Scaffolding English Language Learners and Struggling Readers in a Universal Literacy Environment With Embedded Strategy Instruction and Vocabulary Support
C. Patrick Proctor, Bridget Dalton, and Dana L. Grisham
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As interest and concern rise in U.S. educational circles around the reading achievement of English language learners (ELLs) and struggling readers, researchers and practitioners alike are calling for the increased use of technology as a means to decrease achievement gaps in reading (Jiménez, 2003; Strangman & Dalton, 2005). In this article, we report results from a 4-week study of the English reading comprehension of struggling readers, including Spanish-speaking ELLs. Thirty 4th-grade students read several narrative and informational hypertexts that provided embedded vocabulary and comprehension strategy supports, along with text-to-speech read-aloud functionality. Correlation analyses of pre–post standardized reading vocabulary gain scores revealed that vocabulary gain was associated, although not significantly, with the frequency of access of hyperlinked glossary items throughout the intervention, and that lower pretest vocabulary knowledge was associated with positive vocabulary gains. A similar pattern was detected for comprehension gains, which were significantly associated with the frequency of access of coaching avatars that provided support around the productive use of reading comprehension strategies.

The results reported here suggest that struggling readers and Spanish-speaking ELLs made use of the digitally embedded features in such a way as to promote both learning novel lexical items and effectively applying reading comprehension strategies. The results of the 2003 National Assessment of Educational Progress (NAEP) underscore a well-known and urgent issue for reading achievement in the United States: 37% of students in Grade 4 and 26% of students in Grade 8 could not read at a basic level (National Center for Education Statistics, 2003). Of special concern is the continued gap in achievement for children in different demographic groups, especially given the increasing diversity of U.S. classrooms. The NAEP fourth-grade results showed 75% of White students reading at or above a basic level. By contrast, only 44% of Hispanic students and 40% of African American students performed at this level. Similar gaps in achievement also persist between students who are eligible for free or reduced lunch and their more affluent peers. Although reading research has often targeted understanding how and why children struggle with text comprehension, the vast majority of this research has been conducted with monolingual English-speaking populations (see, e.g., Stanovich, 2000, for an impressive overview of the state of reading research, with little mention of non-English-speaking groups). Considerably more work must be done with English language learners (ELLs) alongside their English-only (EO) counterparts to better understand the components and processes of English reading comprehension and to develop appropriate instructional interventions that target the persistent gap in reading achievement illuminated in the NAEP report.

The RAND Reading Study Group (2002) indicates a number of gaps in the field of reading comprehension research. Specifically, readers’ cognitive and metacognitive strategy development, vocabulary, and linguistic knowledge are variables that exert considerable influence on reading comprehension processes and outcomes. We know little about how to enhance these reader attributes or how to individualize text and instruction to differentially support students’ diverse capabilities and limitations to optimize learning.
Classroom technology use has the potential to provide struggling readers and ELLs with access to crucial digital literacies while working to improve vocabulary and reading comprehension outcomes (Kamil, 2003; Kamil, Intrator, & Kim, 2000; Kim & Kamil, 2003; Laufer & Hill, 2000; Leu, 2000). The most common forms of support provide access to the content (e.g., a struggling reader may use text-to-speech (TTS) support to have text read aloud) or additional information needed to comprehend the text (e.g., a glossary or background knowledge hyperlink). Of particular promise is the relatively small body of research on hypertexts designed to support students’ strategic processing of text (Anderson-Inman & Horney, 1998; Dalton & Strangman, 2006; Reinking, 1988; Strangman & Dalton, 2005).

Digital reading environments can also be designed and programmed to present important information in a systematic and consistent fashion, thus ensuring comparable access for all students. This is particularly promising for speakers of languages other than English, as supports relative to students’ native language (e.g., translations) may be provided in their first language (L1), creating a rich linguistic environment in which to build relevant lexical and metacognitive skills crucial for facile English-language text comprehension. Programmable digital environments are most certainly not intended to replace the teacher, but their use creates opportunities to present important information to students in such a way as to target individual differences in an effort to promote positive reading and learning experiences that can be supplemented offline through typical teacher–student interactions.

The study reported here is an initial investigation into the potential effectiveness of a digital approach to supported reading called a Universal Literacy Environment (ULE). This approach is an adaptation of a prototype previously developed for struggling readers (Dalton & Pisha, 2001; Dalton, Pisha, Eagleton, Coyne, & Deysher, 2002) and derived from classic work on reading comprehension instruction, specifically reciprocal teaching (Palincsar & Brown, 1984, 1989) and the principles of Universal Design for Learning (UDL; Rose & Meyer, 2002). UDL advocates that curricular materials be designed with sufficient flexibility that students of varying levels of aptitude, language proficiency, and cognitive functioning may access, and learn from, equivalent materials. Using a ULE, students may access a number of comprehension-scaffolding features, such as (a) pedagogical coaches who model appropriate responses to comprehension strategy prompts; (b) hyperlinked vocabulary words for which definitions, translations, example sentences, and relevant graphics are provided; and (c) TTS read-aloud functionality that reduces the decoding demands of many challenging texts (Dalton & Strangman, 2006; Rose & Dalton, 2002). The ULE tested here also draws on existing research on bilingual students’ reading behaviors and was developed under the assumption that children learning English as a second language may deploy literacy skills in their L1 to enhance second language (L2) comprehension outcomes, including translations and cognate awareness (see, e.g., Jiménez, García, & Pearson, 1996; Nagy, 1988; Nagy, García, Durgunoğlu, & Hancin-Bhatt, 1993; Proctor, August, Carlo, & Snow, 2006).
We worked with 30 fourth-grade students from two classrooms, 16 of whom were Spanish-speaking ELLs and 14 of whom were native English-speaking monolinguals. This study was designed to address the following research questions:

RQ1: What is the effect of working in the ULE on students’ vocabulary and comprehension growth? Do reading gain scores differ as a function of language status (ELL vs. EO)?

RQ2: Is the use of digitally embedded vocabulary acquisition and comprehension strategy supports over the course of the intervention related to vocabulary and comprehension gains?

Theoretical and Empirical Issues

A wealth of research evidence over the last 20 years strongly supports the teaching of reading comprehension strategies (for recent reviews of this literature, see the report of the National Reading Panel, 2000; Rosenshine & Meister, 1994; Swanson, 1999; Wong, 1991). Specifically, Palincsar and Brown’s reciprocal teaching approach is a promising application of multiple strategy instruction based on an apprenticeship model of learning (Palincsar, 1986, 1998; Palincsar & Brown, 1984). Support for reciprocal teaching has been demonstrated across grade levels and with diverse learners, including students with learning disabilities (Swanson, 1999) and ELLs (Garcia, 1991; Klinger & Vaughn, 1996). Rosenshine and Meister’s (1994) meta-analysis of 16 reciprocal training studies found an average effect size of .88 for researcher-developed tests and .32 for standardized tests. The National Reading Panel (2000) found 11 additional studies not included in the Rosenshine and Meister meta-analysis that also demonstrated positive results. Unfortunately, there is a wide gap between research and practice, with very little strategy instruction (vs. comprehension assessment) taking place in many of today’s classrooms (Pressley, 1998).

Research on monolingual English populations has demonstrated that skilled readers are aware of their reading processes and know their strengths and weaknesses, suggesting that active engagement in self-reflection and goal-setting is a powerful means for enhancing reading comprehension and writing (Englert, Raphael, Anderson, & Stevens, 1991; Paris, Cross, & Lipson, 1984). With support, students can learn to self-assess and set appropriate goals for themselves as learners (Lipson & Wixson, 1997). Indeed, similar phenomena have been observed among Spanish-speaking ELLs. Jiménez, García, and Pearson (1995, 1996) concluded that Spanish-speaking ELLs employed reading comprehension strategies comparable to their monolingual counterparts in reading English-language texts. However, native Spanish speakers also drew on bilingual-specific strategies such as cognate awareness and translation, suggesting that bilinguals have an extended array of strategies on which they draw to make sense of challenging English-language texts.
Vocabulary acquisition has also been shown to be of crucial, if not primary, importance in predicting reading comprehension outcomes among monolingual students (Anderson & Freebody, 1983), as well as Spanish-speaking bilingual students (Proctor, Carlo, August, & Snow, 2005). Such findings are bolstered by research on the apparently causal relations between vocabulary knowledge and reading comprehension noted by McKeown, Beck, Omanson, and Perfetti (1983, cited in Stanovich, 2000). Other research has shown that direct instruction of individual words is not an extremely powerful means of generating high degrees of word knowledge, but rather, continued exposure to text (Nagy & Herman, 1985) is more likely to result in extended semantic networks that will account for increases in children’s vocabulary sizes (Landauer, 1998).

With these issues in mind, there is a growing body of research suggesting the potential for hypertext, hypermedia, and computer-mediated text to support students’ reading development (Anderson-Inman & Horney, 1998; Cognition and Technology Group and Vanderbilt Learning Technology Center, 1993; Dalton & Strangman, 2006; Kamil et al., 2000; Leu, 2000; Reinking, 1988; Strangman & Dalton, 2005). The most common forms of support provide access to the content (e.g., a struggling reader may use TTS support to have the text read aloud via synthetic voice or view a multimedia definition) or additional information needed to comprehend the text (e.g., an ELL may hear a word pronounced, learn the Spanish translation for that word, and write a personal association with the word). Strangman and Dalton (2005) noted the particular promise of the relatively small body of research on hypertexts designed to support students’ strategic processing of text (e.g., a student might type a response to an embedded prompt to make a prediction). Relatively little is known about how supports such as these interact with learner characteristics for EO and ELL students, indicating the need to systematically test features with different groups of learners.

Dalton and colleagues (Dalton et al., 2002) investigated the impact of reading three age-appropriate novels comparing traditional classroom-based strategy instruction with ULE versions of the texts. In the study, 102 middle school students in both conditions used the reciprocal teaching strategies of predict, question, clarify, and summarize (Palincsar & Brown, 1984), as well as visualization (Pressley, 1998). After controlling for gender and initial reading achievement, students in the ULE condition demonstrated significantly greater gains on a standardized measure of reading comprehension than did their peers in the traditional strategy instruction condition. The effect size was moderate, equating to approximately half a grade level in reading achievement gain. For struggling readers who read at or below the 25th percentile prior to intervention, however, this was a meaningful increase. Dalton, Kennedy, Schleper, Lutz, and Strangman (2005) adapted the ULE instructional design to include American Sign Language video and signing avatar representations of the embedded strategy and vocabulary supports for middle school students who were deaf and hard of hearing and reading several grades below level. Pilot study results were promising, with 69% of the students improving their instructional reading level between one and two grade levels, as measured on an informal reading inventory.
A key issue in designing digital texts with embedded learning supports is learner control. The amount of support that is “pushed” to the student, ensuring that he or she is presented the enhancements, versus voluntarily “pulled” by the student is a critical question, the answer to which hinges on a student’s own judgments about when and how often to access a particular support. Several studies have found that students often do not access supports appropriately and that less successful learners have even greater difficulty using help, often ignoring support that would clearly be beneficial (Horney & Anderson-Inman, 1999; van Daal & Reitsma, 1993).

In one of the few studies to examine the effects of user control with young students, Reinking and Schreiner (1985) found that both good and poor fifth-grade readers learned more when they were required to use comprehension supports. However, a subsequent study found no difference in outcomes between students who were free to access supports at will and those who were required to access supports (Reinking, 1988). In their work with middle school struggling readers, Dalton and Pisha (2001) observed that students’ use of supports varied. For example, because most of the students were reading novels that were 3 years beyond their instructional reading level, they relied heavily on TTS to have the text read aloud. Many students also accessed strategy coaches who provided think-alouds and model responses during a reading session. However, it was rare to see students using available multimedia glossary links, even when subsequent conversations revealed unfamiliarity with the terms.

Although the research base for the use and effectiveness of digital reading environments with English-speaking students is growing, interventions specifically targeting non-native English speakers are almost nonexistent. Such an endeavor requires merging the existing research on technology and literacy with the knowledge base around bilingualism, biliteracy, and second language acquisition. Indeed, many of the supports already described, although monolingual in application, are best practice in nature, and thus have a place in the education of language minority learners. However, targeting translation of directions and coaching supports as well as the metalinguistic components of cross-language similarities and differences are bilingual-specific and have a meaningful place in the development of the ULE in this study.
Method

Participants
The participants were 30 fourth-grade students in two classrooms in a school district serving 33,000 students in southern California. The students were recruited from two connected classrooms whose two teachers worked as a team. These teachers selected the students who participated in the intervention, resulting in a group comprising 16 Spanish-speaking ELLs and 14 EO students. There were 11 boys and 19 girls. The district in which the school was located was relatively affluent; however, this particular school was the only school in the district receiving Title 1 funds. The teachers were aware that the pedagogical goals of the intervention were to improve comprehension of ELLs and struggling readers. As a result, they were inclined to select all of the ELL students, as well as the monolinguals they believed were struggling with text comprehension. The result was a group of struggling readers from English- and non-English-speaking backgrounds, performing on average at the 23rd percentile in reading vocabulary and the 31st percentile in reading comprehension on the Gates–MacGinitie Reading Achievement Test administered at the beginning of the study.

Online Reading Environment
The tested ULE is a multimedia digital reading environment derived from the work of Dalton and colleagues (Dalton & Pisha, 2001; Dalton et al., 2002) that gives students the opportunity to read eight hypertexts, four narrative and four informational, with embedded supports targeting depth and breadth of vocabulary development (Lively, August, Carlo, & Snow, 2003; Nagy, 1988) and cognitive and metacognitive strategy development (Palincsar & Brown, 1984). Each text contains prereading, within-reading, and postreading activities and supports designed to scaffold and assess progress toward improving English reading comprehension and vocabulary knowledge. To support students with decoding and fluency problems, the ULE provides TTS with synchronized highlighting, a tool that students may use to have text read aloud at the word, sentence, or passage level. Learners may also use TTS to have their own typed responses read aloud.

The four narrative texts are folktale retellings, authored by members of the research team, from different regions of the world: Mexico (Aztec folktale entitled Bird Cu), Hawaii (Polynesian folktale entitled Why the Sun Travels Slowly Across the Sky), West Africa (Ashanti folktale entitled Hungry Spider and Turtle), and Native America (Klamath folktale entitled How Coyote Stole Fire). The folktales are paired with an informational text that has some bearing on its narrative counterpart. For example, the Bird Cu folktale is paired with an informational text called About the Aztecs. The folktale texts are structured in a traditional, linear storybook format, and their informational counterparts function in a fashion akin to a structured Internet Web page. Students are presented with a home
page that provides five sub-themes relevant to the larger topic (e.g., About the Aztecs has five sub-themes: Aztecs, The Story of a Mighty People, Aztec Religion, Everyday Life in the Aztec Empire, and Lasting Influence). Each sub-theme is linked to a one-page fact sheet with text and relevant images. This format allows the student to choose his or her path through the text, rather than having it presented in typical linear format. After reading about each linked sub-theme, students are prompted to apply a relevant reading strategy, a feature common to both the narrative and informational texts. Table 1 details the readability, word length, and genre of the various texts in the order in which they were read.

Although the narrative texts (folktales) tend to be somewhat longer than their informational counterparts, their readability level is lower, ranging from 4.8 for Hungry Spider and Turtle to 6.0 for Bird Cu (the latter raised partly due to the inclusion of complex Aztec names). Each folktale is partnered with an informational text (e.g., All About Spiders accompanied Hungry Spider and Turtle). The informational texts’ readability ranges from 6.3 to 7.2 and includes many science and social studies terms. We selected texts that would be somewhat challenging for fourth graders primarily because we were interested in learning how they would use the digital supports to assist themselves when they encountered difficulty decoding the text, understanding the vocabulary, and understanding the content. The nature of the embedded learning supports is detailed next.
Prereading Supports: Power Words

To develop students’ vocabulary and to set the stage for their personal glossary building that takes place as they read the text, each text begins with the introduction of five “power words” that are important for fourth graders to know and that are important in the text. Further, each power word has a true Spanish cognate. Students are presented the word in English and Spanish, a brief definition, a contextual sentence, one or two graphics illustrating the word, and an audio pronunciation of the word. Students are prompted (a) to audio-record themselves pronouncing the word, and (b) to type a personal association they might have with the word into a text entry box. Their responses are captured in a work log that can be viewed at any point. Students may click on a bilingual coaching avatar who offers one of several types of model responses. Further the bilingual coach avatar also presents a “cognate alert,” explaining how the target word is related to its Spanish cognate (e.g., “The Spanish word for investigate is investigar. Do you notice that these two words look similar to each other? That means they’re cognates: words that look and mean the same in Spanish and English!”). Once students complete this sequence for the five power words, they begin reading the text.

Within-Reading Supports: Comprehension Strategies and Vocabulary Development

To develop comprehension, strategy instruction prompts, hints, and models are embedded in the digital text. At the end of each page of digital text, a student is prompted to click on “Now would be a good time to stop and think about the story.” Once this link is clicked, the student is given a particular strategy to apply (summarization, prediction, clarification, questioning, or visualization) and is prompted to provide a written or recorded response. For example, a student may be asked to make a prediction about what will happen next in a story. A text box appears and the student types a prediction response. If needed, he or she may click on a coach to obtain expert models, think-alouds, and hints germane to the prompted strategy. The student’s response is then saved to a personal work log that stores all individual responses for both student and teacher review. For example, a strategy coach for the prediction prompt states, “I thought about how cold it gets in the winter when the ice freezes. I don’t see how you could live without fire, so I predicted that some humans would freeze and have a hard winter,” followed by an appropriate model of the strategy: “I predict that some people will freeze and have a very difficult winter.” One of the two coaches is bilingual, and his suggestions are accessible in both English and Spanish. Figure 1 displays a screen shot of the ULE environment with explanations of available features.

Strategy support is leveled so that students move from high to low support, with the goal of independent application of strategies. Consider the summary strategy as an example. A student who is working in the most supported level will choose among three prewritten summaries, one of which is more appropriate than the other two. The student
is given three opportunities to select the correct response, with feedback provided on each selection. At a lower level of support, however, another student is simply prompted to type his or her own summary. Students and their teachers work together in individual conferences to review student work log responses, assess strengths and weaknesses relative to the prompted strategies, and determine when it is appropriate to move on to a lesser degree of support.

Various vocabulary words within each ULE text are hyperlinked so that the user may click to learn a word’s definition and its Spanish translation and read the word in a sentence. Students also have the option of adding any hyperlinked vocabulary word to My Glossary. When a student selects the Add to My Glossary option after clicking a linked vocabulary word, he or she is prompted, “Why did you choose this word for your glossary?” The student then types a response to the question prompt. This feature is consistent with Laufer’s (2003) work indicating that written interactions with novel words are associated with long-term retention of word meaning. Indeed, to finish reading a text, each student must add at least three hyperlinked words to this personal glossary. Like the comprehension responses, the selected words and student responses are stored in the My Glossary work log.

Postreading Supports: Retelling Activity

On completing each text, students engaged in a digitally based retelling activity. Students were presented with eight appropriately sequenced images from the relevant text and were required to write a description of what was occurring in the text as represented by the image. Once all eight images had been described, the student moved to the next screen where all eight descriptions were included in a single text box, whereupon the student began the process of editing the document for clarity and flow. Once the process was complete, the students completed a self-check rubric that asked students if they had included the typical elements of story grammar in their retelling. These elements included descriptions of the characters, setting, plot, culminating event, and resolution.

Digital Feature Use Tracking

Laufer and Hill (2000) made the point that digital environments must track students’ online activities, noting, “If a study does not provide log files which record what learners are doing during the reading task, there is no evidence that they indeed are looking up unknown words, rather than guessing or ignoring them” (p. 59). Accordingly, students working in the ULE access the system via the Internet and all student text interactivity, including vocabulary work, strategy responses, and mouse click selections (e.g., selecting Spanish translations, accessing the strategy and vocabulary coach supports, viewing hyperlinked vocabulary items, and posting vocabulary items to My Glossary) is routed to a remote server, which saves all work in an event usage log.
Procedure

The teachers attended two 3.5-hour training sessions the week prior to the intervention’s start. Training consisted of an overview of reciprocal teaching (Palincsar & Brown, 1984) and a description of the strategies employed in that approach to teaching reading comprehension (i.e., questioning, clarifying, predicting, and summarizing). Teachers also worked with two additional strategies included in the ULE environment: visualizing and feeling responses. In addition, teachers were introduced to the two work storage databases, Work Log and My Glossary, and became familiar with the ULE environment by working with the various texts. In this portion of the training, researchers answered questions pertinent to working in the ULE environment so that the teachers would be prepared for similar queries once the students began their work.

Prior to the intervention, students were administered the Gates–MacGinitie Reading Achievement Test in English to obtain a baseline measure of reading achievement. Once begun, the students spent 45 minutes, three times per week, for 4 weeks, totaling 12 sessions, in a computer lab where they read and worked with the narrative and informational texts, one student per computer. During these times, the technology teacher and one of the two coteachers were present. The adults provided technical assistance and support when requested by the students. The teachers also consulted with students on determining areas of strength and needed improvement and when it was appropriate to move to a less (or more) scaffolded environment.

This was not, however, an active teaching situation. The teachers viewed the program as a potentially useful reinforcement and practice activity to be carried out in the lab; feeling the pressures of preparing for the upcoming state assessments and a very...
full curriculum, they were reluctant to spend any time outside of the scheduled lab sessions on students’ work with these texts. Therefore, whole-class discussion of the texts was limited; in addition, explicit connections between the strategies being learned in the ULE and the strategies they were teaching in their reading programs were not made. The teachers did use their computer time to informally consult with students to make relatively quick decisions regarding progress and required levels of support. On completion of the intervention, students were again given the Gates–MacGinitie Reading Achievement Test in English to obtain postreading scores.

Measures

General vocabulary knowledge.
The Gates–MacGinitie Reading Test, Vocabulary (Forms K and L), a whole-group, timed, multiple-choice English-language assessment, was administered pre- and post intervention as a test of the students’ vocabulary knowledge. These assessments each consisted of 45 short clauses using an underlined target word (e.g., “a quick reply”). The student was given four items from which a correct synonym was to be chosen. Students had 20 minutes to complete the assessment. Test–retest reliability for pre–post testing of the participating students was .88. Raw scores were used for all analyses.

General reading comprehension.
The Gates–MacGinitie Reading Test, Comprehension (Forms K and L), a whole-group, timed, multiple-choice English-language assessment, was administered pre- and post intervention as a test of the students’ reading comprehension. The assessment consisted of 14 passages followed by a series of questions, totaling 48, designed to capture main ideas and details described in a particular passage. Students had 35 minutes to complete the assessment. Test–retest reliability for pre–post testing of the participating students was .88. Raw scores were used for all analyses.

Digital feature use and student strategy and vocabulary work.
The students working with the ULE accessed the texts via the Internet. All of their responses to the various strategy and vocabulary prompts were stored in individual work logs. In addition, the event usage tracker logged all student text interactivity, including vocabulary work, strategy responses, and mouse click selections (i.e., using the strategy and vocabulary coach supports; accessing hyperlinked vocabulary items; and posting vocabulary items to My Glossary). Feature use was tracked on a text-by-text basis, summed across texts for a feature use total, and then divided by the total number of texts read to establish an average feature use variable.
Results

Table 2 displays the raw score means, standard deviations, and average percentile ranking for the Gates–MacGinitie Vocabulary and Comprehension pre- and posttests, both among the group as a whole and disaggregated by language status (ELL or EO). Repeated measures analysis of variance for pre–post vocabulary revealed that there was no significant growth from pre- to posttesting (F < 1); however, a significant difference was detected between ELL and EO students, F(1, 28) = 6.59, p < .05, with no Time × ELL interaction (F < 1). A similar trend was revealed for pre–post comprehension scores. No significant growth was registered from pre- to posttesting, F(1, 28) = 1.29, p = .27, and EO students significantly outperformed their ELL counterparts on this measure, F(1, 28) = 8.25, p < .01 with no Time × ELL interaction (F < 1).

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<tr>
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<th>Preintervention</th>
<th>Postintervention</th>
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<td>EOb</td>
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Table 2: Means and Standard Deviations for Gates-MacGinitie Pre, Pos, and Gains for Reading Vocabulary and Comprehension Assessment

Note: Results are disaggregated by language status (ELL or EO) and presented as percentile rankings. ELL = English language learner; EO = English only.

\*Represents significant differences between ELL and EO groups

The ULE digital architecture in which the texts were developed allowed us to monitor all student–text interactivity, including the viewing of hyperlinked vocabulary items, posting vocabulary items to My Glossary, and use of the various coach supports. These various mouse clicks were routed to a remote server that maintained an event usage log for each text. The records were summed across texts for a feature use total, which was then divided by the total texts read by each student to establish a feature use average. By taking an average feature use, we controlled for students who read more texts than others, who would thus have been more likely to make greater use of the available features. Table 3 details the average texts read as well as average use of the three primary features embedded in the digital environment: strategy coach use, glossary use, and posts to My Glossary.
Table 3 displays a number of characteristics pertaining to the students’ use of the digital environment. Students on average read approximately four of the eight available texts, likely due to the 4-week duration of the intervention. As a group, and disaggregated by language status, students made strongest use of the glossary feature, with lower but comparable use of the My Glossary option and the strategy coaches. No significant differences were found between the ELL and EO students’ use of these features, although ELL students showed higher average use of all features, especially glossary and coach access. Table 4 presents the correlations between these variables and sheds light on differences between ELL and EO students’ use of these features.

<table>
<thead>
<tr>
<th>Group</th>
<th>ELL</th>
<th>EO</th>
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<td>Variable</td>
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<td>Glossary posts</td>
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</table>

Table 3: Average Feature Use Throughout the Intervention

Note: Average feature use was derived by summing total feature use for each student and dividing that figure by the total amount of texts read by the student. ELL = English Language Learner; EO = English Only.

Table 4: Correlations Between Pretest English Proficiency Indicators (Gates Vocabulary and Comprehension), Gain Scores, Average Feature Use, and ELL Status

Note: ELL = English language learner.

ELLs accessed the available supports, particularly the coaches and the glossary, more often than their EO counterparts (although not significantly), an encouraging sign given the focus of the intervention. Also, on average, students who performed less well on baseline measures of English reading comprehension and vocabulary were more likely to access important comprehension and vocabulary supports. Although these correlations were weak ($r = –.12$ to $–.46$), all trended inversely such that students who performed less well on the Gates–MacGinitie reading vocabulary and reading comprehension were, on average, more likely to access these supports. A second notable trend was that accessing the embedded supports was positively associated with posttest gain in
vocabulary and comprehension. Again, these correlations were often weak, and in one case, negative ($r = -0.19$ to $-0.41$); however, a trend was clear, despite the small sample ($n = 30$). Finally, ELL status also showed weak positive correlations with feature use and gain variables ($r = 0.03$ to $0.27$).

It is helpful to characterize these correlations through selected examples of the participating students’ work. Jasmine (pseudonym) was an ELL student who accessed the hyperlinked glossary items 41 times and posted 35 words to My Glossary throughout the course of the intervention. Her glossary posts were varied and suggested surface level (definitional), contextual (personal connections), and metacognitive processes at work. See Table 5.

<table>
<thead>
<tr>
<th>Word</th>
<th>Text</th>
<th>Strategy</th>
<th>Student Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concentrated</td>
<td>Hungry Spider and Turtle</td>
<td>“I chose this word because I didn’t know what it meant so when I see it again I will look it is in my glossary”</td>
<td>Meta cognitive</td>
</tr>
<tr>
<td>Exhausted</td>
<td>Hungry Spider and Turtle</td>
<td>“when you are exhausted is when you feel tired, weak and you don’t want to do anything”</td>
<td>Surface level</td>
</tr>
<tr>
<td>Flexibility</td>
<td>About the Aztecs</td>
<td>“I choose this word because I also have a lot of flexibility because I go to karate”</td>
<td>Contextual</td>
</tr>
</tbody>
</table>

Table 5: Selected Words and Responses From the “My Glossary” of Jasmine, a Spanish Speaking ELL

On average, then, individual students who posted strong comprehension gains appear to have accessed the strategy coach with greater frequency than those with weaker comprehension gains. María (pseudonym) accessed strategy coach support 32 times throughout the course of the intervention. Her clarification strategy responses seemed particularly targeted toward trying to make sense of the various texts. She also made use of sentence starters (e.g., “A confusing part of the passage …”) that were only available by accessing strategy coaches (see Table 6).

Kathy (pseudonym) was another ELL student whose comprehension gains were impressive (28th percentile to 48th percentile). Although she accessed the strategy coaches only 11 times, she was quite active with vocabulary, checking word meanings 25 times and posting 17 words to My Glossary over the course of the intervention. This combination of reasonable strategy support alongside strong vocabulary access is readily apparent in her elaborate and varied strategy responses (see Table 7).
Table 5: Selected Words and Responses From the “My Glossary” of Jasmine, a Spanish Speaking ELL

Note: ELL = English language learner.

**Discussion and Conclusion**

In recent years, the proportion of immigrant students—particularly Latino students—in U.S. schools has increased dramatically. In 2001, Hispanics represented 14.9% of total enrollment in elementary school and 16.7% in kindergarten (Honor, 2001). Hispanic students are the largest non-English-speaking group in U.S. schools (Tabors, Páez, & López, 2003) and have the lowest attainment and achievement rates of all ethnic and racial groups in the United States (NCES, 2003). With the increased literacy demands being placed on all children, it is profoundly important that new technologies be focused on reading and writing environments that support children whose needs differ from average in the population, especially ELLs.
With this study, we began a line of inquiry into using universally designed digital narrative and informational texts to support all students, including English learning students, and their teachers, in using research-based methodologies for enhancing vocabulary and comprehension outcomes. The ULE environment appears well suited for both Spanish-speaking ELLs and struggling readers. Correlational analyses indicated that the use of comprehension-based embedded supports (e.g., the strategy coaches) was associated with pre–post comprehension gain, and that preintervention comprehension was negatively associated with strategy coach access, suggesting that less skilled readers were more likely to access those coaching supports. Indeed, analyses of individual student responses suggested that participants who made use of the embedded supports appeared to be interacting meaningfully with the texts. These qualitative views reveal students responding to the vocabulary and comprehension activities in a way suggesting the potential of this ULE to affect students’ application of cognitive strategies to improve word learning and comprehension.

We find it encouraging that the students in this study chose to take advantage of the vocabulary and strategy supports and in fact accessed supports at a higher level than previously reported in the literature, especially for struggling learners (Anderson-Inman, Horney, Chen, & Lewin, 1994; Horney & Anderson-Inman, 1999; van Daal & Reitsma, 1993). We believe a contributing factor was our intentional embedding of a meaningful purpose for accessing the supports. For example, the requirement to add a minimum of three words to My Glossary for each text read resulted in frequent clicking on vocabulary hyperlinks as students considered various words for inclusion. On average, students added 4.3 words per text, more than was required, despite the fact that adding a word to their glossary also entailed writing an explanation for why they chose that particular word. This phenomenon speaks to the issue of “pushing” and “pulling” support to students in digital environments. Requiring that at least three words per text be added to My Glossary was an example of “pushing” supports to the students. The fact that the students, on average, added more than a full word per text than was required is a prime example of students “pulling” what they apparently perceived to be an important and interesting feature in the service of their own word learning and text comprehension.

Further, students’ willingness to access the strategy coaches might have been due to the coach’s presence at the point of use (i.e., students were prompted to construct a strategy response for each screen). Students were also provided a hint, a think-aloud, and a model response (at the higher levels of scaffold) to guide them in constructing their responses. Embedded supports and help features are a characteristic of many information communication technologies (Reinking, 1988; Strangman & Dalton, 2005); thus, it will continue to be important to integrate measures of students’ use of supports in studies of student learning in these environments (Laufer, 2003). Such integration will ensure the design of more effective learning environments and better prepare students to use the various supports available in digital texts strategically and in service of their own learning goals. We believe that some supports should be “pushed” at
students, especially during the introductory stage when they are learning how to use the support system to their best advantage. However, given that choice is key to engaged learning and the development of strategic learners, we assume that the “pulling” of supports represents a type of self-scaffolding and is a necessity in customizable, digital environments.

Some limitations of this study have implications for future research in this area. The small number of participants, lack of a control group, and relatively short duration of the intervention were obvious deterrents to being able to draw causal connections between working in the ULE environment and literacy gains. Future research in this area would target larger sample sizes with randomized assignment designs and increased intervention times to verify if the patterns detected here indeed result in increased achievement for struggling and English learning readers.

Perhaps not surprisingly, implementation was challenging and highlighted the importance of teacher investment in implementing any curricular intervention. The intervention teachers’ view of the software as a stand-alone program that would provide their struggling readers opportunities to read with individualized support meant that offline instruction was limited. Although understandable, given the teachers’ pressure to prepare for upcoming state testing, this implementation was likely to curtail the effectiveness of this type of digital reading environment. In our ongoing research, we are focusing on how to provide sustained professional development and support for teachers as they implement technology-based instructional approaches. Additionally, better measures of student engagement, motivation, and self-efficacy, which are sensitive to changes over time, are needed in research intervention studies such as these. Our classroom observations and the feature-use data suggest high levels of student interest and effort in the ULE environments. However, we need studies that systematically investigate cognitive and affective processes, with diverse students reading and learning from a range of digital texts, for a variety of purposes and tasks.

A final limitation was that only English language data were gathered on students’ reading achievement. Future research with larger samples should be careful to gather bilingual students’ full complement of literacy skills, including L1 proficiency and both oral as well as reading measures. There is growing evidence that comprehension-related skills have a degree of commutability between orthographically comparable languages, such as Spanish and English (see, e.g., Proctor et al., 2006). Thus, baseline data collection on bilingual students who participate in interventions such as these will not only serve further study of cross-linguistic transfer, but also the more ethical ideal of closing the achievement gap through the promotion of improved outcomes for all learners.

Some might argue that digital support features, such as animated coaches or dramatic graphics, could function as seductive details, drawing the learners’ attention away from the core content, and thereby interfere with productive learning (Garner, 1992). Labbo’s (1996) analysis of popular interactive storybooks for young readers supports this view;
including animation and sound effects that did not contribute to understanding the story line were not facilitative of students’ comprehension, and did draw students’ attention and time away from productive learning. We need studies that systematically investigate cognitive and affective processes and outcomes over time, with diverse students reading and learning from a range of digital texts, for a variety of purposes and tasks.

One final area of future research concerns the distinctive comprehension demands of reading in informational versus narrative format (Duke, 2004). Studies of digital reading environments should seek to investigate the similarities and differences between the appropriateness and application of the various strategies modeled here in these two very different text genres. This study did not seek to answer this question, but surely students’ comprehension varied as a function of the different demands of the text genre. Future research should endeavor to determine whether traditional comprehension strategies are indeed the most effective way to promote comprehension in Web-based learning environments.

The ULE environment also has important implications from a new literacies approach to learning (Leu, Kinzer, Coiro, & Cammack, 2004). A number of researchers have indicated that technology use is perhaps one of the most important new educational frontiers for working with struggling readers and ELLs (see, e.g., Alvermann, 2002; Jiménez, 2003; Rose & Dalton, 2002; Strangman & Dalton, 2005). Giving children access to the variedways of knowing provided in digital environments may require higher level information-processing skills, synthesizing in distinct modalities (text, image, video, etc.) and within nonlinear hypertext structures, and a more fundamental experience with information presentation (tabular vs. text) and general familiarity with computer interfaces. Finally, there is the heightened strategic challenge of learning how to negotiate meaning within digital environments that offer varied types and levels of support. Guided by a UDL instructional framework (Rose & Meyer, 2002) and our previous research on universal literacy environments (Dalton et al., 2002; Strangman & Dalton, 2005), we revised our ULE prototype to more strongly address the vocabulary needs of ELLs and struggling readers. This study, although limited in scope, suggests the value of scaffolded digital literacy environments and highlights the need for continued research and development in the service of improving literacy and learning outcomes for all students.

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References


Scaffolding English Language Learners and Struggling Readers in a Universal Literacy Environment With Embedded Strategy Instruction and Vocabulary Support


