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Designing for Diversity: The Role of Reading Strategies and Interactive Vocabulary in a Digital Reading Environment for Fifth-Grade Monolingual English and Bilingual Students

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Abstract

This study examined the relative contribution of reading comprehension strategies and interactive vocabulary in Improving Comprehension Online (ICON), a universally designed web-based scaffolded text environment designed to improve fifth-grade monolingual English and bilingual students' reading achievement. Seventy-five monolingual English and 31 bilingual students from six classrooms were assigned to one of three ICON conditions: reading comprehension strategies, vocabulary, or a combined version of comprehension strategies and vocabulary. Students read eight multimedia folktales and informational texts within their respective ICON condition and completed embedded activities, researcher measures of comprehension and vocabulary, and pre- and postintervention standardized reading achievement tests. ANCOVA results indicated that after controlling for initial reading achievement, there was a main effect for condition on the researcher measure of vocabulary, with

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the combination group and vocabulary groups both significantly outperforming the strategy group. There was also an interaction effect, with differences between monolingual and bilingual Spanish-speaking students greatest in the strategy group. There was no effect of condition on comprehension, nor was there an effect of language status on narrative comprehension. However, there was a main effect of language status on expository text comprehension and standardized vocabulary achievement, with monolingual students performing more strongly than bilingual Spanish-speaking students. The results add to a growing body of research on the design and use of scaffolded digital text for diverse learners.

Keywords

comprehension, vocabulary, technology, bilingual, English language learner, universal design for learning, e-text

The new millennium ushered in a phase of renewed interest in adolescent literacy and, more specifically, reading comprehension. Many students are not able to read challenging texts required for academic success in high school (Kamil, 2003) and college (ACT, 2010), and little progress has been achieved in reducing the literacy achievement gap for bilingual and English learning students (National Assessment of Educational Progress, 2009). There is also concern that theoretical models of comprehension and instructional methods and materials have not evolved in concert with the rapidly changing technologies and digital literacies characteristic of 21st-century work, learning, recreation, commerce, and civic life (Leu, Kinzer, Coiro, & Cammack, 2004).

In a recent meta-analysis of technology and reading performance in the middle grades, Moran, Ferdig, Pearson, Wardrop, and Blomeyer (2008) concluded that digital tools and learning environments positively affected reading comprehension (weighted effect size = .489). They recommended that educators consider technology as an important resource for improving young adolescent learners' reading achievement, a recommendation consistent with that of the National Reading Panel (NRP; 2000) and others' reviews of technology and literacy (Dalton & Strangman, 2006; MacArthur, Ferretti, Okolo, & Cavalier, 2001). At the same time, Moran et al. pointed to the paucity of research in this area and the need to increase the role of researchers in developing and studying technology-mediated reading comprehension.

The relatively impoverished research base on technology-mediated comprehension is accompanied by limited applications in schools. Outside of school, there is an increasing expectation of multimodal text and personalization; technology and the Internet are embedded in daily life with a permeable membrane between online and offline experiences and between print and digital media. A decade into the new millennium, however, this is still not the case in many schools. Reading language arts programs often include technology as an add-on to a print-based teaching and curriculum model, with teachers feeling ill prepared to integrate technology effectively (National Education Association & American Federation of Teachers, 2008). Students

also report a gap between the kinds of literacies they engage in outside of school and the print-based literacies that remain at the core of school learning (Lenhart, Purcell, Smith, & Zickuhr, 2010).

Within the broad category of technology-mediated comprehension, we use the term *scaffolded digital reading* (SDR) to refer to electronic books and digital reading environments, which, through a variety of embedded supports not available in offline environments, offer promise for students with diverse learning needs (Dalton & Proctor, 2007, 2008; Proctor, Dalton, et al., 2009; Proctor, Uccelli, Dalton, & Snow, 2009). Specifically, in developing this line of inquiry, we have focused on linguistic diversity and the potential effectiveness of SDRs to offer scaffolds in more than one language (e.g., providing access to text in both Spanish and English) in the service of improved outcomes for bilingual learners. Here we use the term *bilingual* to refer to children who speak a heritage language that differs from the dominant societal language and who possess various levels of language and literacy proficiencies in English and the heritage language.

There is still much to be learned about the value and use of different types of scaffolds and the degree to which customization is possible or beneficial in SDR environments. Given the research base demonstrating the positive impact of reading comprehension strategy instruction and active vocabulary learning on print-based reading comprehension, an interesting SDR design question concerns the potentially differential contribution of digital scaffolds in these two areas of instructional effectiveness for students with varying reading and language needs. To explore this question, we developed and tested three versions of ICON (Improving Comprehension Online), a web-based SDR that varies vocabulary and comprehension strategy supports embedded in a series of electronic texts, or e-texts. To push on the potential for student customization, we worked in classrooms with substantial numbers of bilingual learners to explore how vocabulary and comprehension strategies might interact with language status. The overarching goal of this work was to learn how SDR environments might improve fifth-grade students' vocabulary knowledge and comprehension of scaffolded e-texts while also developing their cognitive and metacognitive reading abilities to ultimately improve comprehension of print text.

Conceptual Framework

Reading Comprehension in a Digital Landscape

Coiro (2003), among others (Dalton & Proctor, 2008; Leu et al., 2004), makes a case for expanding current models of reading comprehension to reflect digital texts and information communication technologies. Although there is obvious overlap in the perceptual, cognitive, and affective processes involved in print and digital reading, digital environments and tools potentially alter the dynamic relationship between reader, text, activity, and sociocultural factors in ways that influence reading processes and outcomes for individual learners (Edyburn, 2002; McKenna, Reinking, Labbo, & Kieffer, 1999).

McKenna and Zucker (2009) posit that the simple view of reading (Gough & Tunmer, 1986) and Stanovich's (1980) interactive-compensatory model of reading provide a good conceptual fit for e-book research. Gough's (Gough & Tunmer, 1986) simple view suggests that reading comprehension is derived from the interaction between decoding skill and linguistic comprehension. This perspective provides a foundation for the use of popular digital features, such as text-to-speech and human narration tools (which affect decoding processes), and hyperlinks to vocabulary and listening comprehension supports (affecting linguistic comprehension). Attention to the simple view has also been useful in considering reading processes among Spanish-English bilingual learners, suggesting the importance of having access to both Spanish and English texts for improving comprehension (Nakamoto, Lindsey, & Manis, 2008; Proctor, Carlo, August, & Snow, 2005). Stanovich's interactive-compensatory view explains how comprehension capacity might be expanded through the use of a broader array of SDR conceptual supports, such as summaries, highlighting of critical information, and background knowledge hyperlinks. We agree with McKenna and Zucker (2009) that these two models of reading are useful in conceptualizing the role of various SDR supports as levers for increasing the cognitive capacity of the reader and thereby increasing comprehension (LaBerge & Samuels, 1974).

What is not well represented in these models is the situated, sociocultural nature of reading (Gee, 2003) or the multimodal nature of digital text (Kress, 2003). Along with Coiro (2003), we find the Rand Reading Study Group's (2002) reading comprehension heuristic helpful in thinking about how digital text offers a manipulable environment for influencing reading comprehension in relation to reader, text, and activity. These three factors interact with one another and are situated within a larger sociocultural context.

The current study integrates principles of universal design for learning (UDL), which suggests the potential of technology-based design to scaffold learning through the provision of multiple means of representation, expression, and engagement (Rose & Meyer, 2002). Just as universal design in architecture considers the needs of the broadest range of users from the inception of the design process (Mace, 1998), UDL considers diverse learners from the earliest stages of design, with the expectation that the inclusion of a fuller array of learning supports will better serve all learners, including those with identified needs.

The ICON prototype developed for this study is one example of a universally designed SDR prototype (Dalton & Proctor, 2007). To illustrate how reading with digital text potentially changes the relationship of reader, text, and activity as typically understood when reading printed text, consider the case of a Spanish-English bilingual fifth-grade student reading at approximately a third-grade level. If restricted to reading a print text independently, the struggling reader expends most cognitive resources trying to decode the text, concomitantly limiting comprehension capacity (LaBerge & Samuels, 1974). In the ICON's fifth-grade folktales, reader factors, such as word recognition skill and fluency, no longer function as gatekeepers to the text. The reader may listen to the text through audio-recorded narration or with a text-to-speech

read-aloud tool, interacting with rich grade-level texts even when his or her decoding skills are behind (linguistic comprehension becomes salient in this situation; Gough & Tunmer, 1986). Furthermore, the text is available in both Spanish and English, which, in the case of a Spanish-dominant student, may provide access to lexical information not accessed by reading in English only. In this instance, reading (decoding and fluency) and language (Spanish-English text) factors have been largely offloaded to the SDR.

The negative effects of reader factors, such as less developed comprehension strategies and weak self-regulation skills, can also be ameliorated for the reader through ICON prompts that ask the reader to apply a reading strategy at a key point in the text along with animated coaches, often termed pedagogical agents, to guide their use. To continue, a reader factor such as low engagement can potentially be offset when the ICON text varies the level of support and challenge, offers choice of support and response modes, and provides the reader access to the same text that his or her peers are reading. Finally, activity and sociocultural context factors may be transformed to the learner's comprehension advantage in an SDR such as ICON by offering a range of response options and activities, modeling reading as both a thinking process and an affective experience, including texts representing different cultures and in different languages, and connecting online reading with offline text discussion.

Across various lines of research on digital text, designers are typically motivated to expand learners' reading comprehension capacity by embedding within the digital environment support features and content related to each factor in the Rand Reading Study Group (2002) framework. In the current study, we focus on the relative contribution of reading strategies versus vocabulary knowledge, two prominent reading factors that are sensitive to instruction and are often challenging for young adolescents. We do so within a universally designed SDR developed to provide access for monolingual and bilingual students with a range of language and literacy needs, including those who might otherwise be restricted from engaging with grade-level text.

Reading Comprehension and Reading Strategies

The NRP's (2000) review of effective comprehension instruction provided conclusive evidence that teaching students how to read strategically and to monitor their understanding improves comprehension. Reciprocal teaching (Palincsar & Brown, 1984) is one example of a robust instructional approach that develops students' comprehension ability through scaffolded instructional dialogue (for reviews, see D. S. Davis, 2010; Rosenshine & Meister, 1994). Working within a cognitive apprenticeship framework (Cognition and Technology Group, 1993), the teacher introduces students to ways of thinking with and about text by making predictions, asking questions, seeking clarification, and summarizing shared text. The teacher initially models the strategies and provides feedback, gradually releasing responsibility as students take on increasing leadership of the discussion and internalize the strategies. Since the NRP report, research has deepened our understanding of reading strategies and the role of instruction (Block & Duffy, 2008). There has been increased attention to discourse and the

ways in which members of a discipline approach a text in their domain of expertise (Shanahan & Shanahan, 2008). There is also a heightened awareness of the complexity of teaching strategies so that they are flexible tools for understanding; several years of experience are often necessary for teachers to develop the necessary expertise (Pressley, 2006).

Although reading strategy instruction that is effective for monolingual English students generally benefits English language learners (for a review, see August & Shanahan, 2006, 2010), it would be simplistic to apply the same instructional model to all learners. García (1996) and Jiménez (1997) have shown that native Spanish speakers apply and adapt strategies in ways that make use of their first-language knowledge, cultural background, and experiences living as bilinguals in the United States. Jiménez, García, and Pearson (1996) used think-aloud research to show how Spanish-English bilingual and biliterate learners made sense of text as they translated text segments from Spanish to English and applied Spanish word knowledge to decipher the meaning of English words. Given this rich array of strategies, Handsfield and Jiménez (2009) caution against rigid application of comprehension strategy instruction for bilingual learners, recommending a flexible approach that allows more room to negotiate meaning in ways that take advantage of cross-linguistic strengths and discourse practices.

Reading Comprehension Strategies and Technology

Cognitive and metacognitive reading strategies have been targeted in several technology-based research studies, beginning with Salomon, Globerson, and Guterman's (1989) Reading Partner, a digital reading environment that embedded self-guiding questions on how to be a good reader, reading strategy instruction, and self-monitoring questions and examples in a series of narrative and informational texts. Seventh-grade Reading Partner students outperformed peers reading the digital texts without learning supports and peers reading the digital texts with embedded content questions on a standardized reading comprehension test, a written essay, and a test of metacognitive reconstruction. The majority of hypertext studies that offered strategic reading supports (e.g., a main idea statement, strategy prompt, visual highlighting of related information, etc.) have also improved students' comprehension (Anderson-Inman & Horney, 1998; Dalton, Pisha, Eagleton, Coyne, & Deysher, 2002; Higgins, Boone, & Lovitt, 1996; MacArthur & Haynes, 1995; Reinking & Schreiner, 1985). Recent work with intelligent tutoring systems directly teaching reading comprehension and text structure strategies and self-regulation has similarly produced positive effects on adolescent learners' comprehension (McNamara, O'Reilly, Best, & Ozuru, 2006; Meyer et al., 2010).

Reading Comprehension and Vocabulary

Renewed attention to comprehension has been accompanied by a resurgence of interest in vocabulary learning and assessment (Blachowicz, Fisher, Ogle, & Watts-Taffe, 2006;

Lubliner & Smetana, 2005; Pearson, Hiebert, & Kamil, 2007). Numerous studies have demonstrated a strong, positive correlation between comprehension and vocabulary (F. B. Davis, 1942; Just & Carpenter, 1987; NRP, 2000). Advanced readers' vocabulary far exceeds that of less skilled readers, with wide reading playing an increasingly key role in vocabulary development and literacy achievement (Cunningham & Stanovich, 1991). For English language learners, vocabulary is an area of vulnerability, especially in light of consistently measured discrepancies between bilingual students' vocabulary and comprehension and that of their monolingual peers (Carlo et al., 2004; Proctor et al., 2005).

The strong correlational relationship between vocabulary and comprehension is well documented (NRP, 2000). What remains less clear is how vocabulary instruction might contribute to comprehension. Although studies often find improved comprehension with texts containing instructed words, transfer to norm-referenced achievement measures is far more difficult to achieve (Pearson et al., 2007). Recent reviews of the literature on effective vocabulary instruction support a comprehensive approach integrated at the school level and across the curriculum (Blachowicz et al., 2006; NRP, 2000). A comprehensive approach might include a combination of wide reading to support incidental vocabulary learning (Anderson & Nagy, 1992), direct instruction of academic language and words core to the curriculum (Lubliner & Smetana, 2005; Vitale & Romance, 2008), teaching of word learning strategies (Baumann, Edwards, Boland, Olejnik, & Kame'enui, 2003; Carlo et al., 2004), and development of word appreciation within a language-rich environment (Scott & Nagy, 2004). Repeated exposure to words and multiple opportunities to apply words in speaking and writing contexts are also important if students are to develop deep and flexible vocabularies (NRP, 2000).

Principles of effective vocabulary instruction for monolingual students generally apply to bilingual students (Proctor et al., 2005). However, as with comprehension instruction, bilingual learners may also benefit from attention to vocabulary development across their specific languages (for a review, see August & Shanahan, 2006, 2010). Notably, attention to cognates among languages that share etymologically related words and similar orthographies (e.g., *important* and *importante* in English and Spanish), translations, and cultural understandings of words in varying contexts facilitate vocabulary learning and comprehension (Carlo et al., 2004; García, 1996; Jimenez et al., 1996; Nagy, García, Durgunoglu, & Hancin-Bhatt, 1993).

Vocabulary and Technology

Vocabulary support in the form of hyperlinked definitions, graphics, animated illustrations, translations, and pronunciations of vocabulary are often found in interactive storybooks, hypertexts, and on the Internet. An issue for younger readers and struggling readers in a naturalistic context is that the supports are typically passive; that is, the reader must know when to access and how to apply the information to what they are reading (Blachowicz et al., 2006). Two technology-based studies that connected

vocabulary support with comprehension are particularly relevant to the current study. In the first case, seventh graders reading a digital science text accessed more online definitions and understood the text better than peers using a print dictionary (Reinking & Rickman, 1990). In the second case, students reading a digital text with an anchored video and vocabulary hyperlinks demonstrated greater comprehension than peers reading without the vocabulary support (Xin & Rieth, 2001). Several studies with English and foreign language learners have shown the benefit of online glosses that provide a definition, graphic, and/or video (Plass & Chun, 1998), although Koren's (1999) study suggests that greater benefit is derived when students are required to actively draw inferences rather than simply view a text gloss.

The Present Study

Given the increasing numbers of bilingual students in U.S. classrooms and the legion numbers of young adolescents who have difficulty reading academic text, we focused our efforts on developing an SDR prototype that would be responsive to language and literacy differences and would support differentiated instruction and learner-directed customization of the reading experience using age-appropriate text. As discussed above, the particular targets of scaffolding are reading comprehension strategies and vocabulary acquisition. Research on scaffolded digital text comprehension has tended to focus on one component or the other, leaving much to be learned about the relative contribution of reading strategy and vocabulary scaffolds in digital texts that are designed to improve comprehension. Furthermore, even less is known about the potentially differential effects of these kinds of digital scaffolds for bilingual and monolingual students with varying language and literacy abilities. To address this gap in the research on technology-mediated reading and comprehension, we designed three versions of ICON. The first version embedded an adaptation of reciprocal teaching comprehension strategies (Palincsar & Brown, 1984), the second version embedded interactive vocabulary activities and support, and the third version combined the comprehension and vocabulary features of the first two versions. The two primary research questions were as follows:

1. What is the effect of ICON condition (comprehension strategy vs. vocabulary vs. combination) on fifth-grade students' comprehension and vocabulary learning within the ICON SDR? What is the effect on students' standardized reading achievement test performance?
2. Do ICON condition effects vary by language status (monolingual English vs. bilingual Spanish vs. bilingual other)?

We hypothesized that the combination ICON condition would prove most beneficial to fifth-grade students because it merged a focus on reading strategically with interactive vocabulary learning, both areas of instructional importance at the intermediate grade levels. With regard to language status, however, our hypotheses were not so straightforward. On one hand, bilingual learners are typically vulnerable in relation

to English vocabulary knowledge (August & Shanahan, 2006) and thus may derive the greatest benefit from vocabulary support. On the other hand, it may be that vocabulary support is insufficient to improve bilingual learners' comprehension and that, like their monolingual peers, they would benefit from an ICON with both reading strategies and vocabulary.

Method

Participants and Setting

Three classes in one school in the Payton school district (all names are pseudonyms) and three classes in two schools in the Winter school district participated in the study. Located outside a major northeastern city, both districts were characterized by rising immigration trends accompanied by rapidly changing demographics. All three schools had a substantial number of bilingual students (i.e., students who come from households where a language other than English was spoken), ranging from 33% to 45%. Furthermore, the majority non-White population was composed of Latino students in all three schools. Each school also had between 34% and 57% students eligible for free or reduced lunch.

In total, six fifth-grade teachers (three from each district) and their classes participated, composing a sample of 106 students. The average class size of 17.6 was attributable to generally lower enrollment the year of the study (classes ranged from 18 to 21 students) and the deletion of data for several students who did not have complete data sets. To control for potential classroom effects, teachers were ranked by years of experience and then assigned to one of three conditions: comprehension strategy, vocabulary, or combination. In each condition, students read the same ICON digital texts, but with different embedded supports related to condition:

1. Comprehension strategy: Students were prompted to apply a particular reading strategy at the end of each "screen" of digital text, typing or audio-recording their response to an electronic work log.
2. Vocabulary: Students completed prereading and within-reading vocabulary activities designed to promote depth and breadth of word knowledge relative to 40 "power words" (5 per text). They also added words to their personal digital glossaries and listened to language alerts to heighten awareness of words and strategies for using first-language knowledge, such as Spanish-English cognates.
3. Combination: Features from (1) and (2) above were combined into what we hypothesized would be an optimal learning environment.

Table 1 describes the demographics of the sample, as well as the preintervention standardized reading achievement results for each group. Analysis of variance for entering differences by condition and language type indicated that there were no significant condition differences in Gates-MacGinitie Reading Test (MacGinitie,

Table 1. Student Demographics and Pretest Reading Achievement by Condition

Variable	Total (N = 106)	Comprehension strategy (n = 38)	Vocabulary (n = 36)	Combination (n = 32)
Demographics				
Boys	62	24	22	16
Girls	44	14	14	16
English monolinguals	68	28	23	17
Spanish-English bilinguals	21	7	9	5
Other bilinguals	17	3	4	10
Gates MacGinitie subtest (preintervention)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)
Comprehension ESS	505.33 (37.71)	500.60 (37.1)	501.50 (43.09)	514.81 (30.61)
English monolinguals	514.32 (36.58)[a]	508.58 (34.96)[a]	515.52 (44.42)[a]	521.47 (26.5)[a]
Spanish-English bilinguals	474.70 (26.57)	472.17 (29.19)	470.00 (28.43)	486.20 (21.15)
Other bilinguals	506.47 (35.85)	488.33 (50.2)	491.75 (20.69)	517.80 (35.12)
Vocabulary ESS	509.40 (37.64)	503.11 (34.9)	509.78 (40.22)	516.25 (37.63)
Monolinguals	520.36 (36.39)[b]	515.07 (31.79)[b]	519.48 (43.34)[b]	529.94 (33.05)[b]
Spanish-English Bilinguals	478.76 (27.25)	472.17 (29.19)	488.00 (29.22)	474.20 (29.17)
Other Bilinguals	504.06 (32.46)	472.33 (4.04)	503.00 (24.89)	514.00 (34.88)

Note: ESS = extended scaled scores. ESS are based on a norming sample mean of 501 (*SD* = 36.9) for Vocabulary and a norming sample mean of 502 (*SD* = 38.2) for Comprehension.
a. Monolinguals and other bilinguals outperform Spanish-English bilinguals.
b. Monolinguals outperform Spanish-English bilinguals.

MacGinitie, Maria, & Dreyer, 2002) Comprehension, $F(2, 103) = 1.88$, $p = .158$; however, significant differences did exist for language type, $F(2, 103) = 9.29$, $p < .001$. That is, students in the three ICON conditions began the study with comparable levels of entering reading comprehension. However, across ICON conditions, the monolingual and bilingual-other groups demonstrated significantly stronger entering comprehension than their bilingual-Spanish peers (ps = .001 and .019, respectively). There was no interaction of ICON condition and language type ($F < 1$). Similar effects were found for Gates-MacGinitie pretest vocabulary achievement. There were no ICON condition differences, $F(2, 104) = 2.02$, $p = .138$, but significant differences did exist for language type, $F(2, 104) = 13.75$, $p < .001$. On average, students in the three ICON conditions demonstrated comparable levels of vocabulary achievement. In this case, however, the monolingual group significantly outperformed the bilingual-Spanish group ($p < .001$) and performed comparably to the bilingual-other group. The difference between the two bilingual groups was weaker, with the bilingual-other group outperforming the bilingual-Spanish group at a level approaching significance ($p = .064$). There was no interaction of ICON condition and language type ($F < 1$).

Spanish language data were collected for 20 of the 21 students in the bilingual-Spanish group using the Woodcock Muñoz Language Survey–Revised (Woodcock, Muñoz-Sandoval, Ruef, & Alvarado, 2005). The Spanish-English bilinguals performed below the norming sample average of 100 (*SD* = 15) on the three literacy measures

collected: word decoding ($M = 76.45$, $SD = 26.65$), expressive vocabulary knowledge ($M = 56.05$, $SD = 24.4$), and passage comprehension ($M = 48.3$, $SD = 20.52$). Five of the 20 students scored above the norming sample average on the word decoding measure (scores ranged from 108 to 120), 2 students scored within ±1 standard deviation of the norming sample average on the expressive vocabulary measure (scores of 90 and 101), and 1 student scored within –1 standard deviation of the norming sample on the passage comprehension measure (score of 85). All other students scored more than 1 standard deviation below the norming sample mean, suggesting a group of Spanish speakers who, on average, lacked well-developed Spanish literacy skills.

Materials

ICON strategic digital reading environment, Versions 1, 2, and 3. The ICON strategic digital literacy environment consisted of eight multimedia texts with a common set of features: text-to-speech read-aloud functionality in English and Spanish; Spanish translation of instructional supports; pedagogical agents that function as coaches, providing models, think-alouds, and hints, including a Spanish-English bilingual coach; an electronic work log that collected student responses and was revisable; a multimedia glossary; anaphoric reference highlighting; and graphics illustrating the narrative and informational text content. In addition to these shared features, each of the three ICON versions had specialized features corresponding to condition, which are described in more detail below. Table 2 presents an overview of ICON SDR design features, Figures 1 through 3 display representative screen shots, and Table 3 shows sample student work log responses.

Eight folktale and partner informational SDRs had been developed previously and used with students in Grades 4 through 6. Teachers and students rated the texts as interesting and appropriate for this age group (Proctor, Dalton, & Grisham, 2007). The titles include an Ashanti tale, "Hungry Spider and Turtle," partnered with "All About Spiders"; a Native American tale, "How Coyote Stole Fire," partnered with "All About Coyotes"; a Mexican tale, "Bird Cu," partnered with "All About the Aztecs"; and a Polynesian tale, "Why the Sun Travels Slowly Across the Sky," partnered with "All About the Sun." The Flesh-Kinkaid readability of the folktales averaged 5.4, whereas the informational texts averaged a more challenging level of 6.7 because of technical vocabulary and geographical terms. Traditional readability figures do not have the same implications in a digital environment, where the language and learning supports potentially compensate for difficulties with decoding, vocabulary, and comprehension (Edyburn, 2002; McKenna et al., 1999).

ICON 1: Comprehension strategy. ICON 1 enhanced the basic features with comprehension strategy support. Building on previous research and development with scaffolded novels and stories (Dalton et al., 2002; Proctor et al., 2007), we adapted reciprocal teaching (Palincsar & Brown, 1984) for the ICON digital reading environment. The teacher introduced reading strategies offline with print text; students then read eight digital texts with embedded strategy prompts that asked students to apply

Table 2. Improving Comprehension Online (ICON) E-Text Design Features and Principles of Universal Design for Learning

Universal design for learning (Rose & Meyer, 2002)	ICON 1: Reading comprehension strategies	ICON 2: Vocabulary
1. Support strategic learning through multiple means of action and expression	a) After reading a screen of text, student prompted to apply reading comprehension strategy (predict, question, clarify, summarize, visualize) or personal response (feeling). Student chooses strategy at Level 5. b) Pedagogical agents provide text-specific and generic comprehension strategy hints, models, and think-alouds. Corrective feedback on closed responses. c) Closed, constructed, and open-response options. Open response typed or audio-recorded and saved to electronic work log.	a) Before reading, student works with power words to make personal connection, caption an image, complete a word web, and listen to a language alert. During reading, student adds words to glossary and explains why. b) Pedagogical agent provides model, think-aloud, or feedback specific to vocabulary task. c) Open response and constructed graphic organizer. Open response typed or audio-recorded and saved to electronic work log.
2. Provide access to content through multiple means of representation	Shared features: a) All texts and instructional supports can be read aloud at word or passage level via text-to-speech (TTS) tool with synchronized highlighting, in English and Spanish. b) Spanish text translations provided via En Español hyperlink. c) Bilingual pedagogical agent speaks Spanish and English. d) Vocabulary hyperlinked to multimedia glossary. e) Anaphoric reference highlighting. f) Illustrations complement text and contain alt tags. g) Font size and screen contrast can be changed.	
3. Support affective learning through multiple means of engagement	a) Age-appropriate and appealing folktales and informational texts with quality illustrations. b) Quality interface design and functionality. Easy to navigate. c) Value first language. Language alert highlights value of leveraging first-language knowledge. Student can access Spanish translations of text and directions, Spanish TTS, and a Spanish-speaking bilingual agent. Student can write or record in first language. d) Challenge varied by level and student choice of supports. e) Multiple opportunities for student choice and customization. Student controls use of learning supports, chooses whether to type or audio-record responses, and selects visual text display and TTS voice and rate. f) Emphasis on thinking rather than correct answers. Responses recorded in electronic work log for review and revision.	

Note: ICON 3 combines the ICON 1 comprehension and ICON 2 vocabulary features.

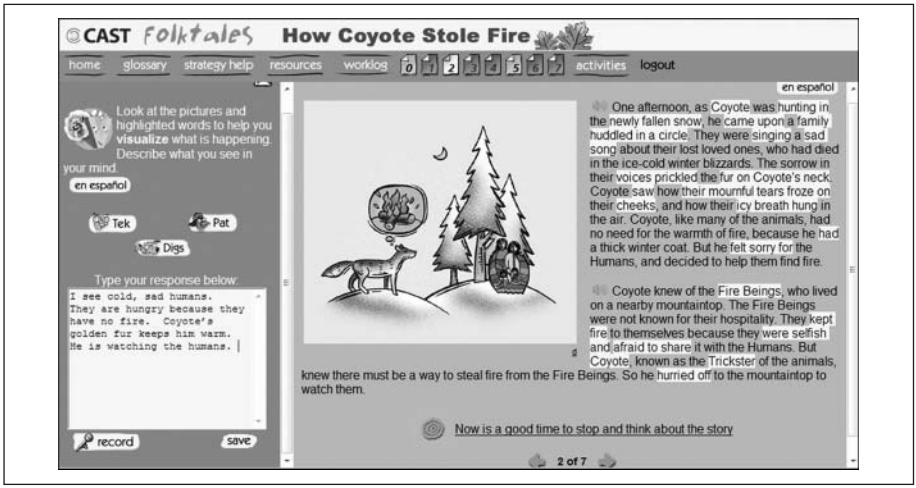

Figure 1. Screen shot of Improving Comprehension Online visualization strategy and student response. Reprinted with permission of CAST, Inc.

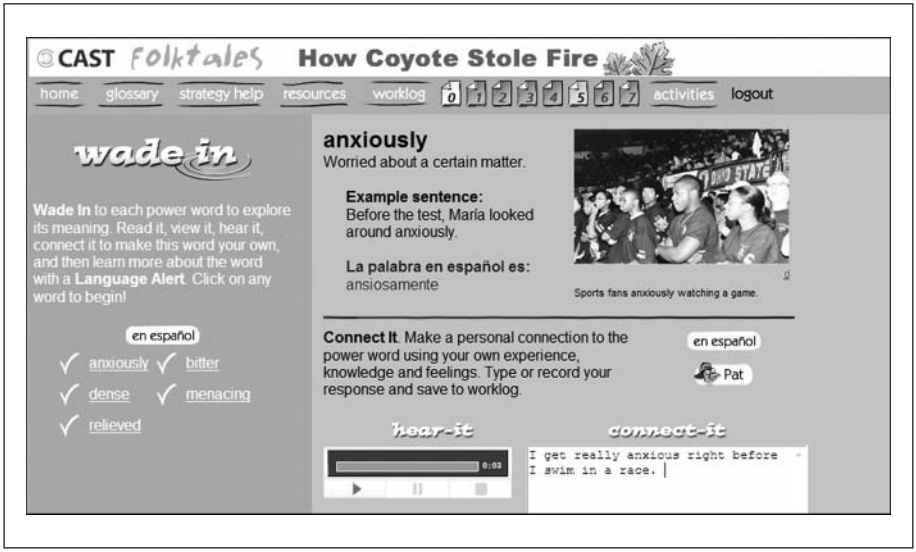

Figure 2. Improving Comprehension Online screen shot showing Connect It! vocabulary activity. Reprinted with permission of CAST, Inc.

one of six strategies to the passage (e.g., predict, question, clarify, summarize, visualize, and feeling). Pedagogical agents provided think-alouds and models of strategy use. Students typed or audio-recorded their responses to an electronic work log, which

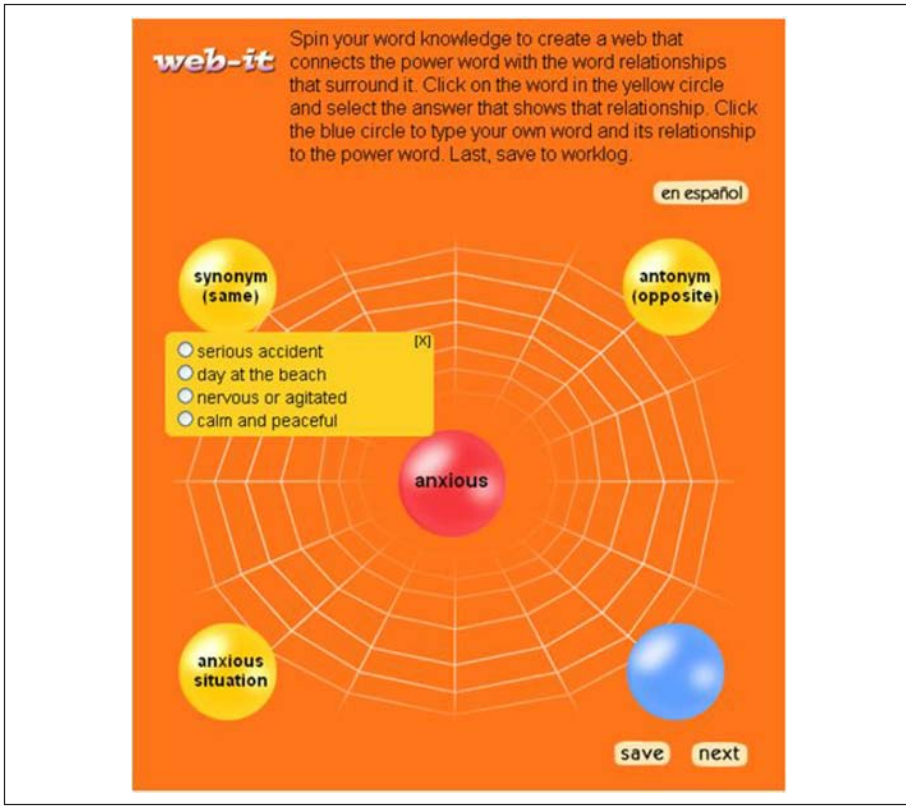

Figure 3. Improving Comprehension Online screen shot showing Web It! vocabulary activity. Reprinted with permission of CAST, Inc.

was accessible by teacher and student and which could be viewed and revised at will. The strategies were scaffolded in relation to the students' response mode (typed or audio-recorded responses for open-ended items and multiple choice for closed and constructed items), the type of coaching support (a text explicit model and think-aloud vs. a generic think-aloud or hint), and representation of the text (highlighting of key information). For example, students develop summarization skill as they move from identifying the best summary (Level 1) to selecting four important points out of six possible choices (Level 2), to writing or audio-recording a summary using information highlighted in the text (Level 3), to creating a summary without highlighting (Level 4), and to choosing their own strategy (Level 5). For the easier prediction strategy, students generated open-ended responses at all five levels and clicked on coaches who provided less explicit help as the level increased. As with all ICON versions, students were able to toggle back and forth between English and Spanish texts, pedagogical agents, and text-to-speech read-aloud functionality.

Table 3. Students' Strategy and Vocabulary Responses in Improving Comprehension Online Work Log

Vocabulary	Target word and student typed response
Connect It!	*Hospitality*: I remeber [*sic*] one day I had to go to a hotel in Florida and they were showing hospitality by cleaning the rooms when we left to the pool or at Disney!
	Generation: I am the fourth generation in my family that's still living.
Web It!	*Avoid*: Related word/phrase: nutritious food. Relationship: example of what not to avoid.
	Unique: Related word/phrase: different. Relationship: synonym.
Caption It!	*Contribute* (photo of three children building a bird house): Kate: Look at the birds, They look like they need a place to nest!!!!!!!!! Bob: Maybe I will build them a bird house.....Oh look there is Joe!!!!!!!!! Joe: what are you doing?????????????????? Kate: building a bird house....Do you wamt [*sic*] to help?????????????????????? Bob: we can all contribute!!!!!!!!!!!!! *Venom* (diagram of snake with fangs being milked for venom): The snake's venom is running out from underneath its teeth and you can see it on the stick.
Comprehension strategy	**E-text and student typed response**
Predict	"Bird Cu": I predict that Bird Cu will take Owl's advise [*sic*] and find a way to be the most fanciest bird around.
	"All About the Aztecs": I think I might learn that the AZTECS were the great rulers of the sentrel [*sic*] America.
Question	"Why the Sun Travels Slowly": Q: Did Maui become a shark? A: He probably acted like he was.
	"All About the Sun": Why can't you see the sun at night?
Clarify	"Hungry Spider": I didn't get why turtle was mean to spider.
	"All About Spiders": A confusing part is why are they putting silk in cows and goats gene.
Summarize	[Students remained at Levels 1 (selecting the best summary from four options) and 2 (selecting four key points out of a possible six to include in a summary). No written summaries were produced.]
Visualize	"How Coyote Stole Fire": What I am visualizing is the little fire beans all mad and screaming furiously.
	"All About Coyotes": I see a wide open flied and a bunch of coyote's running free. I hear some of the barking and huffing.
Feeling	"Why the Sun Travels Slowly": I feel that she wasn't going to give her hair up, at least I wouldn't except to the cancer children.
	"All About the Sun": I feel scared becuase [*sic*] I don't want to get skin cancer or a big hurricane hitting earth.

We suggest that this type of SDR is somewhat akin to the guided practice phase of print-based strategy instruction. A key difference between print and digital coaching relates to the timing and content of the feedback and social construction of understanding.

Obviously, ICON coaches are more constrained than a human coach; they were able to offer models and think-alouds and provided corrective feedback to multiple-choice and constructed-strategy responses but were not able to analyze and respond to students' open-ended responses, nor could they build a collaborative response—all core aspects of reciprocal teaching conversations. However, the coaches were ever present and available as just-in-time support during the process of reading along with other cognitive and language supports that students were able to use at will. The network of support, opportunities for increased self-regulation through choice of support usage, and the heightened requirement to respond while reading changed the nature of the guided reading process in ways we theorized might be helpful to diverse readers. However, the increased need for monitoring and self-regulation of an array of supports, as well as text comprehension, might also increase cognitive load and diminish performance (Chandler & Sweller, 1991).

ICON 2: Vocabulary. ICON 2 enhanced the basic features with a series of interactive activities designed to expand students' vocabulary depth and breadth, develop metacognitive awareness, and encourage use of first-language strengths to support vocabulary learning (Proctor, Uccelli, 2009). Before reading each text, students completed Wade In!, where they were introduced to five power words, read a definition and example sentence, viewed an image, and listened to the word. They typed or audio-recorded a personal connection (Connect It!) to the word and saved their response to their electronic work log. They were presented a "language alert" that highlighted the use of cognates or other linguistic information (e.g., the language alert for the word *anxiously* was "Think about a Spanish word that looks or sounds like the English word. If they have similar meanings, they are cognates. *Anxiously* and *ansiosamente* are cognates. Is all this talk of cognates making you anxious?"). Students then began reading the text, stopping to explore the power words further in Dive In!, which included two activities, Web It! and Caption It! Web It! presented a semantic word map with the power word at the center and asked students to connect the power word to related words represented in nodes of the map. Caption It! asked students to generate a caption for a provided image using the relevant power word. Finally, during reading, students were asked to add a minimum of three hyperlinked glossary words to their personal glossaries, writing an explanation for why they chose the word. For each activity, students were able to click on a pedagogical agent who provided a model response with an explanation of his or her thinking. Students could also move back and forth between English and Spanish texts, and coaches and could write or audio-record responses in any language of their choosing.

ICON 3: Combination. ICON 3 combined the strategy and vocabulary versions so that students completed the Wade In! and Dive In! vocabulary activities, added words to their personal glossary, and responded to reading strategy prompts for each screen of the text. Because the combination version required more time, students in the other conditions read additional online texts related to the ICON text (e.g., for "Bird Cu," they could read other Latin American folktales or learn more about Mexico).

Norm-Referenced Reading Achievement Test

To obtain initial reading achievement levels and assess growth in print reading, we administered the Gates-MacGinitie Reading Test Vocabulary and Comprehension subtests (Forms S and T; MacGinitie et al., 2002) in each class pre- and postintervention. This test has been widely used in the United States and possesses strong psychometric properties (Kuder-Richardson Formula 20 reliability coefficients of .90 to .92 for the fifth-grade test are reported). Extended scaled scores were used for all analyses so that standardized growth could be assessed. Gates-MacGinite norms for the fall sample are reported at 502 (*SD* = 39.8) for the Comprehension subtest and at 500 (*SD* = 38.4) for the Vocabulary subtest. Spring norming sample averages are reported at 509 (*SD* = 39.1) for Comprehension and 508 (*SD* = 37.4) for Vocabulary (Maria & Hughes, 2008).

ICON's Embedded Vocabulary and Comprehension Assessment

The ICON SDR included vocabulary and comprehension assessments. After reading each ICON text, students completed a power word vocabulary assessment. For the vocabulary activities, previous pilot work had led to the selection of 40 power words, 5 per text, which would be considered Tier 2 words and/or core to understanding the text (Beck, McKeown, & Kucan, 2002). Approximately 60% of the words were Spanish-English cognates, and diverse parts of speech were represented (i.e., nouns, verbs, adverbs, adjectives). First, students rated how well they knew each of the 5 words on a scale of 1 to 4. Then, they completed Word Star (selecting 1 of 4 words to match an image), Word Master (completing a sentence constructed-cloze activity), and Word Wizard (selecting 1 of 4 words that relates best to the sentence context and requires inferencing). After the power word assessment, students completed a comprehension assessment that included factual and inferential questions, varying between 10 and 12 points possible. Proportions correct for each post–text assessment were determined, and students' average scores across texts were summed and averaged to create an overall comprehension or vocabulary performance measure, modeled as a proportion correct. Because of genre differences, we separately analyzed students' comprehension performance on the narrative and expository assessments. However, genre did not influence vocabulary outcomes; thus we assessed overall vocabulary performance across the eight e-texts.

Procedure

During November through April, researchers administered pretests to students and, in collaboration with the participating teachers, introduced students to their respective ICON prototype. All teachers used their school's basal literacy program, integrating ICON within their usual 90-min literacy block. None of the bilingual students received

specialized language services. Students attended the computer lab twice a week for approximately 24 sessions to read four ICON folktales and four ICON informational texts on the computer, completing embedded activities and comprehension and vocabulary assessments. After two of the folktales, students created multimedia retellings using PowerPoint and presented them to their classmates and invited school guests. The study concluded with posttesting, a student focus group, and a teacher–researcher meeting.

Teacher Professional Development and Technical Assistance

Prior to intervention, teachers participated in a 2-day workshop to prepare them for teaching with their respective ICON SDR and instructional approach. They used the ICON prototype and planned for how they would integrate ICON into their curricula. To ease some teachers' anxiety about using technology, researchers introduced students in each class to ICON and cotaught the first folktale and informational text with teachers. A research assistant was available for most sessions to provide technical assistance as needed. Midway through the intervention, teachers participated in an all-day workshop focusing on analysis of student responses in the electronic work logs and technology integration issues. After the intervention was completed, teachers and researchers gathered to share experiences, examine student data, and generate recommendations for future ICON development.

Classroom Observations and Fidelity of Treatment

Researchers observed each teacher's class for most, if not all, of their computer lab sessions. Classes spent an average of three computer sessions per e-text. Researchers took field notes to document teachers' and students' enactment of ICON in the lab. In addition, we adapted Foorman and Schatschneider's (2003) structured observation protocol, including items about teacher interaction with students while on the computer and explicit attention to comprehension strategies or vocabulary. We piloted the protocol for several sessions during the last phase of data collection. Observer reliability was not assessed at this phase of protocol development. While students worked individually on the computer, teachers engaged in a variety of activities, such as observation of students to ensure they were on task, instructional conversations with students about their work, and review of students' work in the electronic work logs, as well as occasional unrelated tasks, such as checking e-mail. In addition to reading on the computer, teachers periodically led students in discussing the texts and strategies and conducted informal conferences with students. Led by the first two authors, the research team met weekly to review field notes and discuss examples of teacher implementation and student learning. In addition to these weekly discussions, the senior researchers observed each classroom several times to verify that the level of fidelity documented in the reports and weekly discussion was acceptable. And finally, we

sampled the students' electronic work logs to obtain additional evidence that students were reading and responding within their respective ICON on schedule.

Analysis and Results

We assigned two classrooms to each condition (comprehension strategy, vocabulary, or combination) while analyzing learning outcomes at the student level. Students were nested within classes; however, the relatively small sample of six classes and 106 students, which we deemed necessary for a technology-intensive development project, constrained the validity of inferences that could be made using hierarchical linear modeling (Raudenbush & Bryk, 2001). Following recommendations for analyzing data when there is a mismatch between units of randomization and units of analysis (What Works Clearinghouse, 2008), we tested for initial reading achievement differences among the three ICON groups. As described above and in Table 1, there were no significant pretest reading differences by condition. In addition, we included students' pretest standardized reading comprehension scores as a control variable in all effect size analyses. We conducted repeated-measures and one-way ANOVAs to assess uncontrolled group differences for the standardized and researcher-developed measures. Next, we employed ANCOVA to test for postintervention effects of condition, language, and Condition × Language interactions for all researcher and standardized vocabulary and comprehension measures, controlling for initial reading achievement.

Table 4 presents the posttest results for researcher-designed measures, as well as the pre- and postintervention changes in standardized comprehension and vocabulary performance. Repeated measures ANOVAs revealed no growth on the Gates-MacGinitie Comprehension test, $F(1, 96) = 1.71$, $p = .194$, with no effect for condition, $F(2, 96) = 1.31$, $p = .275$. There was significant growth for Gates-MacGinitie Vocabulary from Time 1 to Time 2 for the sample as a whole, $F(1, 101) = 34.57$, $p < .001$, with no effect for condition, $F(2, 101) = 1.63$, $p = .201$. No Time × Condition interactions were significant.

One-way ANOVAs tested condition differences on the researcher-developed comprehension measures and revealed a significant effect for condition on students' average proportion correct for narrative comprehension, $F(2, 104) = 3.54$, $p = .033$. The effect approached significance for average proportion correct for expository comprehension, $F(2, 104) = 2.80$, $p = .066$. Tukey's post hoc testing of narrative comprehension indicated that the combination group significantly outperformed the strategy group but not the vocabulary group, which performed comparably to both the combination and strategy groups. With regard to vocabulary, there was also a significant effect for condition, $F(2, 104) = 8.04$, $p = .001$. Tukey's post hoc testing of vocabulary performance showed that both the combination and vocabulary groups performed comparably to one another while significantly outperforming the strategy group.

Having established the descriptive differences, we ran a series of ANCOVA models that controlled for entering Gates-MacGinitie reading score and tested the effects of

Table 4. Mean Performance of Comprehension Strategy, Vocabulary, and Combined Groups on Improving Comprehension Online (ICON) E-Text Vocabulary and Comprehension Quizzes and Gates-MacGinitie Reading Achievement Test

Variable	Total (n = 106)	Strategy (n = 38)	Vocabulary (n = 36)	Combination (n = 32)
ICON assessments (proportion correct)				
Expository comprehension	0.69 (0.15)	0.67 (0.16)	0.67 (0.15)	0.75 (0.14)
Narrative comprehension	0.79 (0.17)	0.76 (0.18)	0.76 (0.19)	0.86 (0.12)
Vocabulary	0.76 (0.18)	0.68 (0.19)	0.78 (0.16)	0.84 (0.14)
Standardized measures (ESS)				
Gates-MacGinitie Comprehension				
Preintervention	505.33 (37.71)	500.60 (37.1)	501.50 (43.09)	514.81 (30.61)
Postintervention	508.58 (41.39)	500.49 (40.15)	509.55 (43.24)	516.97 (40.33)
Pre- to postintervention mean difference	3.25	–.11	8.05	2.16
Pre- to postintervention effect size	0.08	0.0	0.19	0.06
Gates-MacGinitie Vocabulary				
Preintervention	509.40 (37.64)	503.11 (34.9)	509.78 (40.22)	516.25 (37.63)
Postintervention	523.03 (45.28)	513.84 (44.05)	521.94 (49.41)	534.88 (40.26)
Pre- to postintervention mean difference	13.63	10.73	12.16	18.63
Pre- to postintervention effect size	0.33*	0.27	0.27	0.48

Note: Standard deviations in parentheses. ESS = extended scaled scores. Effect sizes calculated using a pooled standard deviation. For the standardized measures, 95% confidence intervals for all calculated effect sizes encompassed 0, except for those marked with an asterisk. Preintervention ESS results are based on a norming sample mean of 501 (SD = 36.9) for vocabulary and a norming sample mean of 502 (SD = 38.2) for comprehension. Postintervention ESS results are based on a norming sample mean of 508 (SD = 38.3) for Vocabulary and 509 (SD = 37.7) for Comprehension.

condition (strategy, vocabulary, combination), language status (monolingual, bilingual Spanish, bilingual other), and their interaction on the five outcomes specified for intervention evaluation (Gates-MacGinitie Vocabulary and Comprehension subtests, researcher-developed expository comprehension, narrative comprehension, and vocabulary knowledge assessments). The adjusted means and their standard errors for these analyses are presented in Table 5. Table 6 presents the condition and language effects of the ANCOVA analysis. Partial eta-squared is included in Table 6 as an effect size indicator whereby estimates between .01 and .05 are considered small, .06 to .14 are considered medium, and estimates greater than .14 are considered strong.

Table 5. Adjusted Means for Condition and Language × Condition Controlling for Entering Reading Comprehension

	Comprehension strategy (n = 38)	Vocabulary (n = 36)	Combination (n = 32)
Comprehension expository text	0.64 (0.03)	0.69 (0.02)	0.69 (0.02)
English monolinguals	0.70 (0.02)	0.68 (0.02)	0.74 (0.03)
Spanish-English bilinguals	0.61 (0.04)	0.68 (0.04)	0.60 (0.05)
Other bilinguals	0.59 (0.06)	0.70 (0.05)	0.74 (0.03)
Comprehension narrative text	0.76 (0.03)	0.80 (0.03)	0.83 (0.03)
English monolinguals	0.78 (0.03)	0.75 (0.03)	0.81 (0.03)
Spanish-English bilinguals	0.79 (0.06)	0.82 (0.05)	0.83 (0.07)
Other bilinguals	0.71 (0.08)	0.84 (0.07)	0.85 (0.04)
Vocabulary	0.62 (0.03)	0.83 (0.02)	0.80 (0.02)
English monolinguals	0.74 (0.02)	0.77 (0.02)	0.81 (0.03)
Spanish-English bilinguals	0.65 (0.05)	0.81 (0.04)	0.77 (0.05)
Other bilinguals	0.48 (0.07)	0.90 (0.06)	0.82 (0.04)
Postintervention Gates-MacGinitie Comprehension ESS	504.49 (6.37)	515.06 (6.01)	506.72 (5.10)
English monolinguals	508.27 (5.11)	507.04 (5.63)	511.60 (6.30)
Spanish-English bilinguals	501.49 (10.72)	522.72 (8.93)	497.63 (11.50)
Other bilinguals	503.70 (14.78)	515.43 (14.73)	510.93 (8.12)
Postintervention Gates-MacGinitie Vocabulary ESS	502.89 (6.86)	520.90 (5.93)	522.50 (5.51)
English monolinguals	529.13 (5.52)	529.16 (5.80)	530.37 (6.81)
Spanish-English bilinguals	502.57 (11.56)	519.95 (9.62)	505.17 (12.42)
Other bilinguals	476.85 (15.96)	513.58 (13.82)	531.96 (8.77)

Note: Standard errors in parentheses. ESS = extended scaled scores.

ANCOVA results indicated no significant main effects for condition, language status, or their interaction for Gates-MacGinitie Comprehension (Fs < 1). There was, however, a significant main effect for language status on Gates-MacGinitie Vocabulary, $F(2, 102) = 5.42$, $p = .006$, such that the monolingual group significantly outperformed both bilingual groups ($t = 2.57$, $p = .012$), which were comparable to one another. This result is depicted in Figure 4. Additionally, the effect for condition on Gates-MacGinitie Vocabulary was approaching significance, with the vocabulary and combination groups outperforming students in the strategy condition.

ANCOVA results for the researcher-developed measures were variable. For expository text comprehension, there was a main effect for language, $F(2, 102) = 3.53$, $p = .033$, partial $\eta^2 = .071$, but not for condition, $F(2, 102) = 1.81$, $p = .17$, partial $\eta^2 = .038$, with no significant interactions. Post hoc testing of expository comprehension indicated that the monolingual group significantly outperformed the bilingual-Spanish group ($t = 2.24$, $p = .03$), and the bilingual-other group performed comparably to the bilingual-Spanish group ($t = 1.43$, $p = .16$) and to the monolingual group ($t = .49$, $p = .624$; see Figure 5). For narrative comprehension, there was no effect for condition, $F(2, 102) = 1.35$,

Table 6. ANCOVA of Standardized and Researcher-Developed Measures of Vocabulary and Comprehension

	Standardized measures		Researcher-developed measures		
Statistic	Gates-MacGinitie Comprehension	Gates-MacGinitie Vocabulary	Expository comprehension	Narrative comprehension	Vocabulary
Intercept					
F	3.10	5.29	21.23	11.21	18.76
p value	0.082	0.024	0.000	0.001	0.000
Partial η^2	0.034	0.054	0.188	0.109	0.168
Entering reading					
F	132.36	106.03	80.76	53.97	75.95
p value	0.000	0.000	0.000	0.000	0.000
Partial η^2	0.598	0.535	0.467	0.370	0.45
Condition					
F	0.872	2.86	1.81	1.35	17.40
p value	0.422	0.062	0.17	0.27	0.000
Partial η^2	0.019	0.059	0.038	0.028	0.272
Language status					
F	0.043	5.42	3.52	0.407	0.922
p value	0.958	0.006	0.033	0.667	0.401
Partial η^2	0.001	0.105	0.071	0.009	0.019
Language × Condition					
F	0.996	2.24	1.98	0.767	4.94
p value	0.414	0.071	0.104	0.549	0.001
Partial η^2	0.043	0.089	0.079	0.032	0.175

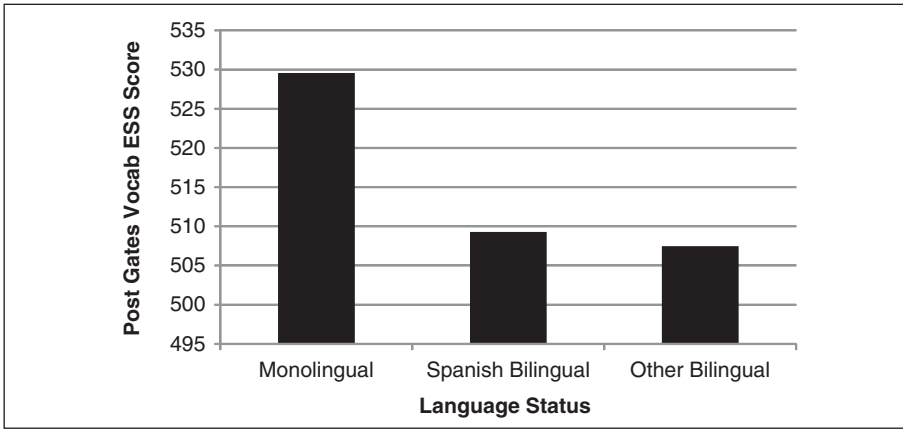

Figure 4. Adjusted proportion correct on Gates-MacGinitie postintervention vocabulary performance as a function of language status

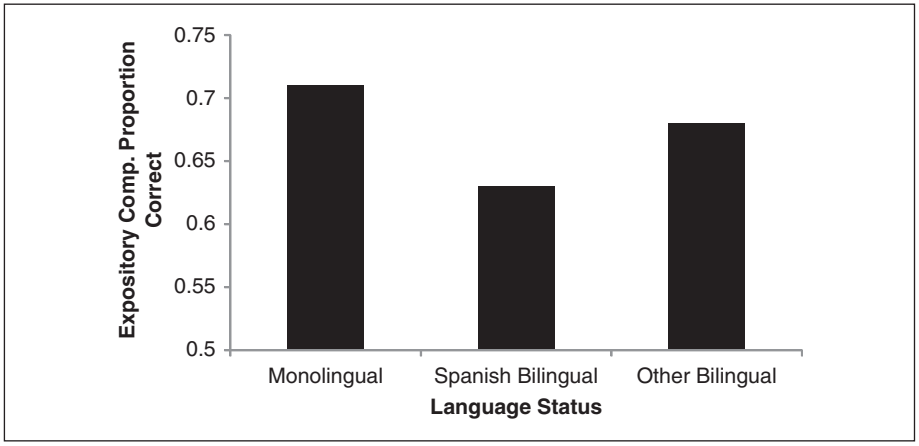

Figure 5. Adjusted proportion correct on researcher-developed expository comprehension as a function of language status

$p = .27$, partial $\eta^2 = .028$; language, $F(2, 102) = .407$, $p = .67$, partial $\eta^2 = .009$; or the interaction of condition and language.

For vocabulary knowledge, there was a significant condition effect for the researcher-developed measure, $F(2, 103) = 17.40$, $p < .001$, partial $\eta^2 = .272$, along with an interaction between condition and language status, $F(2, 103) = 4.94$, $p = .001$, partial $\eta^2 = .175$. Tukey's post hoc analysis revealed that the strategy group's vocabulary performance was significantly lower than that of the combination group ($t = –4.51$, $p < .001$, partial $\eta^2 = .18$) and of the vocabulary group ($t = –3.28$, $p = .001$, partial $\eta^2 = .15$). Significant interactions existed within the strategy condition only, with the monolingual group outperforming the bilingual-Spanish group ($t = 3.21$, $p = .002$, partial $\eta^2 = .10$). See Figure 6.

Discussion

This study investigated the relative contribution of reading comprehension strategy and interactive vocabulary learning embedded in ICON, a universally designed strategic digital reading environment for fifth-grade monolingual and bilingual students. The results provide additional evidence that middle-grade students benefit from scaffolded digital text (Dalton et al., 2002; Moran et al., 2008; Proctor et al., 2007, Proctor, Dalton, et al., 2009; Proctor, Uccelli, et al., 2009; Salomon et al., 1989). The results also provide new, albeit preliminary, evidence that designing digital text as a transitional guided reading experience with interactive reading strategy and vocabulary features embedded before and during reading of the online text supports students' vocabulary learning in context.

Improving vocabulary in context was a major goal of the study. After controlling for initial reading achievement, the vocabulary and combination groups performed

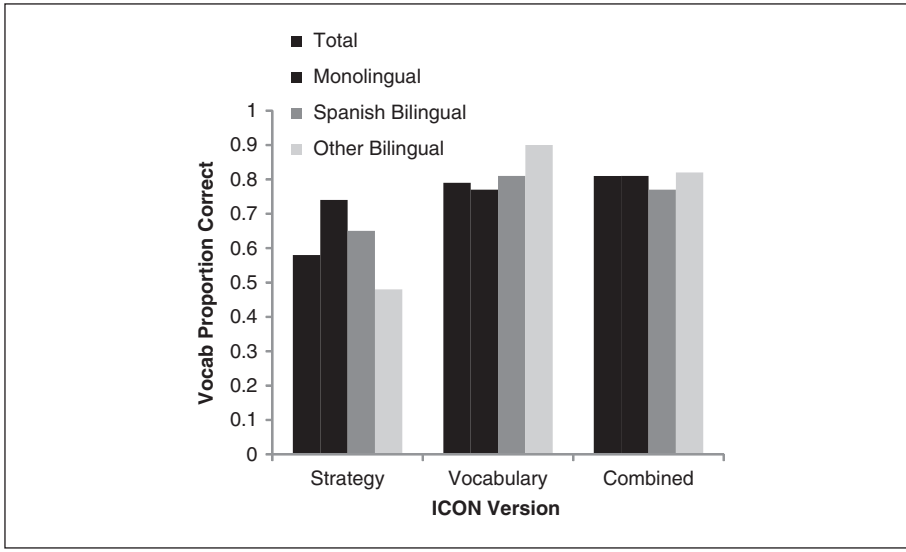

Figure 6. Adjusted proportion correct on researcher-developed vocabulary performance as a function of condition and language status

comparably on the ICON vocabulary assessment, with both groups significantly outperforming the strategy group. In this case, it appears that engaging with word and text meaning simultaneously may contribute to vocabulary at the same level as working with vocabulary alone. As might be predicted, applying comprehension strategies, even when students used the clarification strategy to address vocabulary confusion, was less helpful than direct interaction with word meanings and word relationships that were connected with the texts they were reading. Interestingly, bilingual students in particular had difficulty developing vocabulary if it was indirectly addressed through reading comprehension strategies alone.

Improving comprehension was the overarching goal of the study. Contrary to prediction, the type of instructional scaffolding did not differentially affect comprehension, with interactive vocabulary proving as helpful as the other two versions containing comprehension strategies. One possibility is that in this context, and for these readers, strategic reading and vocabulary knowledge exerted an equal influence on comprehension. Another explanation may be that students had sufficient exposure to reading strategies instruction in their classrooms (strategies were a part of the basal literacy program in each school) and that vocabulary learning was just as helpful to understanding the text as additional work with strategies. A third possibility is that the dialogic conversation that is at the heart of Palincsar and Brown's (1984) reciprocal teaching is weakly applied in the ICON environment, where students may access coaching and language support at will but are not able to engage in a dynamic conversation about the text and strategy use. Positive findings from other studies of scaffolded digital text

may have been attributable in part to the heavier emphasis on teacher and peer offline discussion (Dalton et al., 2002) or more structured feedback (Salomon et al., 1989).

Designing for diversity and differentiating instruction for students with different language and literacy strengths and needs is a challenge for teachers and thus an opportunity for developers of digital learning environments. We find it encouraging that both bilingual and monolingual students benefited from, and were able to manage, reading within a strategic digital reading environment that offered an array of supports. Although these results are consistent with other research showing that bilingual students benefit from instruction developed for monolingual students (August & Shanahan, 2006, 2010), an important difference in this context was the inclusion of features designed for bilingual learners and, specifically, for Spanish-English bilinguals. We observed Spanish-speaking students accessing the bilingual coaches, listening to Spanish narration of the text, and accessing Spanish translations of the power words. From a universal design perspective, ICON's range and flexibility of supports and options for interaction and response may have been important in supporting students with varying language and literacy profiles. The relative complexity of the system did not appear to produce cognitive overload (Chandler & Sweller, 1991), a concern frequently expressed in relation to less skillful learners' use of digital resources (Anderson-Inman & Horney, 1998).

The ICON design is guided by UDL principles (Rose & Meyer, 2002). Specifically, our SDR framework (Dalton & Proctor, 2008) applies the Rand Reading Study Group's (2002) reading comprehension heuristic to show how the interaction of reader, text, and activity factors as enacted within a sociocultural context is transformed in a digital context. Reader and activity factors may be offloaded in part to the digital environment, with changes in the sociocultural context indirectly and directly affected and reading comprehension potential expanded. The current study does not test this expanded strategic digital reading comprehension heuristic. However, the approach and findings are consistent with such a framework. We believe that a more sophisticated approach is needed, both technically and methodologically, to tease out the interaction of reader, text, activity, and context variables. Actively working within ICON to develop a deep understanding of words while simultaneously grappling with understanding the text supported monolingual and bilingual students' learning. This makes sense in many ways. We cannot help but speculate, however, that if the ICON environment were more sensitive to variations in the reader, text, activity, and sociocultural factors contributing to comprehension, we might have found different results. In medicine, the concept of personalized, customized treatment (and prevention) is progressing in line with technological advances supporting individualization.

Although we apply a medical model to this reading comprehension scenario with hesitation, it seems possible, and potentially achievable, that ICON, or other strategic digital reading environments, could serve up a mix of vocabulary, reading strategies, and bilingual language support in dynamic response to each reader as situated in a particular literacy event. It may be that striving for an optimal version (as we did in this study) reflects an assembly-line model of innovation and production that no

longer works well. Customization on the fly will require more sophisticated theory, practice, and technology. We believe it will also require resources to work with larger samples so that individual differences can emerge and be studied in dynamic interaction with digital environments.

Limitations

This study was carried out in six fifth-grade classrooms in two districts. Within district, we randomly assigned teacher to condition and conducted our analyses with student as the unit of analysis. This was necessary because of sample size constraints and our development goal. Although we included students' pretest reading achievement as a control variable in our analyses to address initial differences within the students, even this control does not ameliorate the effects of very small cell sizes within each condition, particularly for the non-Spanish-speaking bilingual students. Indeed, the Language × Condition interactions detected may have simply been an artifact of sample size and should be interpreted with great caution. Clearly, it would be useful to replicate this study with a larger sample and with students randomly assigned to condition.

The positive impact of the ICON vocabulary and combination versions on vocabulary is based on a researcher-designed measure and should be judged accordingly. We did not achieve transfer to a standardized reading achievement test. It may be that the intervention was of insufficient duration or that our decision to provide access to grade-level e-text resulted in text that was still too difficult for some students in the study. Another possible factor that merits further study is student control of coaching help. The pedagogical agents carried important instructional information that students could access if they so chose. Despite positive feedback on their usefulness, students often ignored the coaches, a finding that is consistent with previous research (Anderson-Inman & Horney, 1998; McKenna, 1998).

Finally, we do not want to suggest that this study supports providing students a steady diet of scaffolded strategic digital texts. With regard to comprehension strategies, it seems reasonable to predict that some students will need a relatively brief period of reading within a highly supported digital text environment, whereas others, and especially those with more serious reading difficulties, may need extended opportunities with multiple texts. Vocabulary may merit a somewhat different approach. Although it is likely that students were developing metalinguistic awareness as they interacted with ICON, they were primarily involved in constructing knowledge of specific words through a series of interactive experiences. For bilingual students learning English vocabulary and for other students who have less-developed background knowledge and language abilities, it might be beneficial to provide interactive, multimedia vocabulary support for sustained periods of time in coordination with more challenging academic text. These questions are key to scalability. The recent release of the iPad and other mobile reading platforms accelerates the need to develop e-text design principles to guide development and use of online literacy scaffolds.

Conclusion

The results of this study provide additional evidence that digital tools and reading environments can be scaffolded to support individual differences and contribute to young adolescents' learning from e-text (Moran et al., 2008). Although there is a substantial research base supporting the use of reading strategies to improve comprehension and a well-established connection between vocabulary and comprehension (NRP, 2000), much less is known about the relative contribution of reading strategies and vocabulary learning to comprehension, especially in the context of scaffolded digital text. These results suggest that monolingual and bilingual fifth-grade students benefit from reading age-appropriate e-text that has been universally designed to promote engagement, provides access to text (word recognition and linguistic access, per Gough and Tunmer's [1986] simple view of reading), and scaffolds active learning related to linguistic, cognitive, and metacognitive aspects of reading comprehension (conceptual support, per Stanovich's [1980] interactive compensatory reading model). However, the benefit was realized in relation to vocabulary learning. The type of scaffolded e-text differentially affected vocabulary in the direction anticipated, with both vocabulary and a combination of vocabulary and comprehension strategy support proving more beneficial than comprehension strategies alone. The usual gap in performance between English-monolingual and bilingual students disappeared in the vocabulary and combination groups, suggesting that the right type of scaffolds can level the playing field for diverse learners. Contrary to prediction, the type of scaffold did not differentially affect comprehension. We did not study the effect of supports unique to the bilingual Spanish-speaking students, such as cognate awareness alerts, bilingual coaches, and Spanish translations. Within our universal design for learning strategic digital reading framework, they functioned as access supports; however, advancing the theoretical understanding of online reading comprehension and developing design principles for effective scaffolded e-text will require further research in this area.

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References

ACT. (2010). *The condition of college and career readiness 2010*. Retrieved from http://www.act.org/research/policymakers/cccr10/pdf/ConditionofCollegeandCareerReadiness2010.pdf

Anderson, R. C., & Nagy, W. (1992). The vocabulary conundrum. *American Educator: The Professional Journal of the American Federation of Teachers*, *16*(4), 14-18, 44-47.

Anderson-Inman, L., & Horney, M. A. (1998). Transforming text for at-risk readers. In D. Reinking, M. C. McKenna, L. D. Labbo, & R. D. Kieffer (Eds.), *Handbook of literacy and technology: Transformations in a post-typographic world* (pp. 15-43). Mahwah, NJ: Lawrence Erlbaum.

August, D., & Shanahan, T. (2010). Response to a review and update on *Developing Literacy in Second-Language Learners: Report of the National Literacy Panel on Language Minority Children And Youth*. *Journal of Literacy Research*, *42*(3), 341-348. doi:10.1080/1086296X.2010.503745

August, D., & Shanahan, T. (2006). *Developing literacy in second-language learners: Report of the national literacy panel on language-minority children and youth*. Mahwah, NJ: Lawrence Erlbaum.

Baumann, J. F., Edwards, E. C., Boland, E., Olejnik, S., & Kame'enui, E. J. (2003). Vocabulary tricks: Effects of instruction in morphology and context on fifth-grade students' ability to derive and infer word meaning. *American Educational Research Journal*, *40*(2), 447-494.

Beck, I., McKeown, M., & Kucan, L. (2002). *Bringing words to life: Robust vocabulary instruction*. New York, NY: Guilford Press.

Blachowicz, C. Z., Fisher, P. L., Ogle, D., & Watts-Taffe, S. (2006). Vocabulary: Questions from the classroom. *Reading Research Quarterly*, *41*(4), 524-539.

Block, C. C., & Duffy, G. G. (2008). Research on teaching comprehension: Where we've been and where we're going. In C. C. Block & S. R. Parris (Eds.), *Comprehension instruction: Research-based best practices* (2nd ed., pp. 19-37). New York, NY: Guilford Press.

Carlo, M. S., August, D., McLaughlin, B., Snow, C. E., Dressler, C., Lippman, D. N., . . . White, C. E. (2004). Closing the gap: Addressing the vocabulary needs of English-language learners in bilingual and mainstream classrooms. *Reading Research Quarterly*, *39*(2), 188-215.

Chandler, P., & Sweller, J. (1991). Cognitive load theory and the format of instruction. *Cognition and Instruction*, *8*(4), 293-332.

Cognition and Technology Group, Vanderbilt Learning Technology Center. (1993). Examining the cognitive challenges and pedagogical opportunities of integrated media systems: Toward a research agenda. *Journal of Special Education Technology*, *12*(2), 118-124.

Coiro, J. (2003). Reading comprehension on the Internet: Expanding our understanding of reading comprehension to encompass new literacies. *Reading Teacher*, *56*(6). Retrieved from http://www.readingonline.org/electronic/elec_index.asp?HREF=/electronic/RT/2-03_column/index.html

Cunningham, A. E., & Stanovich, K. E. (1991). Tracking the unique effects of print exposure in children: Associations with vocabulary, general knowledge, and spelling. *Journal of Educational Psychology*, *83*(2), 264-274.

Dalton, B., Pisha, B., Eagleton, M., Coyne, P., & Deysher, S. (2002). *Engaging the text: Reciprocal teaching and questioning strategies in a scaffolded digital learning environment*. Final report to U.S. Department of Education, Office of Special Education Programs, Washington, DC.

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. Knobel, C. Lankshear, & D. Leu (Eds.), *Handbook of research on new literacies* (pp. 297-324). Mahwah, NJ: Lawrence Erlbaum.

Dalton, B., & Strangman, N. (2006). Improving struggling readers' comprehension through scaffolded hypertexts and other computer-based literacy programs. In D. Reinking, M. C. McKenna, L. D. Labbo, & R. D. Keiffer (Eds.), *Handbook of literacy and technology* (2nd ed., pp. 75-92). Mahwah, NJ: Lawrence Erlbaum.

Davis, D. S. (2010). *A meta-analysis of comprehension strategy instruction for upper elementary and middle school students* (Doctoral dissertation). Vanderbilt University, Nashville, TN. Retrieved from http://etd.library.vanderbilt.edu/available/etd-06162010-100830/

Davis, F. B. (1942). Two new measures of reading ability. *Journal of Educational Psychology*, *33*(5), 365-372.

Edyburn, D. L. (2002). Cognitive rescaling strategies: Interventions that alter the cognitive accessibility of text. *Closing the Gap*, *1*, 10-11, 21.

Foorman, B. F., & Schatschneider, C. (2003). Measuring teaching practice during reading/language arts instruction and its relation to student achievement. In S. Vaughn & K. L. Briggs (Eds.), *Systems for observing teaching and learning* (pp. 1-30). Baltimore, MD: Brooks.

García, G. E. (1996, December). *Improving the English reading of Mexican-American bilingual students through the use of cognate recognition strategies*. Paper presented at the National Reading Conference, Charleston, SC.

Gee, J. P. (2003). *What video games have to teach us about learning and literacy*. New York, NY: Palgrave/St. Martin's.

Gough, P. B., & Tunmer, W. E. (1986). Decoding, reading, and reading disability. *Remedial and Special Education*, *7*(1), 6-10.

Handsfield, L. J., & Jiménez, R. T. (2009). Cognition and misrecognition: A Bourdieuian analysis of cognitive strategy instruction in a linguistically and culturally diverse classroom. *Journal of Literacy Research*, *4*(2), 151-195.

Higgins, K., Boone, R., & Lovitt, T. (1996). Hypertext support for remedial students and students with learning disabilities. *Journal of Learning Disabilities*, *29*(4), 402-412.

Jiménez, R. T. (1997). The strategic reading abilities and potential of five low-literacy Latina/o readers in middle school. *Reading Research Quarterly*, *32*(3), 224-243.

Jiménez, R. T., García, G. E., & Pearson, P. D. (1996). The reading strategies of bilingual Latina/o students who are successful English readers: Opportunities and obstacles. *Reading Research Quarterly*, *31*(1), 90-112.

Just, M. A., & Carpenter, P. A. (1987). *The psychology of reading and language comprehension*. Boston, MA: Allyn & Bacon.

Kamil, M. L. (2003). *Adolescents and literacy: Reading for the 21st century*. Washington, DC: Alliance for Excellent Education.

Koren, S. (1999). Vocabulary instruction through hypertext: Are there advantages over conventional methods of teaching? *Teaching English as a Second or Foreign Language*, *4*(1), 1-13.

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

LaBerge, D., & Samuels, S. (1974). Toward a theory of automatic information processing in reading. *Cognitive Psychology*, *6*(2), 293-323.

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.

Lubliner, S., & Smetana, L. (2005). The effects of comprehensive vocabulary instruction on Title 1 students' metacognitive word-learning skills and reading comprehension. *Journal of Literacy Research*, *37*(2), 163-199.

MacArthur, C. A., Ferretti, R. P., Okolo, C. M., & Cavalier, A. R. (2001). Technology applications for students with literacy problems: A critical review. *Elementary School Journal*, *101*(3), 273-302.

MacArthur, C. A., & Haynes, J. B. (1995). Student assistant for learning from text (salt): A hypermedia reading aid. *Journal of Learning Disabilities*, *28*(3), 50-59.

Mace, R. L. (1998). Universal design in housing. *Assistive Technology*, *10*(1), 21-28.

MacGinitie, W., MacGinitie, R., Maria, K., & Dreyer, L. (2002). *Gates MacGinitie reading tests* (4th ed.). Itasca, IL: Riverside.

Maria, K., & Hughes, K. E. (2008). *Gates MacGinitie reading tests: Technical report supplement forms S and T*. Itasca, IL: Riverside.

McKenna, M. C. (1998). Electronic texts and the transformation of beginning reading. In D. Reinking, M. C. McKenna, L. D. Labbo, & R. Kieffer (Eds.), *Handbook of literacy and technology: Transformations in a posttypographic world* (pp. 45-59). Hillsdale, NJ: Lawrence Erlbaum.

McKenna, M. C., Reinking, D., Labbo, L. D., & Kieffer, R. D. (1999). The electronic transformation of literacy and its implications for the struggling reader. *Reading and Writing Quarterly*, *15*(2), 111-126.

McKenna, M. C., & Zucker, T. A. (2009). Use of electronic storybooks in reading. In A. G. Bus & S. B. Neuman (Eds.), *Multimedia and literacy development: Improving achievement for young learners* (pp. 254-272). New York, NY: Routledge.

McNamara, D. S., O'Reilly, T., Best, R., & Ozuru, Y. (2006). Improving adolescent students' reading comprehension with iSTART. *Journal of Educational Computing Research*, *34*(2), 147-171.

Meyer, B. F., Wijekumar, K., Middlemiss, W., Higley, K., Lei, P., Meier, C., & Spielvogel, J. (2010). Web-based tutoring of the structure strategy with or without elaborated feedback or choice for fifth- and seventh-grade readers. *Reading Research Quarterly*, *45*(1), 62-92.

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.

Nagy, W. E., García, G. E., Durgunoglu, A. Y., & Hancin-Bhatt, B. J. (1993). Spanish-English bilingual students' use of cognates in English reading. *Journal of Reading Behavior*, *25*, 241-259.

Nakamoto, J., Lindsey, K. A., & Manis, F. R. (2008). A cross-linguistic investigation of English language learners' reading comprehension in English and Spanish. *Scientific Studies of Reading*, *12*(4), 351-371.

National Assessment of Educational Progress. (2009). *The nation's report card: Reading 2009* (NCEC 2010-458). Washington, DC: Institute of Education Sciences, U.S. Department of Education.

National Reading Panel. (2000). *Teaching children to read: An evidence-based assessment of the scientific research literature on reading and its implications for reading instruction.* Washington, DC: National Institute of Child Health and Human Development.

National Education Association & American Federation of Teachers. (2008). *Access, adequacy, and equity in education technology*: *Results of a survey of America's teachers and support professionals on technology in public schools and classrooms.* Washington, DC: Author. Available from http://www.nea.org/

Palincsar, A. S., & Brown, A. L. (1984). Reciprocal teaching of comprehension-fostering and comprehension-monitoring activities. *Cognition and Instruction*, *1*(2), 117-175.

Pearson, P., Hiebert, E. H., & Kamil, M. L. (2007). Vocabulary assessment: What we know and what we need to learn. *Reading Research Quarterly*, *42*(2), 282-296.

Plass, J. L., & Chun, D. M.(1998). Supporting visual and verbal learning preferences in a second-language multimedia learning environment. *Journal of Educational Psychology*, *90*(1), 25-36.

Pressley, M. (2006). *Reading instruction that works: The case for balanced teaching* (3rd ed.). New York, NY: Guilford Press.

Proctor, C. P., Carlo, M. S., August, D., & Snow, C. E. (2005). Native Spanish-speaking children reading in English: Toward a model of comprehension. *Journal of Educational Psychology*, *97*(2), 246-256.

Proctor, C. P., Dalton, B., & Grisham, D. (2007). Scaffolding English language learners and struggling readers in a multimedia hypertext environment with embedded strategy instruction and vocabulary support. *Journal of Literacy Research*, *39*(1), 71-93.

Proctor, C. P., Dalton, B., Uccelli, P., Biancarosa, G., Mo, E., Snow, C. E., & Neugebauer, S. (2009). Improving comprehension online: Effects of deep vocabulary instruction with bilingual and monolingual fifth graders. *Reading and Writing: An Interdisciplinary Journal.* Advance online publication. doi:10.1007/s11145-009-9218-2

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.

Rand Reading Study Group. (2002). *Reading for understanding: Toward an R&D program in reading comprehension*. Santa Monica, CA: RAND.

Raudenbush, S. W., & Bryk, A. S. (2001). *Hierarchical linear models: Applications and data analysis methods* (2nd ed.). Thousand Oaks, CA: Sage.

Reinking, D., & Schreiner, R. (1985). The effects of computer-mediated text on measures of reading comprehension and reading behavior. *Reading Research Quarterly*, *20*(5), 536-552.

Reinking, D., & Rickman, S. S. (1990). The effects of computer-mediated texts on the vocabulary learning and comprehension of intermediate-grade readers. *Journal of Reading Behavior*, *22*, 395-411.

Rose, D., & Meyer, A. (2002). *Teaching every student in the digital age: Universal design for learning*. Alexandria, VA: Association for Supervision and Curriculum Development.

Rosenshine, B., & Meister, C. (1994). Reciprocal teaching: A review of the research. *Review of Educational Research*, *64*(4), 479-530.

Salomon, G., Globerson, T., & Guterman, E. (1989). The computer as a zone of proximal development: Internalizing reading-related metacognition from a reading partner. *Journal of Educational Psychology*, *81*(4), 620-627.

Scott, J. A., & Nagy, W. (2004). Developing word consciousness. In J. Baumann & E. Kame'enui (Eds.), *Vocabulary instruction: Research to practice* (pp. 201-217). New York, NY: Guilford Press.

Shanahan, T., & Shanahan, C. (2008). Teaching disciplinary literacy to adolescents: Rethinking content-area literacy. *Harvard Educational Review*, *78*(1), 40-59.

Stanovich, K. E. (1980). Toward an interactive-compensatory model of individual differences in development of reading fluency. *Reading Research Quarterly*, *16*(1), 32-71.

Vitale, M., & Romance, N. (2008, April). *A multi-part instructional strategy for accelerating vocabulary acquisition as an inductive process*. Paper presented at the annual meeting of the American Educational Research Association, New York, NY.

What Works Clearinghouse. (2008). *Procedures and standards handbook: Version 2.0*. Washington, DC: Institute of Education Sciences, U.S. Department of Education. Retrieved from http://ies.ed.gov/ncee/wwc/references/idocviewer/doc.aspx?docid=19&tocid=1

Woodcock, R. W., Muñoz-Sandoval, A. F., Ruef, M., & Alvarado, C. F. (2005). *Woodcock Muñoz Language Survey–Revised*. Itasca, IL: Riverside.

Xin, J. F., & Rieth, H. (2001). Video-assisted vocabulary instruction for elementary school students with learning disabilities. In *Information technology in childhood education annual* (pp. 87-104). Norfolk, VA: Association for the Advancement of Computing in Education.

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