

Investigating Methods of Kindergarten Vocabulary Instruction: Which Methods Work Best?

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ABSTRACT FOR OUTSTANDING STUDENT RESEARCH AWARD WINNER

Early vocabulary knowledge provides an important foundation for children's reading development (National Institute of Child Health and Human Development [NICHD], 2000; Snow, Burns, & Griffin, 1998). Thus, the many children who enter school with limited vocabulary knowledge may be at risk for experiencing later difficulty in reading. In order to provide support for the language and literacy development of young children, researchers and educators must focus on identifying the most effective ways to build children's word knowledge.

Currently, in standard practice, teachers usually comment only cursorily on potentially unknown vocabulary words during storybook reading. When teachers do stop to discuss words with students, they typically just relate words to children's background knowledge or personal experiences. Researchers McKeown and Beck (2004) suggest that this kind of vocabulary instruction is not the most effective way to build children's vocabulary. These researchers advocate a method of instruction that is more direct and analytic, and they suggest that this method has much greater potential for teaching children words.

Beck, McKeown, and Kucan (2002) recommend that teachers engage children in such activities as comparing and contrasting words and evaluating word appropriateness in contexts other than the storybook. Other researchers (Juel & Deffes, 2004; Juel C., Biancarosa, G., Coker, D., & Deffes, R., 2002) have suggested that augmenting direct and analytic vocabulary instruction with attention to the letters and sounds of words may be even more effective than this kind of instruction alone. The objective of the study described here was to provide evidence about which methods of kindergarten vocabulary instruction are most effective. The study compared three methods of instruction during storybook reading: one based on standard practice typically seen in elementary classrooms ("Standard Practice Instruction"), one that attempted to replicate the more direct and analytic methods supported by Beck, McKeown, and Kucan (2002) ("Analytic Instruction"), and one that augmented this more direct and analytic method by anchoring instruction of vocabulary with attention to the letters and sounds in words ("Anchored Instruction").

The study consisted of a six-week read-aloud intervention in six kindergarten classrooms. The main research question guiding this study was the following: Are "Analytic" and "Anchored" vocabulary instruction methods more effective than "Standard Practice" instruction at promoting children's word learning? The study was conducted in a northeastern public school district located in a major metropolitan area. A total of 96 kindergarteners participated in the study. The sample of kindergarteners was demographically diverse: about a third of the sample received free or

reduced lunch and nearly half of the sample was English language learners (ELL). Classrooms were assigned to one of the three instructional conditions. In each classroom, the intervention took place for 30 minutes a day, three days a week, for six weeks. The same six books were used and the same five words per book were targeted in all conditions.

In the Standard Practice condition, teachers discussed target words in a way that mirrors the kind of vocabulary instruction typically seen in kindergarten read-alouds. Teachers asked children about whether the story reminded them of something in their own lives and guided children to talk about the target words in the context of the story. As in the Standard Practice condition, teachers in the Analytic Instruction condition asked questions to help children think about the words in the context of the story and connect their experiences to the words in the story. Also, teachers guided students through activities which required them to think analytically about the meaning of the words in different contexts and in relation to other words. Teachers in the Anchored Instruction condition had children talk about words in relation to the story they were reading (as in the Standard Practice condition). Teachers engaged children in activities that had them actively analyze word meanings in various contexts (as in Analytic Instruction condition). Additionally, in the Anchored condition, teachers had children focus on the letters and sounds in the target words. To keep the intervention to 30 minutes per day in each of the conditions, less time was spent on discussion of the storybook in the Analytic and Anchored conditions than in the Standard Practice condition, and less time was spent on Analytic activities in the Anchored condition than in the Analytic condition.

Two classrooms were randomly assigned to each condition. Classroom teachers carried out instruction according to scripted curriculum for their condition. Instruction was observed and videotaped to document fidelity to the curriculum. Teachers demonstrated high fidelity to the curriculum. To control for children's general vocabulary knowledge and literacy, the Test of Oral Language (TOLD P:3) (Newcomer & Hammill, 1997) and the Dynamic Indicators of Basic Literacy Skills [DIBELS] letter fluency subtest (Good & Kaminski, 2002) were administered to the participants prior to the intervention. A researcher-designed vocabulary assessment, modeled on the TOLD P:3, was administered pre- and post-intervention to evaluate children's knowledge of the words taught in the intervention.

Analysis of Covariance (ANCOVA) revealed that, on average, the Analytic and the Anchored conditions enabled children to learn the words in the curriculum more effectively than the Standard Practice condition, regardless of the general vocabulary knowledge, letter-naming fluency, and background characteristics of the children. The effect sizes of the Analytic and Anchored conditions over the Standard Practice condition were greater than 1.0. The effect of the Analytic and Anchored conditions did not differ significantly.

The findings of this study lend support to the call of researchers such as McKeown and Beck (2004) for more direct and analytic vocabulary instruction in the early elementary grades. In this study, Analytic and Anchored instruction were equally effective. These findings suggest that incorporating a focus on the letters and sounds of words into analytic vocabulary instruction may not interfere with children's word learning. In fact, children may be able to simultaneously learn

word meanings and the letters and sounds in the words. Further research investigating this possibility is needed.

Most teachers use storybook reading primarily to provide children with time to talk about stories and how their experiences relate to those stories. Given that research has shown that such conversations between adults and children can foster children's language skills, it is likely that standard practice does encourage children's language development (Bruner, 1978; Snow, 1983). The findings from this study suggest, though, that having children actively analyze words and their meanings is a more effective way to teach children words than discussion-based instruction alone during storybook reading time. Also, the findings of this study suggest the possibility that instruction targeting decoding skill and instruction focusing on word meanings can be delivered simultaneously. Thus, teachers may be able to use instructional time to meet multiple instructional objectives for children's early language and literacy learning.

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Speaking Literacy and Learning to Technology, Speaking Technology to Literacy and Learning¹

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As we prepare this review of research for publication in the *National Reading Conference Yearbook*, two billion Instant Messages are being sent daily, 92% of public school classrooms in the U.S. have access to the Internet, the U.S. College Board is introducing a test of technological literacy, Wikipedia, a free-content encyclopedia, is available in 57 languages, and the University of Michigan has negotiated with Google to digitize its seven million volume collection to be accessed via the Internet by anyone the world over. In short, one needn't look far to find examples of the continual reshaping of literacy by virtue of technologies. In fact, the evolution of literacy is a series of sociotechnical changes; from papyrus, to paper, to printing press, to electronic spaces, technologies have influenced how we use and make meaning with text.

To set the stage for this review, consider for a moment the multiple forms of literacy that are required to interpret and learn from a typical website. Upon first entering the site, the user must immediately interpret navigational cues and chart a path that will support knowledge building with the site. Frequently, the user can select from among several media links, simultaneously listening to and reading information, and activating simulations that also must be interpreted. The user must decode meaning-bearing icons. Mouse-overs may cause an image to pop up; that image may, in turn, expand to provide additional information. Graphs and diagrams may be called up and manipulated to address specific questions. All of this information must be coordinated, integrated, and evaluated for its credibility and relevance to the questions guiding the user. Color cues signaling glossary terms and links must be decoded. In addition, the user may have the option of participating in a forum discussion or forwarding the site to a fellow learner. The user is at once both reader and author, both consumer and generator of knowledge, engaging in both an individual and collective enterprise.

We chose to explore the intersection of literacy, learning, and technology, crafting our review as a travelogue. Our purpose was to transport the audience through various landscapes, resting at particular sites, and offering what John Urry (2002) has called the *tourist gaze*, that is, a socially organized and systematized way of looking on a set of different scenes or landscapes. Furthermore,

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we invited a number of scholars who have helped shape this terrain to join us in this travelogue. Although their ideas were presented via audio and video recordings in the conference presentation of this review, they will appear as edited quotations in this written document.

We delimited our search of *technology* to digital texts, that is, to “texts in digital forms displayed electronically on dynamically alterable surfaces such as computer screens” (Reinking, 1998, p. xx-xxi). We appropriated Jim Gee’s definition of *learning*:

For me there are two different ways to learn anything. One is a verbal way, to learn it in terms of words, where you know about the word, or just other words, something like a definition. But a second form of learning—a much deeper form of learning—is to learn concepts of words ...where you can see the world in terms of how that word would apply to the world either to engage in action or engage in dialogue with other people. That form of understanding is far deeper than just knowing the meaning of words. If you know the meanings of words verbally, just in terms of other words...you can pass a test on them, but you can’t necessarily engage in action or dialogue with them. What we are after in schooling is surely situated understanding. So now the question becomes: How do you learn situated understanding of words? What is learning if what you are after is situated understanding? Well, the way that you learn situated understanding is by engaging in body and mind in the activities in which social groups engage. You affiliate with people in terms of their values, in terms of identity, how they look at the work they do; you learn to see the world the way they see it and that teaches you how to use the words that the group uses in their distinct ways (James Gee, personal communication, November 2004).

Delimiting our definition of *literacy* was somewhat more problematic. As Jay Lemke (1998) noted, “Literacies are legion. Each one consists of a set of interdependent social practices that link people, media objects, and strategies for meaning making” (p. 283). As we sought to define the terrain so that it would be manageable, we encountered the admonitions of literacy colleagues who kept pushing open the boundaries of literacy. For example, Margaret Hagood (2003) has argued that “notions of reading and text defined broadly must become an underlying premise rather than one for which we must continually argue” (p. 390). In addition, we were mindful of a burgeoning perspective called *new literacies*: “The new literacies of the Internet and other ICTs [information and communication technologies] include the skills, strategies, and dispositions necessary to successfully use and adapt to the rapidly changing information and communication technologies and contexts that continuously emerge in our world and influence all areas of our personal and professional lives. These new literacies allow us to use the Internet and other ICTs to identify important questions, locate information, critically evaluate the usefulness of that information, synthesize information to answer these questions, and then communicate the answers to others” (Leu, Kinzer, Coiro, & Cammack, 2004, p. 1572). Finally, we were mindful of Chuck Kinzer’s reflections:

In a sense, I’m not sure the term *becoming literate* is useful to us in our new, electronic and ever changing environment. Becoming literate is something that has been around actually for quite awhile, when we take a look at things such as emergent literacy and the understanding that vocabulary develops and continues to develop over time and that literacy in general changes and adapts as we go

through our lives and experience more types of literate behaviors. What I've been trying to wrestle with is the notion of *adaptive literacy*, modeled somewhat on the notion of adaptive expertise. If we think about becoming literate, that almost implies or presupposes that one can *become* literate - that there *is* a literacy standard or goal and eventually we will do things that will allow us to reach it or become it. I think the notion of *adaptivity* is actually very valuable. As new technologies evolve, we adapt the abilities and skills and literate knowledge that are needed for particular tasks and activity. But adaptive literacy also implies that we will need to adapt our literacy practices in terms of learning new ones. So, as technologies evolve, we need to adapt our behaviors in terms of learning new literacy skills, and those kinds of learnings continue to evolve. So this notion that literacy is a fixed point in time, and we become literate over time, is, in my mind, a little less productive than this notion of an adaptive set of skills and strategies, adaptive both in terms of what we do with them and also adaptive in terms of their changing nature (Charles Kinzer, personal communication, November 2004).

We delimited our review to research on technology in the teaching and use of literacy to advance the acquisition and development of knowledge about oneself and the world. We did not include in our review studies that focused solely on the acquisition of reading, writing, and oral language; nor did we review studies that focused on the acquisition of computer, Internet, or media skills. Our focus was on the application of these kinds of skills to the advancement of learning.

Method of Conducting Review

To conduct this review, we began with a close survey of the four primary literacy journals, *Journal of Literacy Research*, *Reading Research Quarterly*, *Written Communication*, and *Research on the Teaching of English*, essentially replicating the review that Kamil and Lane (1998) reported when they surveyed these journals from 1990-1995 and found that only 2.7% percent of the research articles published in these journals during that time addressed technology. As Figure 1 suggests, there has been only a slight increase, to 5.2%, in technology-related research articles published in these journals during the last eight years.

In addition to our search of these literacy journals, we conducted hand searches of *Cognition and Instruction* and the *Journal of the Learning Sciences* for the past five years. When we searched by topic, we surveyed the following: intelligent tutoring systems, hypermedia, assistive technology, and adaptive hypermedia systems. These topics took us to journals in computer science and information and computer technology. In addition, we consulted a number of recent handbooks. Finally, recognizing, as others have, that some of the most exciting work at the intersection of literacy, learning, and technology is being championed and conducted by teachers rather than researchers, we also attended to those venues that feature the work of teachers, such as *Reading Online's* "Teacher Voices" series, www.readingonline.org.

The scheme we chose to report our findings was to organize the research according to the purposes of the inquiry. Specifically, *ethnographic studies* have been conducted, in and out of school, for the primary purpose of capturing how technology shapes contexts, activity, and users and how users shape technology, context, and activity. *Psychological studies* have principally informed our

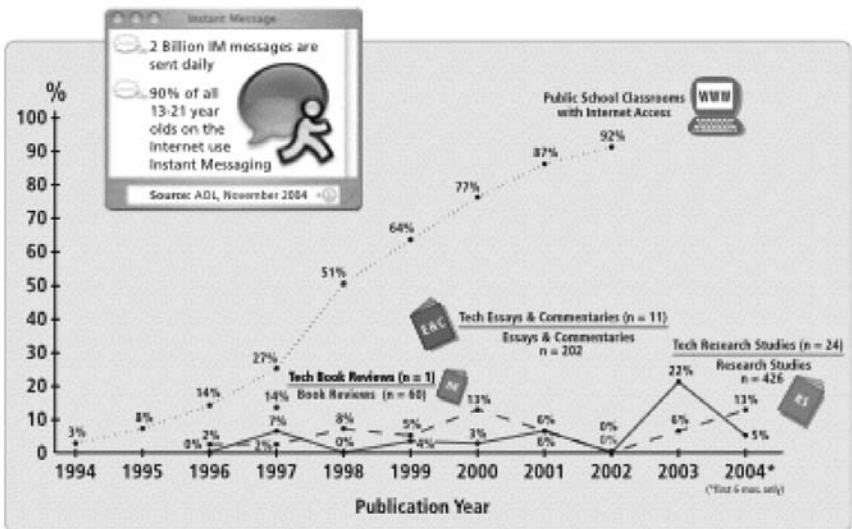
understanding of how we learn with these new technologies. Finally, *intervention studies* have focused on changing the nature of the learner or the learning context and employing technology to achieve particular outcomes. Rather than attempt a global review of the studies that fell into these categories, we concentrated on a select number to identify general issues at the intersection of learning, literacy, and technology.

Ethnographic Studies: Capturing the Interactions Among Technology, Contexts, Activity, and Users

Ethnographic studies have played a key role in illuminating what is occurring at the intersection of literacy, learning, and technology. Their value is particularly salient when they are viewed synergistically. For example, Michele Knoebel reporting on her inquiry of students' out-of-school literacy activities observed:

My commitment to sociocultural theories means that I'm not so much interested in looking at the effects of technology on young peoples' literacy proficiency at school, but rather, I'm much more interested in looking at what young people do when they're using new technologies, how their ways of being are tied to particular kinds of social purposes and are embedded within and woven into networks of social relationships. Some of the research I was doing in the 1990s took me into classrooms. What I noticed about most of the classrooms that we went into was that the computers they were using were usually equipped with scaled down child-friendly sorts of software. But when I went into the homes of the students I was studying, I noticed that they were all using full-scale adult

Figure 1 Percentages of technology-related articles, essays, and book reviews published in the last 10 years, percentage of U.S. classrooms with Internet access, and number of Instant Messages sent daily in 2004.



versions of software without any trouble at all. I remember one young man named Jacques who had had a long painful history of failure at school. He wasn't all that interested in using the computers at school, but he'd had access to some very powerful computer programs associated with business. And at home, he used the computer to produce a very proficient file with his mother and brother and very quickly established a thriving ongoing business. And it's cases like Jacques' that really underscore the importance of paying attention to how young people are using new technology in their lives in order to better understand some of the implications of these uses, and purposes, and practices for literacy education (Michelle Knoebel, personal communication, November 2004).

Kevin Leander has similarly documented the sophisticated skills, motivation, and persistence of adolescents as they engage in new literacies, crossing borders between out-of-school and in-school contexts. Literacy educators wrestle to identify the appropriate integration of popular culture into school literacy learning.

Donna Alverman (personal communication, November 2004) challenges her students to think about this integration by asking them: "If your principal interprets the new state standards in Georgia to mean that you must include media literacy in the curriculum, how would you attempt to bridge between your students' media readings of the latest TV reality shows and your own goals that you have for literacy learning in your own classroom?" In response, one of her students connects the TV reality show, *I'd Do Anything*, in which contestants take on unusual challenges in order to win a prize for someone they love, with Chris Crutcher's sports novels that explore self-sacrifice in caring relationships.

Ethnographic studies in school settings yield a mixed picture. Research reported by Wallace, Kupperman, Krajcik, and Soloway (2000) explored sixth grade students' activity on the web as they engaged in information-seeking within a unit of science study. Their results, which were consistent with those reported by Maya Eagleton and her colleagues in their study of Internet inquiry (Eagleton, Guinee, & Langlais, 2003), painted a rather bleak picture of students' use of technology to advance learning. Using audio and video records of online activity, Wallace and her colleagues found that their participants demonstrated low engagement with the subject matter, poor search and navigation strategies, and a tendency to reduce the task to that of searching for the keywords that yielded the smallest number of hits regarding their topic.

This is a striking contrast with the portrait painted in the inquiry conducted by Kinzer and Leu (1997) whose second grade participants revealed sophisticated understanding and use of the Internet and an array of technological tools (such as PowerPoint) in the conduct of research on topics in the social studies.

Finally, Labbo (2005), in collaboration with pre-school and kindergarten teachers, explored children's reading, viewing, designing, production, and publication of multimedia in the familiar context of engaging in language experience approaches to literacy instruction that are enhanced with the addition of digital technologies. She documented the ways in which the affordances of the technologies were changing the teaching and learning experience, for example, enabling multiple representations of one's ideas and facilitating revision of these presentations (see Figure 2), with improved language outcomes for children.

In summary, ethnographic research at the intersection of literacy, learning, and technology has revealed a complex and nuanced picture. Clearly, there is exciting potential at this intersection for both revealing and supporting learners' competence with literacy learning and use via information and communication technologies. On the other hand, there is work to be done to ascertain how the knowledge and dispositions that students reveal in out-of-school settings can be more purposely incorporated to advance literacy learning more generally and in school settings, in particular.

Psychological Studies: Informing Our Understanding of How People Learn with New Technologies

The preponderance of research informing our understanding of text comprehension has been conducted with traditional print text. There have been numerous and vivid attempts to capture the differences between traditional (print) text, multimedia, and electronic media and the implications of these differences for defining and studying literacy, broadly writ. Typically, while print literacy is described as linear, ordered, sequential, hierarchical, and logical, hypertext is characterized as fluid, spatial, decentered, bottom up, and playful (Burbulus, 2001; Ryan, 1999).

As Hegarty, Narayanan, and Freitas (2002) have noted, there is a tantalizing spectrum of choices that authors might make relative to the design of hypermedia presentations but few empirically validated guidelines for choosing among these capabilities. One might, for example, ask: Are diagrammatic presentations better than sentential representations? Are three-dimensional

Figure 2 Example of a child's multimedia representation in response to a language experience lesson.

D-LEA: Elicits Richer & More Complex Language than LEA





*We took a picture of me. I wanted to
Be a clown. I made myself a clown
With paint on the computer. Clown
Starts with C. "Tonehsa is a Clown
Today." said Tonesha*

representations better than two-dimensional? Are animated representations better than static? Are interactive better than non-interactive? In this section, we present a summary of the research conducted by Hegarty and her colleagues for the purpose of highlighting the model of inquiry in which they engage as well as reporting the findings of their work. We then proceed to summarize design principles derived from a complementary program of research conducted by Mayer.

Hegarty and her colleagues (Hansen, Schrimpscher, Narayanan, & Hegarty, 1998; Hegarty et al., 2002; Kozhenikov, Hegarty, & Mayer, 2002) have argued that because new media are studied in contexts using novel methods of instruction (e.g., discovery, collaborative learning, inquiry) and then are compared to traditional media in traditional contexts, there is a confounding. The overarching question guiding their program of research is whether multimedia presentations, including animations, commentaries, and hyperlinks, lead to different learning outcomes, when compared to traditional printed media, when both contain the same information and are designed according to empirically validated guidelines.

In a typical study conducted by this research group, the content would be a complex system, such as a mechanical system (e.g., a flushing cistern). They begin their research by studying the potential sources of comprehension problems learners might encounter specific to the content under study. This research informs the design of content hypothesized to ameliorate these difficulties. This content is then presented using different formats. Their participants are typically undergraduate students. Learning is assessed with an array of measures including: *mental animation questions* (i.e., asking students to predict how the motion of one component of a system will influence another), *function questions* (e.g., “what is the function of the float and float arm?”), *“fault-behavior” questions* asking how the system would behave were there to be a breakdown in one part of the system, and *“trouble-shooting” questions* that asks the learner to diagnose all possible problems with the system, given a set of symptoms. In one experiment (Hegarty, Quilici, Narayanan, Holmquist, & Moreno, 1999), the researchers compared the learning of students assigned to one of three conditions: a hypermedia manual (complete with hyperlinks and animations), and two text conditions.

They found no learning differences among the three groups, even though participants in the hypermedia group spent more time interacting with the content than did the groups in the text conditions. The researchers proposed that the additional information presented via the hypertext was possibly superfluous given the fact that a toilet tank is a common household item with which the participants were already sufficiently familiar. In a second experiment, they compared the effects of constraining the learner’s use of the hypermedia manual with a condition in which the learner could navigate freely. While participants who viewed the navigation-restricted version spent more time in the system than did those in the free-navigation condition, the type of presentation did not affect performance on any of the four types of comprehension assessments. The authors cautioned that this was a limited test of navigational freedom due to the fact that the total number of sections to be navigated was relatively small (seven). In a third set of experiments, the authors queried the effects of (a) viewing a static diagram, (b) engaging in a mental animation (in which the learners studied the static diagram but then attempted to explain to the experimenter how it

worked), (c) following the viewing of a static version with an animation of the system, accompanied by a verbal commentary, or (d) a condition that combined (b) and (c). The results indicated that viewing the animation and hearing the commentary significantly enhanced performance on the outcome measures. Furthermore, attempting to animate the machine mentally before viewing the animation enhanced the ability to describe how a machine works. What is the import of this research? Although some of their work does show that computer animation can facilitate learning, on the whole these studies suggest that merely translating information from a traditional print medium to a hypermedia system does not affect comprehension and learning when the content is held constant.

A second program of research addressing multimedia learning has been conducted by Richard Mayer and his colleagues and is summarized in Mayer (2001). This program of research has yielded seven principles regarding the effective integration of words and pictures: (a) Multimedia Principle—Students learn better from words and pictures than from words alone, (b) Spatial Contiguity Principle—Students learn better when corresponding words and pictures are presented near rather than far from each other on the page or screen, (c) Temporal Contiguity Principle—Students learn better when corresponding words and pictures are presented simultaneously rather than successively, (d) Coherence Principle—Students learn better when extraneous material is excluded rather than included, (e) Modality Principle—Students learn better when an animation is accompanied by spoken rather than printed text, (f) Redundancy Principle—Students learn better from an animation accompanied with spoken text rather than an

Figure 3 Screenshot illustrating embedded comprehension strategy supports (Palincsar et al., 2004).

The screenshot displays the CAST Folktales website interface for the story "How Coyote Stole Fire". The page features a navigation bar with links for "home", "my options", "glossary", "worklog", "resources", and "strategy help", along with a page indicator "7 of 7".

On the left side, there is a sidebar with a "Close" button and a strategy prompt: "Look at the highlighted words in the text to help you identify the key information, then summarize the passage. Self check and revise if needed." Below this are buttons for "AI's Strategy" and "Genie's Hint", and a text input area labeled "Type your response below:". At the bottom of the sidebar is a "Self Check" section with two questions: "Does this summary Tell what is important?" and "Have the right amount of detail?", each with "no" and "yes" radio button options.

The main content area is divided into three columns. The left column contains a black and white illustration of a large evergreen tree with a smaller tree in front of it. The middle column contains the text of the story, with several words highlighted in yellow: "convince", "Clever", "ignored", "hanging", "gave up", and "defeated". The right column contains a black and white illustration of two women sitting on a bench, with a small child sitting between them. Below the illustration is a small "d" icon.

At the bottom right of the page, there is a circular icon and the text: "This is a good place to stop and think about the story."

animation accompanied with spoken text and printed text, and (g) Individual Differences Principle—Differences in students' domain knowledge and spatial ability interact with the effectiveness of design elements.

Although research conducted in the psychological tradition has been very useful to raising questions about the processes in which learners engage when using new literacies and learning from multimedia, there is an important caveat regarding this research. Nearly all of the research done from a psychological perspective examining learning from hypermedia and multimedia has been conducted with university learners. We and our colleagues have been engaged in experimental studies in which we are investigating the learning processes and outcomes as fifth-grade students learn about light and vision from identical prose and diagrams in one of three digital environments. The design of these environments has been informed by descriptive research in which we investigated the interactions of struggling and typical readers as they learned from digitized narrative and informational text (Palincsar, Dalton, Magnusson, DeFrance, Proctor, Hapgood, Khasnabis, 2004). In one condition, students have access to text-to-speech and an online glossary. In a second condition, students are able to animate the diagram and are instructed in how to conduct an investigation using the diagram. In addition, they are supported in examining the relationship between the information presented in the prose and the diagram. In the third condition, students have the support of a coach as they engage in their inquiry with the prose and interactive diagram (see Figure 3).

In this study, we are interested in identifying the skills and strategies that students employ in this type of environment, the paths they create, the role that the interactive graphics and text play in their learning, the patterns of use as a function of such learner characteristics as literacy and language abilities and modality preferences. This research is bridge building from psychological to intervention research, to which we turn next.

Intervention Studies: Changing the Nature of the Learner, Text, Learning Context, and Learning Outcomes

Innovation often occurs in the margins, where dramatic gaps exist between desired outcomes and prevailing practices (Rose & Meyer, 2002). Accordingly, there is a strong line of research investigating the role of hypertext and digital reading environments for struggling readers. Within the special education community in particular, there is a commitment to using the power of technology to ensure that all children have access to the general education curriculum and, more importantly, that they go beyond access to meaningful participation and progress. A conceptual framework that has been helpful in guiding this work is Universal Design for Learning developed by David Rose and Anne Meyer (2002) among others.

Universal Design for Learning was originally stimulated by the universal design movement in architecture and environmental design. Ron Mace (1998), an architect with physical disabilities, introduced what was then a revolutionary idea but is now accepted in schools of architecture and design around the world. He argued that we should design from a universal perspective, that is, considering the needs of the broadest range of users from the beginning of the design process,

rather than building and then retrofitting for those individuals for whom the usual ways of accessing and navigating spaces did not work, a practice all too prevalent in education where we retrofit curricula to meet the needs of individual students. So, now we all enjoy the fruits of universal design in our daily lives as we use curb cuts, view television captions, and listen to audio-taped books.

Just as a staircase represents a barrier for an individual with a physical disability, print, a one-size-fits-all technology, represents a barrier, rather than a gateway, to learning for many struggling learners. In the following quotation, Rose expands on the transformative capacities of digital text and media and speaks to an important change in national policy and the educational publishing landscape:

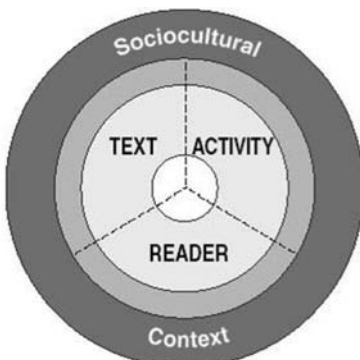
The new technologies for literacies have a number of advantages. First, we are able to represent the text itself in very flexible ways that were not possible in print. Taking advantage of that flexibility means that we can have words talk themselves aloud for students who are blind or seriously struggling, in very individualized ways. We can make the text be whatever size a child needs. We can have the semantics of vocabulary link easily to its meaning. Even more importantly, the text now can be deeply structured with components shown to one child and not to another. We can individually support kids in becoming strategic readers, building in coaches and ways of providing students individualized feedback. The advantages of these wonderful, flexible, embedded texts have become apparent to a broad set of policy makers and educators, ushering in changes that are on the horizon. For example, the National Instructional Material Accessibility Standards stipulate to publishers that digital versions of traditional texts must be provided to states and school districts. We look to researchers in reading and literacy to help identify the features that need to be built into text to enable every student to comprehend and learn from text (David Rose, personal communication, November 2004).

How do we design optimal learning environments and tools that are responsive to the tremendous variation in learners, teachers and instructional contexts, goals and purposes, and

texts? One way to approach the design of supported reading environments is to consider the various factors that contribute to any particular comprehension event. Consider the heuristic of reading comprehension, developed by the RAND Reading Study Group (2002) (see Figure 4).

In a digital environment, the relationship of these components and their contributions to a particular instance of comprehension can change dynamically. For example, students with decoding or fluency difficulties can use

Figure 4 A heuristic for thinking about reading comprehension (RAND Reading Study Group, 2002)



text-to-speech to gain access to the text, potentially freeing up cognitive capacity for meaning construction. An English language learner might use hyperlinked glossary terms and background knowledge links to help her read with understanding. The teacher can offload some coaching and guided practice through the use of computer avatar coaches who provide models and feedback. The notion of readability and what makes a text difficult or easy is essentially stood on its head in digital environments (McKenna, Reinking, Labbo, & Kieffer, 1999; Reinking, 1988).

From a universal design perspective, there are multiple ways to scaffold the learner such as, for example, providing access to the content, supporting strategic learning, enhancing engagement, and building self-awareness and efficacy. Most of the researcher-designed digital environments designed to improve comprehension provide multiple supports, combining representational supports (e.g., images and animated graphics to support prose vocabulary definitions, background knowledge links, graphic organizer overviews, or main idea statements), with supports for strategic learning (self-monitoring questions, note-taking tools, strategy coach-avatars) (Anderson-Inman & Horney, 1999; Boone & Higgins, 1992, 1993; Dalton et al, 2002; Reinking & Schreiner, 1985; Reinking, 1988). Figure 5 shows an example of a digital reading environment offering a range of supports.

Turning to the findings from research regarding these supportive environments, several researchers have investigated the potential of speech feedback, either through text-to-speech (TTS) or recorded digital speech, to support struggling readers' comprehension. The hypothesis is that

Figure 5 Screenshot illustrating embedded comprehension strategy supports (Dalton & Palincsar, 2005).

The screenshot displays a web browser window with the title "How Do We See?". The browser's address bar shows "Page 3" and navigation buttons for "Compare Pages", "Glossary", "Worklog", and "Logout". The main content area contains text explaining how light enters the eye through the pupil and strikes the retina. A diagram labeled "Figure 3. Light going into the eye through the pupil." shows a cross-section of an eye with light rays from a "light source" entering through the "pupil" and hitting the "retina". The "optic nerve" is also labeled. Below the diagram is a "Reset" button. To the left of the diagram, there is a "Directions to Investigate" box with two bullet points: "To show light and see the direction it will travel, click a light source. Predict whether the light will enter the eyeball." and "To see where the light goes, click a light source again." Below this is an "Investigate This" section with two questions: "1. What did you observe?" and "2. What did you learn?". A text input field contains the answer: "I observed that light ray 5 bounced off the eyeball." There are "Record" and "Save to Worklog" buttons next to the input field.

providing students more fluent access to the text will free up capacity for constructing meaning, thereby improving comprehension. Some have assessed students' comprehension within the supported text environment (Elkind, Cohen, & Murray, 1993; Lundberg & Oloffson, 1993), whereas others have also assessed transfer to comprehension of printed text (Aist & Mostow, 1997; Elbro, Rasmussen, & Spelling, 1996). If one looks across studies, TTS does not appear to influence comprehension. However, because it is possible to design digital environments that are responsive to individual differences, we can ask for whom do these environments work, and under what conditions? For example, positive results have been found in studies involving older students who were struggling readers (Lundberg & Olofsson, 1993) and who were using TTS to read digital texts over a sustained period of time, such as a class semester (Elkind et al, 1993).

Examining the outcomes of embedded learning supports designed to improve comprehension (for a review, see Dalton & Strangman, in press), we generally find that although there are positive effects on comprehension within the supported environment, some of which, in fact, transfer to improvement with print, the findings are mediated by a number of contextual variables such as the teacher's views on literacy and experience with technology integration, and the level of technology access for learners. Outcomes also vary in relation to student characteristics, highlighting the need for a more comprehensive model of reading and of the learner to guide the design of customized learning environments. Furthermore, given that ICTs (information and communication technologies) and new literacies represent a moving horizon, one that may always be somewhat in advance of our current school literacy practices, two key issues arise: (a) that of learner control, that is, how much support is pushed at the learner versus controlled by the learner; and, (b) how actively do we work to ensure near and far transfer to other digital environments and to print, a technology that will remain an important literacy in our society.

Before leaving the interventions portion of our review, we consider briefly a long-standing instructional project that has been under development for many years, with each generation of the research contributing important innovations: Computer Supported Intentional Learning Environment (CSILE), now referred to as Knowledge Forum (KF), designed and investigated by Marlene Scardamalia, Carl Bereiter, and their colleagues (Scardamalia, Bereiter, & Lamon, 1994). Underlying the design of this environment is the tenet captured in the following quote from Scardamalia (2004):

Historically, learning has been an adequate objective for education because knowledge has not been thought of as growing, but rather in danger of being lost...the information revolution spells unprecedented growth in information ... and requires staying up to date as a prerequisite to contributing in your own right to the cultural wealth of society. Preparing students for knowledge generation represents a radically different challenge for education (p. 191).

Consistent with this perspective on learning, KF is designed as a multi-media community knowledge space in which students are supported by an array of tools designed to promote knowledge building. These tools include (a) annotation, citation, and reference links; (b) interconnected views through interlinking; (c) author assigned indices (e.g., keywords, titles, problem fields); (d) automatically assigned indices (e.g., author, date, semantic field); (e)

knowledge scaffolding processes supporting theory refinement and constructive criticism; and (f) “rise above” notes presenting new ideas that represent an advance over previous ideas. Scardamalia and Bereiter are careful to note that the KF is not a collection of tools, but rather is an environment specifically designed to support inquiry, information searches, and creative work. The reader is referred to Scardamalia (2004) for an illustration of how KF represents an open environment, without predetermined boundaries or structures around ideas or activities, that, with the participation of contributors with diverse expertise, supports the emergence and refinement of big ideas.

Research on CSILE/KF has revealed significant, positive, differences on standardized tests of achievement, measures of depth-of-explanation for particular phenomena (such as extinction), graphical knowledge representation, beliefs about learning, depth of inquiry, and collaboration. While Knowledge Forum has been shown to be very successful at supporting many dimensions of literacy learning and knowledge building, it is also worth noting that not all implementations of CSILE/KF are equally effective; without careful monitoring and mediation by teachers, time spent in this environment can yield shallow learning (Lipponen, Rahikainen, Hakkarainen, & Palonen, 2002).

Teacher Research

While serving as co-editors of *Reading Online*, Dalton and Grisham recruited Michael Milone and Nicole Strangman to write an interview series featuring teachers who have developed outstanding projects integrating technology and literacy. These articles provide a window into the kind of innovative and impressive projects taking place in classrooms, using a variety of ICTs and situated in diverse learning contexts. In this section of the review, we share two of these projects in order to highlight a few emergent themes in new literacies in the classroom. The first project, entitled “A Digital Journey to Altoona’s Past” (Strangman, 2002) is a collaborative project between Irene Huschak, a high school multimedia teacher in Altoona, PA, and high school English and computer science students. Together, they developed a collection of historically-based, interactive stories about their home town, with the reader actually being incorporated into each story as a character. The English students researched and wrote the stories and the computer science students developed the illustrations and web pages to bring them to life.

The second, and quite unique, project is called “The Many Faces of Alice” (Strangman, 2003). This project is the work of New York teacher Monica Edinger and her 4th graders. Every year, Ms. Edinger and her students study the book *Alice in Wonderland*, which is then showcased on a website. Ms. Edinger turns conventional literature study on its head: whereas most classrooms focus on printed text, with students reading the printed text and responding largely through writing, in Ms. Edinger’s classroom, learning takes place in several modalities, with much less emphasis on the printed word. Ms. Edinger reads the book aloud, providing students with her own annotations, and a major focus is studying and responding to the book’s illustrations. The unit culminates in a student-produced, Toy Theater production of the book that is digitally recorded and put on the Web.

As we conclude our review, we turn to identifying potential agendas that literacy researchers might productively pursue at the intersection of literacy, learning, and technology, as well as some of the design/methodological and theoretical issues germane to these agendas.

Possible Agendas to Guide the Scholarship of Literacy Researchers

We hope that this brief review has communicated the enormous richness of the terrain that is at the intersection of literacy, learning, and technology. Indeed, we hope the reader has come to share our amazement that so little attention is being paid to this area of inquiry, at least as reflected by the attention it is receiving in our professional journals. As we thought about directions this research might take, we had a few nominations we wished to make. The time is ripe for “border crossing,” in which researchers, for example, apply the findings from the kinds of ethnographic research we reported to the design of intervention research. As another illustration, psychological research might productively be conducted investigating the process and outcomes of engaging in interventions that employ technology to advance literacy acquisition/development and learning.

In addition to studies that examine the application of technology for the purpose of specifically advancing computer and media literacy, it would also be worthwhile to investigate how computer and media literacy follow from engagement in learning for deep understanding and knowledge generation. It would be helpful to complement the decontextualized study of learning from hypertext/hypermedia with the study of real-world learning. Finally, there is significant research to be done identifying how technology can support diverse learners, such as students acquiring English as a second language, students with sensory impairments, and students with cognitive challenges, so that advanced knowledge building is the work of all students.

Methodological and Theoretical Issues

In terms of design and methodological issues, the time seems ripe for applying methods such as multi-dimensional scaling and small space analysis for the purpose of examining patterns of relationships among individuals, technologies, and learning environments. As Lemke (1999) has argued, we need to shift from a fixation upon technological tools to mapping the ecosocial systems of their use.

Drawing upon a methodological tradition that has received considerable attention in some areas of educational research such as science education, literacy researchers might explore the use of design experiments (Brown, 1992; Collins, 1992; Design-Based Research Collective, 2003) as a research methodology. The goal of design experiments is to engineer innovative learning environments and simultaneously come to understand salient aspects of human cognition and learning involved with those innovations. Design experiments would be fruitfully complemented by the conduct of intensive case studies of classrooms focused on the complex interaction among learners, teachers, information and communication technologies, and the context of individual classrooms in the service of learning.

There is an important role in this research arena for methods that provide more direct access to causal mechanisms. For example, logfiles that document each keystroke and every feature in a

digital environment that is activated by the user can be used to examine the relationship between the activity in which the user engages and the outcomes of that activity. Eye-fixation studies, using web-cams, would be helpful to providing information about how the user approaches and navigates through complex digital environments, such as websites that offer many choices of where to begin and how to move through the environment. Think-aloud protocols would be a helpful complement, providing evidence about the reasoning and decision-making of the user.

The complexity of the research questions one is likely to ask and the instructional contexts in which one is likely to be working at this intersection suggest that there is an important role for collaborating across projects regarding, for example, the design and use of measures of engagement and learning, the coding and analyses of data sources, and the design of learning environments. Some of this complexity is revealed by examining the scholarship of the members of the New Literacies Research Lab, led by Don Leu, which is focused on the information and communication potential of the Internet for learning, as well as the new skills and strategies in reading, writing, and communication that are required by these new technologies. While Don's primary focus is on the development of a theoretical framework to guide the conduct of research on new literacies, the members of his research group have a range of foci: Laurie Henry investigates the skills that students use when searching for information; Julie Coiro studies the nature of reading comprehension and how it looks the same and different when reading on the Internet, within websites or while using search engines; Melissa McMullen investigates online collaborative learning, while Jill Castek investigates communication on the Internet, particularly in classroom contexts and how classroom teachers can facilitate reading and writing using communication vehicles developed for technologies.

There has been active discussion in the literacy community about the need for expanded definitions of literacy and new theories that place information and communication technologies (ICTs) at their center. Leu, Kinzer, Coiro, and Cammack (2004) have argued that for the past 500 years, literacy has emerged from a variety of social contexts but has primarily been shaped by the book and printing press. But today, both the social context and technologies are rapidly changing with ICTs and the Internet becoming the central technologies of literacy. Leu and his colleagues (2004, p. 15) have identified a set of ten principles to guide a theory of new literacies:

1. New literacies and ICTs are central technologies for literacy within a global community in an information age.
2. The Internet and other ICTs require new literacies to fully access their potential.
3. New literacies are deictic.
4. The relationship between literacy and technology is transactional.
5. New literacies are multiple in nature.
6. Critical literacies are central to the new literacies.
7. New forms of strategic knowledge are central to the new literacies.

8. Speed counts in important ways within the new literacies.
9. Learning often is socially constructed within new literacies.
10. Teachers become more important, although their role changes, within new literacy classrooms.

Leander (2003), similarly recognizing the need for grounding a theory of media in the cognitive and social processes by which knowledge is constructed, has proposed that cultural historical activity theory (CHAT), with its focus on “the analysis of mediation, material technologies, language, culture, and the relations between individual and systemic change” (p. 395) render it ideal for the study of ICTs.

Given the proportion of web-based text that is presented graphically, there is the need for theory that considers the syntactically- and semantically-dense properties of graphical representations. Finally, given the constantly changing nature of technology, there is a significant role for visionary theory.

CONCLUSION

As we bring this review to a close, we thank the scholars who served as generous “co-presenters” by responding to our queries and sharing their scholarship with us. In addition, following on Gunther Kress (2003) who noted that readers and writers become designers in these digital, multimodal, interactive environments, we acknowledge that we have been designers as we prepared this travelogue making decisions about the contours of the landscape, the studies upon which we would linger, and how we would represent the features of this scholarship.

We close with an observation from a member of the literacy community who has indeed been a visionary working at the intersection of literacy, learning, and technology: Chip Bruce. In a 1997 volume of the *Journal of Literacy Research*, Bruce wrote: “Technology is not just over there, but out there, at most in a distant suburb of literacy, if not on another planet” (p.). We wondered what Chip’s sense of the state of literacy and technology was now, in the year 2004-2005.

In 1996-97, I was fortunate to spend a year living in Beijing, and later, Brisbane, Australia. I was struck then by the way that the web, email, electronic bulletin boards, databases, digital photography, etc., were changing the *literacy* practices of young people. If we mean by literacy an assemblage of social practices through which people construct, represent, and share meaning, then young people there were engaged in a dramatic re-shaping of their literacies. They were:

- learning English through the web;
- using email, fax, and digital photography for political action;
- developing new forms of jokes and story-telling;
- playing games across the Internet;
- finding new ways to construct and express their identities;
- sharing their experiences of living in a changing China with those outside.

These activities were not unique to China, of course, but they were especially dramatic in the context of China then. I felt that we couldn't ignore those experiences. If we wanted to understand the meaning of literacy in the lives of young people, then we needed to focus more on what they were actually doing, on how their literacy was changing, and how their practices were in fact creating the new technologies of literacy.

In short, we needed to see technology as more than technique. The practices of young people around mobile phones, weblogs, e-zines, instant messaging, digital photography, network gaming, wireless networking, GPS, and more, are not simply means to accomplish pre-defined tasks, but new ways of being in the social and physical world.

Back in the US, the mainstream of literacy educators and literacy researchers were oblivious to what these events might mean. Many people conceived new information and communication technologies as irrelevant, or even antithetical, to the values they ascribed to literacy. They might, for example, acknowledge a role for computer-based instruction on an isolated literacy skill, but that very acknowledgement contained within it their view of the new technologies as reductionist.

The field of literacy has since made major strides in understanding the meaning and potentials of the new technologies. There are projects, programs, curricula, and analyses that accept the reality of the changes in social practices associated with multimedia, computers, the web, and such. But for many, technology still means specific techniques, which can be attended to or not.

Doing that compartmentalizes technology, and fails to comprehend its deeper connections to literacy. It also allows us to avoid such questions as:

- Who has access to these resources? controls the use? owns the content? judges the value?
- How are people transforming the tools?
- How are senses of community, play, and identity being reshaped?
- How do concepts such as story, meaning, communication, and knowledge need to be reexamined?
- How are the very means by which we enact literacy changing?

I'm speaking to you today from Tampere, Finland, not far from what must be cell phone heaven in Nokia. It reminds me of an eight-year-old who can send instant text messages, invent new linguistic forms, program the cell phone for international calls, download music and ring tones, surf the web on the phone, and more. She, along with millions of other young people around the world, are creating new literacies through technologies such as this. Meanwhile, the principal response of schools to cell phones has been to ban their use.

No! I'm not saying to put cell phones or iPods in every classroom! But, if we want to understand literacy, we cannot afford to ignore the lived experience of people who are remaking it right in front of us (Bertram "Chip" Bruce, personal communication, November 2004).

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