an interactive multimedia computer program. *Journal of Autism and Developmental Disorders, 25*(5), 459–480.

Heinze, J. (2004, November/December). Supporting English language learners with technology. *Instructor.* Retrieved from http://www2.scholastic.com/browse/article.jsp?id=10516.

Hetzroni, O., Rubin, C., & Konkol, O. (2002). The use of assistive technology for symbol identification by children with Rett syndrome. *Journal of Intellectual and Development Disability, 27*(1), 57–71.

Higbee, K. L. (1988), Practical aspects of mnemonics. In M. M. Gruneberg, P. E. Morris, & R. N. Sykes (Eds.), *Practical aspects of memory: Current research and issues,* (Vol. II., pp. 403–408). Chichester, UK: John Wiley & Sons.

Hofstetter, F. T. (1994). Is multimedia the next literacy? *Educators' Tech Exchange, 2*(3), 6–13.

Holliday, W. G., Brunner, L. L., & Donais, E. L. (1977). Differential cognitive and affective responses to flow diagrams in science. *Journal of Research in Science Teaching, 14*, 129–138.

Holloway, W., & Valentine, G. (2003). *Cyberkids: Children in the information age.* London, England: RoutledgeFalmer.

Jewitt, C. (2009). *Handbook for multimodal analysis.* London, UK: Routledge.

Kalaitzakis, E., Dafoulas, G., & Macaulay, L. (2003, June). *Designing online communities: Community-centered development for intensively focused user groups.* 10th HCI International Conference, Heraklion, Greece (HCII 2003).

Khalili, A., & Shashaani, L. (1994). The effectiveness of computer applications: A meta -analysis. *Journal of Research on Computing in Education, 27*, 48–61.

Klingner, J. K., Urbach, J., Golos, D., Brownell, M., & Menon, S. (2010). Teaching reading in the 21st century: A glimpse at how special education teachers promote reading comprehension. *Learning Disability Quarterly, 33*(2), 59–74.

Kozma, R. B. (1991). Learning with media. *Review of Educational Research, 61*(2), 179–212.

Krashen, S. D. (1993). *The power of reading: Insights from the research.* Englewood, CO: Libraries Unlimited.

Kress, G. (1997). Visual and verbal modes of representation in electronically mediated communication: The potentials of new forms of text. In I. Snyder (Ed.), *Page to screen* (pp. 53–79). Sydney: Allen & Unwin.

Kress, G. (2003). *Literacy in the new media age.* New York, NY: Routledge.

Kulik, J. A., Bangert, R. L., & Williams, G. W. (1983). Effects of computer-based teaching on secondary school students. *Journal of Educational Psychology, 75*, 19–26.

Kulik, J. A., Kulik, C. C., & Bangert-Drowns, R. L. (1985). Effectiveness of computer-based education in elementary schools. *Computers in Human Behavior, 1*, 59–74.

Kulik, J. A., Kulik, C. L. C., & Cohen, P. A. (1980). Effectiveness of computer-based college teaching: A meta-analysis of findings. *Review of Educational Research, 50*(4), 525–544.

Lankshear, C., & Knobel, M. (2003). *New literacies: Changing knowledge and classroom learning.* Philadelphia, PA: Open University.

Lebow, D. (1993). Constructivist values for instructional systems design: Five principles toward a new mindset. *Educational Technology Research and Development, 41*(3), 4–16.

Lenhart, A., Purcell, K., Smith, A., & Zickuhr, K. (2010). *Social media and mobile Internet use among teens and young adults.* Washington, DC: Pew Internet and American Life Project.

Leu, D. J., Jr., Kinzer, C. K., Coiro, J. L., & Cammack, D. W. (2004). Toward a theory of new literacies: Emerging from the Internet and other information and communication technologies. In R. B. Ruddell & N. J. Unrau (Eds.), *Theoretical models and processes of reading (*5th ed., pp. 1570–1613). Newark, DE: International Reading Association.

Levy, R. (2008). *Becoming a reader in a digital age: Children's self-perceptions as they start School.* (Unpublished doctoral dissertation). University of Cambridge, Cambridge, UK.

Lewis, C., & Fabos, B. (2005, October/November/December). Instant messaging, literacies, and social identities. *Reading Research Quarterly, 40*(4), 470–501. doi: 10.1598/RRQ.40.4.5

Lin, H., & Chen, T. (2007). Reading authentic EFL text using visualization and advance organizers in a multimedia learning environment. *Language Learning & Technology, 11*(3), 83–106.

Macaulay, M. (2002). Embedding computer-based learning with learning aids: A preliminary study. *International Journal of Instructional Media, 29*(3), 305–315.

Mayer, R. (2001). *Multimedia learning.* New York, NY: Cambridge University Press.

McKenzie, J. (2010). The 21st century skills bookmark a dozen I-words trump the 4-r's. *From Now On: The Educational Technology Journal, 19*(3), 1–4.

Miller, C. C., & Bosman, J. (2011, May 20). E-books outsell print books at Amazon. *The New York Times.* Retrieved from http://www.nytimes.com/2011/05/20/technology/20amazon.html?_r=1

Moran, J., Ferdig, R. E., Pearson, P. D., Wardrop, J., & Blomeyer, R. L. (2008). Technology and reading performance in the middle-school grades: A meta-analysis with recommendations for policy and practice. *Journal of Literacy Research, 40*(1), 6–58.

Morris, D. (2003). Of Studebakers and reading clinicians. *Proceedings from the 2003 American Reading Forum Yearbook.* Retrieved from http://www.americanreadingforum.org/yearbook//yearbooks/03_yearbook/volume03toc.Htm

National Center for Education Statistics. (2009). *The nation's report card: Reading 2009* (NCES 2010–458). Washington, DC: Institute of Education Sciences, U.S. Department of Education.

New London Group. (1996). A pedagogy of multiliteracies: Designing social futures. *Harvard Educational Review, 66*(1), 60–92.

Paivio, A. (1971). *Imagery and verbal processes.* New York, NY: Holt, Rinehart, Winston.

Parker, J. F., Brownston, L., & Ruiz, I. (1993). Does imagery impede or facilitate transfer of learning? *Bulletin of the Psychonomic Society, 31*(6), 557–559.

Parker, M., & Hurry, J. (2007, August). Teachers' use of questioning and modelling comprehension skills in primary classrooms. *Educational Review, 59*(3), 299–314. doi: 10.1080/00131910701427298

Pearson, P. D., & Gallagher, M. C. (1983). The instruction of reading comprehension. *Contemporary Educational Psychology, 8*(3), 317–344.

Pressley, M. (2000). What should comprehension instruction be the instruction of? In M. L. Kamil, P. Mosenthal, P. D. Pearson, & R. Barr (Eds.), *Handbook of reading research* (Vol. 3, pp. 545–561). Mahwah, NJ: Erlbaum.

Proctor, C. P., Uccelli, P., Dalton, B., & Snow, C. E. (2009). Understanding depth of vocabulary online with bilingual and monolingual children. *Reading and Writing Quarterly, 25*(4), 311–333.

Puchalski, M. M., Morra, M. J., & von Wandruszka, R. (1992). Fluorescence quenching of synthetic organic compounds by humic materials. *Environmental Science and Technology, 26*, 1787–1792.

Radcliffe, R., Caverly, D., Hand, J., & Franke, D. (2008). Improving reading in a middle school science classroom. *Journal of Adolescent & Adult Literacy, 51*(5), 398–408.

Reinking, D., Labbo, L., McKenna, M., & Kiefer, R. (Eds.). (1998). *Handbook of literacy and technology.* Hillsdale, NJ: Erlbaum.

Rigney, J. W., & Lutz, K. A. (1976). Effect of graphic analogies of concepts in chemistry on learning and attitude. *Journal of Educational Psychology, 68*, 305–311.

Royer, J. M., & Cable, G. W. (1976). Illustrations, analogies and facilitative transfer in prose learning. *Journal of Educational Psychology, 68*, 205–209.

Samuels, S. J., Biesbrock, E., & Terry, P. R. (1974). The effect of pictures on children's attitudes toward presented stories. *Journal of Educational Research, 67*, 243–246.

Schmidt, M., Weinstein, T., Niemic, R., & Walberg, H. J. (1985). Computer-assisted instruction with exceptional children. *Journal of Special Education, 9*, 493–502.

Sewell, E. H., Jr., & Moore, R. L. (1980). Cartoon embellishments in informative presentations. *Educational Communication and Technology Journal, 28*, 39–46.

Smith, L. A. (2006). Think-aloud mysteries: Using structured, sentence-by-sentence text passages to teach comprehension strategies. *The Reading Teacher, 59*(8), 764–773.

Smith, S. J., & Meyen, E. L. (2003, February). Applications of online instruction: An overview for teachers, students with mild disabilities, and their parents. *Focus on Exceptional Children.* Retrieved from http://findarticles.com/p/articles/mi_qa3813/is_200302/ai_n9188029/

Stahl, S. A., Kuhn, M. R., & Pickle, J. M. (1999). An educational model of assessment and targeted instruction for children with reading problems. In D. H. Evensen & P. B. Mosenthal (Eds.), *Advances in reading/language research: Reconsidering the role of the reading clinic in a new age of literacy* (pp. 249–272). Greenwich, CT: JAI Press.

Street, B. (1995). *Social literacies: Critical approaches to literacy development, ethnography, and education.* London, UK: Longman.

Svantesson, I. (1998). *Learning maps and memory skills.* London, UK: Kogan Page.

Sweller, J. (1999). *Instructional design.* Melbourne, Australia: ACER Press.

Tjortjis, C., Dafoulas, G., Layzell, P., & Macaulay, L. A. (2002, August). Model for selecting CSCW technologies for distributed software maintenance teams in virtual organisations, IEEE Workshop on Cooperative Supports for Distributed Software Engineering Processes (CSSE 02) in *26th Annual International Computer Software and Applications Conference,* Oxford, UK (pp. 1104–1108). IEEE Computer Social Press.

Tjus, T., Heimann, M., & Nelson, K. E. (2001). Interaction patterns between children and their teachers when using a specific multimedia and communication strategy: Observations from children with autism and mixed intellectual disabilities. *Autism: The International Journal of Research and Practice, 5*(2), 175–187.

Trinkle, D. (2007). *Program to prepare students for digital world.* Retrieved from http://www.valpo.edu/news/news.php?releaseId=3095

U.S. Department of Education. (2001). *No Child Left Behind.* Retrieved from http://www2.ed.gov/nclb/landing.jhtml

Wade, B. (Ed.). (1990). *Reading for real.* Milton Keynes, UK: Open University Press.

Walsh, C. S. (2009). The multimodal redesign of school texts. *The Journal of Research in Reading, 32*(1), 126–136.

Wilber, D. J. (2010). Special themed issue: Beyond "new" literacies. *Digital Culture & Education, 2*(1), 1–6.

Williamson, G. L., Koons, H., Sandvik, T., & Sanford-Moore, E. (2012). *The text complexity continuum in grades 1–12* (MetaMetrics Research Brief). Durham, NC: MetaMetrics.

Wissick, C. A., & Gardner, J. E. (2002). Multimedia or Not to Multimedia? *Teaching Exceptional Children, 52*(4), 34–43.

Yeh, S., & Lehman, J. (2001). Effects of learner control and learning strategies on English as a foreign language (EFL) learning from interactive hypermedia lessons. *Journal of Educational Multimedia and Hypermedia, 10*(2), 141–159.