CHAPTER 23

Multimedia Learning of Reading

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Abstract

Addressing how multimedia learning intersects with teaching reading and learning to read entails unique challenges when compared to other school subjects. Those challenges spring from the prominent place that reading instruction occupies in the school curriculum and in daily life. As the first of the three Rs, learning to read is foundational to all school subjects. Further, the ability to read and comprehend textual information is integral to all schooling and indeed to living a productive and fulfilling life in developed areas of the world (Brandt, 2001).

Introduction

In part because the stakes are high and in part because reading is an intriguingly complex cognitive activity, the teaching and learning of reading have historically attracted attention from diverse disciplines. The literature pertaining to reading is an interdisciplinary amalgam including not only mainstream scholars of reading pedagogy, but also educational researchers in other curricular areas, psychologists of every stripe, sociologists, historians, philosophers, and even those in the medical field such as ophthalmologists. The appearance of multimedia forms of communication made possible by computer technology has reinforced and extended the interdisciplinary mix to include scholars in fields such as journalism and mass media, library science, instructional design, and computer science.

Further, because a citizenry's collective reading achievement is perceived to have important economic and political consequences, reading pedagogy and the scholarly work that informs it are almost daily in the public eye. Multimedia forms of communication have likewise attracted interest in the pedagogical and political dimensions of how best to prepare children to be more broadly literate in digital, multimedia environments (e.g., Flood, Heath, & Lapp, 1997; Leu & Kinzer, 2000), and to compete in a global economy (Wagner & Kozma, 2003).

The content of reading instruction is likewise diverse and sometimes controversial

often raising issues about the appropriate and most effective ways to teach beginning reading (e.g., the debate over whole-language and phonics often termed the *Reading Wars*); the causes of reading difficulties and how to ameliorate them; how to assess reading; how reading and writing interact; and so forth. Digital, multimedia forms of communication have complicated these issues while raising interesting possibilities for enhancing instruction. Although a diversity of computer-based multimedia materials and activities for teaching reading have been widely available since the earliest days of instructional computing (e.g., the Stanford Project; see Atkinson & Hansen, 1966–67) and there has been much interest in their use, they have not had a notable effect on instruction (International Reading Association, 2001; Leu, 2000; Reinking, Labbo, & McKenna, 2000). Many educators and researchers who are invested in conventional print and the instruction based on it have done little to accommodate or assimilate new digital forms into their work and sometimes greet digital forms as interlopers of marginal importance to mainstream reading pedagogy and research (Reinking, 1995, 1998).

Limitations and Caveats

The preceding brief summary provides the background for several limitations and caveats to a review of multimedia and learning to read. First, the relevant literature is broad, but shallow. It is broad in the sense that it cuts across a wide range of disciplinary, theoretical, topical, and methodological terrain. That it is shallow is evidenced in part by the relatively few studies investigating issues of digital literacy in the mainstream journals publishing research about learning to read (see Kamil, Kim, & Intrator, 2000; Kamil & Lane, 1998). Further, previously published reviews of the literature pertaining to reading and digital technologies (Blok, Oostdam, Otter, and Overmaat, 2002; Labbo & Reinking, 2003; Leu, 2000; Leu & Reinking, 1996; Reinking & Bridwell-Bowles, 1991; Reinking, Labbo, & McKenna, 1997) do not attend predominantly to multimedia as a dimension of learning to read and make broad generalizations rather than specific recommendations. Thus, the present review focusing on multimedia and what recommendations might be derived from the available literature seems warranted.

Another caveat is that much of the available research related to digital technologies and learning to read has been judged to be methodologically weak. For example, in an early review of the research on computers and reading Reinking and Bridwell-Bowles (1991) pointed out that many of the available studies were atheoretical, horserace-like comparisons of reading with and without a computer. More recently, computer technology and reading instruction was one of a few key topics investigated by the National Reading Panel (2000) charged by the U.S. Congress to draw conclusions about reading instruction based on scientific evidence. Scientific evidence was defined narrowly as experimental studies (supplemented secondarily by correlation studies) that met certain standards of methodological rigor with the aim of conducting meta-analyses across studies. However, a comprehensive search of the literature on technology and reading between 1986 and 1999 produced only 21 studies that met the panel's criteria, which was deemed an insufficient number for conducting a meta-analysis. Further in a meta-analysis of 42 studies published since 1990 and investigating computer-assisted instruction in beginning reading instruction, Blok, Oostdam, Otter, and Overmaat (2002) indicated that the relatively low overall effect size ($d = 0.2$) should be interpreted with caution, in part because many of the studies were of poor quality.

Another caveat is that approaching the topic of multimedia and reading pedagogy depends to some extent upon one's theoretical and pedagogical orientation to reading and reading instruction. If reading is viewed as a bottom-up process (e.g., Gough, 1984) in which decoding letters and words are foundational to comprehension,

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beginning reading instruction is likely to be conceived as a hierarchy of subskills. If reading is viewed as a top-down process (e.g., Goodman, 1976) where existing knowledge allows predictions that aid and direct decoding, beginning reading instruction is likely to be conceived as a more holistic, less linear endeavor. These alternative views affect how multimedia materials and texts might be conceptualized, developed, and researched in relation to learning to read, particularly in the early stages of learning to read (Miller & Olson, 1998).

Further, much of the research literature pertaining to multimedia and reading is targeted toward increasing the comprehension of particular textual content or studying the processes by which readers come to understand textual content presented in multimedia formats. Many of the other chapters in this volume present work in this area. That research is relevant and important to reading instruction, particularly as it pertains to comprehension and learning in other subject areas and in determining how best to prepare students for new reading environments. However, given the scope of this chapter and the fact that many other chapters in this volume address those issues, in this chapter I will focus my review on multimedia materials aimed specifically at learning to read as a subject in the elementary and middle school where instruction in reading is more often a distinct curricular area. However, first I define multimedia in relation to teaching and learning to read.

Defining Multimedia in Relation to Texts and Learning to Read

The term *multimedia* has different meanings and these different meanings vary by context and by discipline (Mayer, 2001). In relation to teaching and learning subjects in schools, *multimedia* is frequently used to modify words such as *program*, *materials*, *presentation*, *learning*, and so forth. In that usage, *multimedia* typically refers to computer-based presentations of instructional content and activities that blend prose (written or verbal), sound effects, and dynamic rather than static graphical information (i.e., animations and video clips, as opposed to still pictures or illustrations). To teachers and educational researchers *multimedia* usually means more than words and pictures conjoined in conventional printed texts, and more than simply employing an array of independent audio-visual technologies to teach in a classroom, the latter of which has a long history in teaching reading (e.g., Dale, 1946). Instead, it means using the capability of a computer to combine in interactive formats the capabilities of previously independent, stand-alone technologies for presenting audio and visual information.

However, the term *multimedia* as used in such contexts is problematic from a theoretical point of view (Reinking, 2001). First, general, nonspecific uses of the term provide no clear basis for distinguishing the acquisition of information from written texts in general and printed texts in particular and from other sources of information, and thus leaves unanswered what reading really is in relation to listening and viewing. This ambiguity is reflected to some extent in calls for expanded definitions of literacy to include listening and viewing (e.g., Flood et al., 1997; Cognition and Technology Group at Vanderbilt University, 1994), which essentially begs the issue of why that might be advisable other than that there are now more multimedia forms of communication. Second, it provides no basis for conceptualizing, predicting, or assessing what digital technologies might contribute instructionally to learning to read in a conventional sense nor what the dimensions of reading might be in digital, multimedia environments.

These issues remain to be sorted out precisely. However, several theoretical positions are relevant. In relation to the first issue, for example, Birkerts (1994) is an often-cited apologist for the benefits of reading conventional printed texts over digital, multimedia texts, although his argument is more romantic and literary than theoretical. Bolter (1991), on the other hand, has suggested that the essence of reading is that it establishes a space for reflection not

naturally afforded by multimedia forms that provide less mediated experience (virtual reality being an extreme form). However, he has also introduced the concept of *remediation*, which argues that there is a natural tendency to use one medium to mimic the characteristics of other media (e.g., paintings that look like photographs and vice versa), but that vestiges of established media typically survive in new media forms (e.g., the "electronic book" or "e-book"). However, the development and use of various media are always shaped by a press to reach an ideal of unmediated experience (Bolter, 2001). Lanham (1993) has argued a complementary perspective postulating that digital texts, because they create options that subordinate alphanumeric text (see also Reinking & Chanlin, 1994), are naturally more visual than printed texts and thus more rhetorical and less philosophical. That idea is captured by his distinction between printed texts, which fundamentally encourage readers to look *through* the text to find meaning, and digital texts, which more fundamentally encourage readers to find meaning by looking *at* the text.

There is also theoretical work related to how the dynamic, audio-visual capabilities of computer-based materials might contribute to learning to read or to defining more clearly what new directions in teaching reading might be warranted. For example, Salomon's (1979) seminal work outlining the characteristics that distinguish one medium from another suggests that printed and digital texts may be distinctly different media with different cognitive requirements and with different opportunities to effect cognitive processing. That is, the technologies supporting digital texts make available new symbol systems (an open-ended technology that can flexibly use diverse symbol systems, which arguably is a more precise definition of multimedia; see Reinking, 2001) as well as new situations (e.g., Internet usage) and contents (e.g., easy juxtapositions of diverse information). In his theory, two consequences of different media are particularly important from an instructional standpoint: (a) media vary in the cognitive skills necessary to extract information from them and thus what skills become well practiced in using a medium; and (b) media vary in the extent to which their symbol systems and technologies can model or supplant requisite cognitive skills. In an example directly related to the focus of this chapter, he and his colleagues demonstrated that digital texts specifically designed to scaffold novice readers' understanding of texts in ways not possible in conventional printed materials increased metacognitive awareness and comprehension (Salomon, Globerson, & Guterman, 1989).

Using Salomon's theoretical perspective Reinking (1992, 1997) has argued that five differences distinguish reading printed and digital texts, which justifies thinking of them as different media, but which also suggests differences that might guide the teaching and learning of reading. In this scheme, the unique characteristics of digital texts are that they: (a) create literal (as opposed to a metaphorical) interactions between texts and readers (e.g., dynamic texts capable of responding and adapting to an individual reader's needs); (b) enable information to be organized and accessed in nonlinear formats (i.e., hypertexts); (c) use a broader range of symbolic elements to carry meaning (e.g., ranging from the easier use of colored, stylized fonts to the use of audio, animation, and video); (d) broaden the boundaries of freedom and control available for accessing information during reading (e.g., hotlinks in Web-based documents on the freedom side and making access to subsequent text contingent on demonstrated mastery of essential concepts on the control side); and (e) change the conventions or pragmatics of written communication (e.g., e-mail and listservs have emerging acceptable and unacceptable uses and behaviors for users).

In summary, *multimedia* is a term that has been used in the education literature to refer to the use of a computer to present instructional content and activities in flexible, interactive formats employing a variety of audio and visual effects. In this usage *multimedia* refers to audio-visual capabilities that were previously unavailable to print-based

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learning. However, in a theoretical sense the term *multimedia* may mean something more specific and less consistent with the etymological roots of the term (literally "many media"). That is, it refers to fundamental differences between print-based and digital texts that make them separate media and that suggest new content and avenues for teaching and learning, particularly in relation to textual materials. Although it is debatable from the standpoint of learning content whether alternative media (e.g., print or digital texts) make a difference in learning (see Jonassen & Reeves, 1996), it seems less debatable that learning how to extract information from various media has implications for developing competence in a cognitive skill such as reading. Although understandings of multimedia at a theoretical level are at least implicit in the review that follows, the field has not yet produced a comprehensive theory.

Multimedia Applications in Learning to Read: Examples, Research, and Theory

Teaching reading as a school subject can be roughly divided into three areas, each of which has an extensive theoretical, empirical, and pedagogical base in the literature of reading education: (a) decoding (identifying words automatically for the sake of developing reading fluency); (b) comprehending (building capacity and strategies to understand and think critically about texts); and (c) building interest in reading (instilling an enjoyment of reading as a pleasant and fulfilling activity). In this section I provide examples of multimedia materials that have been developed and used instructionally in each of these areas, and I summarize and evaluate the status of theory and research supporting their use.

Decoding

The capability to incorporate audio-visual presentations into learning to read has had the most direct and obvious influence in the area of decoding. That influence can be understood by considering the nature of decoding and how it fits into reading instruction. At the decoding stage of learning to read, the emphasis is on breaking the alphabetic code, typically by teaching sound-symbol correspondences, although the extent and focus of that emphasis as well as how it should be dealt with instructionally has long been controversial. Nonetheless, there is a fair degree of consensus that an important goal of beginning reading instruction is to develop fluent readers (i.e., automatic decoders) whose attention and cognitive resources can be devoted to comprehension rather than to decoding. Thus, any technology facilitating the ability to highlight sound-symbol correspondences toward helping students become fluent, automatic decoders fits well into conventional conceptions of beginning reading instruction and is likely to be favorably accepted even by educators and researchers invested in printed forms.

Unlike printed materials, a computer can provide individualized, on-demand access to pronunciations and allows instructional designers to set contingencies that provide different types or levels of access to pronunciations. For example, certain readers under certain conditions may benefit from the availability of audio that provides pronunciations at the level of a syllable, a word, a phrase, a sentence, or a connected text. These contingencies have been investigated extensively, at least more extensively than most other applications that might be referred to as multimedia, and they have been more often guided by theories relevant to the pedagogy of reading.

The intuitive appeal of using computer for multimedia applications related to decoding surfaced early in the era of instructional computing long before synthesized and digitized speech became more feasible and commonplace as it is today. For example, in early work in this area McConkie and Zola (1987) used specially designed equipment interfaced with a computer to allow marginally literate adults in prison to read high-interest content on a

touch-sensitive computer screen, which allowed them to access the pronunciation of unfamiliar words. The growth in reading ability for the adults in this essentially free-reading condition compared favorably to more conventional instruction.

However, most of the research and development in this area has focused on young children or on children in the elementary grades experiencing difficulties in learning to read. Clearly, the most prominent researchers in this area are Richard Olson and Barbara Wise, whose incremental, ongoing, collaborative work began in the mid 1980s. Several useful findings have emerged from their work. For example, in preliminary studies they established that synthetic speech could equally support children's recognition of targeted words when compared to actual spoken language (Olson, Foltz, & Wise, 1986a) and that providing feedback for difficult words in stories promoted more learning of those words than simply reading stories (Olson et al., 1986b). Later they investigated providing children with alternative segmentation patterns of audio feedback when encountering unfamiliar words (whole word, e.g., *pencil*; syllable, e.g., *pen-cil*; and onset-rime, e.g., *p-en/c-il*) finding that segmentation pattern made little difference. However, they found that the computer-based feedback did accelerate the progress of participants when compared to a control group (Wise et al., 1989) and that children who had established phonemic awareness (the ability to hear the smallest units of sounds in a language) benefited more than those who did not (Olson & Wise, 1992). Their subsequent work varied conditions of training and implementation and examined transfer to more distal measures (e.g., Wise, Ring, & Olson, 1999, 2000). In a more recent paper (Olson & Wise, 2004) they have provided a notably candid evaluation of the limitations of their research and findings, future directions for research, and a critique of research on commercial programs employing computer-based speech for reading development, which unfortunately has often been conducted by researchers who have a financial interest in the success of those programs.

Other researchers have investigated similar approaches to using the computer to develop decoding skills, but with different populations. These include, for example, Reitsma and Wesseling (1998) with emergent readers; Barron, Lovett, and McCabe (1998) with neurologically impaired readers; Lundberg (1995) with special education students; Segers and Verhoeven (2004) with children diagnosed with speech and language problems; and Ho and Ma (1999) with Chinese children labeled as dyslexic. Reitsma and Wesseling's (1998) study, which demonstrated positive effects for using the computer to develop phonological awareness, is noteworthy because it was a methodologically strong longitudinal study that took into account multiple factors including various student characteristics and the school and home environments.

McKenna, Reinking, and Bradley (2003) have also investigated providing various conditions of digitized speech to children in regular kindergarten and first-grade classrooms in conjunction with reading online versions of popular children's books. In one condition they provided digitized oral phonics analogies when children clicked on a word. That is, when children clicked on the word *fix*, they would hear a female voice compare the word *fix* to *six*, a more familiar and analogous word that was also displayed on the screen. They were interested in determining whether various conditions might effect improvements not only in the identification of target words, but new, analogous words, as well as sight words (i.e., high frequency, but often irregularly spelled words, decoded as units by sight; such as *have*, *was*, *done*, and *of*). In a two-part experiment, children who had not reached the alphabetic stage of development (i.e., some awareness of sound-symbol correspondence) exhibited no statistically significant benefits in decoding development. However, in a second experiment, children who had reached that stage exhibited an increase in sight word development, thus supporting a theoretically hypothesized relation between phonological

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Comprehension

Comprehension is the ultimate goal of reading instruction, but unlike decoding, it entails ill-defined, open-ended, and complex cognitive processes (Paris, in press). Consequently, it is less clear how it might be developed as a general cognitive ability through teaching activities. Traditionally, classroom reading instruction aimed explicitly at developing comprehension ability has been shown to be sparse. Typically it has included engaging children in activities requiring them to do little more than demonstrate that comprehension had occurred such as finding the main ideas of text, separating fact from opinion, or interpreting tables and graphs (Durkin, 1978–79). More recently, there has been an emphasis on improving comprehension through activities aimed at helping students become more engaged and strategic readers (Pressley, 2000) and heightened interest in instructional activities aimed at externalizing the internal process of comprehension. Expanding students' meaning vocabulary has also traditionally been considered to be part of comprehension instruction, although this area too has benefited from more innovative teaching strategies and activities, many of which proceeded from theoretical advances in cognitive psychology.

Computer applications, employing multimedia, have played a role in comprehension instruction, but those applications, although often more innovative in their conception when compared to decoding applications, have nonetheless been more diverse and less well researched. They have also often been embedded in the context of learning subjects such as social studies and science. Excluding applications aimed at increasing comprehension of a particular text, there are several lines of research and development in the literature. These include investigating (a) how digital forms of reading might enhance strategic reading and engagement with texts, including how new forms such as hypertexts may uniquely develop conventional skills and new comprehension skills associated with reading digital texts; (b) whether multimedia elements may distract readers, therefore undermining comprehension; and (c) whether multimedia may play a role in developing a more evaluative or critical stance toward texts. Subsequently, I provide examples in each of these areas.

Interestingly, perhaps the earliest example of using a multimedia application involving computers in the area of reading comprehension was developed and investigated by the famed psychologist George Miller and reported in *Scientific American* (Miller & Gildea, 1987). Based on his work demonstrating that children's use of dictionary definitions alone in seeking meanings of unfamiliar words led to sometimes humorous misuses of those words, he explored how a computer interfaced with a video player might remedy this phenomenon. For example, after viewing a video of the film *Raiders of the Lost Ark*, children were shown a text describing the scene in which targeted vocabulary words had been highlighted. Fifth-grade children could then select to see a definition of the word, the word used appropriately in a sentence, and a video clip illustrating the words meaning, the latter option being particularly useful with words such as *jovial*, in which the video could show someone who was projecting that emotional state. He found that children using this application recognized more meanings of targeted words and used them more appropriately in a sentence. Complementing these findings is the work of Reinking and Rickman (1990) who found that upper-elementary school children who had immediate access to technical terms while reading a science text on a computer screen were more likely to investigate the words' meanings, choose their correct meanings on a postexperimental vocabulary measure, and to comprehend the text in which the terms appeared. However, students in their study were provided written definitions without audio or video support.

Another relatively early example of a multimedia application aimed at increasing comprehension ability is the Young Sherlock Project, one of several projects developed by the Learning Technology Center at Vanderbilt University (Kinzer & Risko, 1988). Based on a theoretical orientation referred to as anchored instruction, the overall aim of these projects was to (a) increase students' abilities to solve problems and to learn independently; (b) teach general literacy skills involving reading and writing; and (c) build background knowledge including vocabulary, story grammars, and historical information (Sharp et al., 1992). The Young Sherlock project engaged children in a variety of online and offline activities centered on an interactive exploration of the popular film *Young Sherlock Holmes* within the context of learning about the Victorian era. A study of fifth-grade, at-risk, and average-ability students revealed that they outperformed a control group in their spontaneous use of targeted vocabulary, in the number of story elements and links to characters in writing about the movie, and in the use of historical information to make inferences (Risko et al., 1989).

In another study, also focusing on historical content, Stahl, Hynd, Britton, McNish, & Bosquet (1996) investigated the potential of using hypertext to engage high school students in critically evaluating textual information more like historians. The computer application allowed students to easily access and compare different accounts and explanations of the Gulf of Tonkin incident, a controversial event used to justify American's entry into the Vietnam War. Specifically, they were interested in investigating the extent to which hyptertextual presentations of historical events would enrich students' mental models, how students would approach the historical information, whether students would integrate information across texts, and whether students would engage in corroborating, sourcing, and contextualizing, three activities found to characterize the way historians approach textual information (Wineburg, 1991). They found that students' mental models were more consistent after reading at least two source documents, but the overall results were disappointing to the extent that students tended to gravitate toward the textbook explanations of events rather than to form opinions based on comparisons across original source documents. They concluded that hypertextual access to multiple texts presenting conflicting information may not benefit students without specific instruction in relevant strategies and orientations.

This finding is consistent with other studies suggesting that simply exposing students to unique reading experiences on the computer does not produce immediate, profound improvements or changes in general comprehension ability (cf. Hynd, Jacobson, & Reinking, 1999; Rouet, Levonen, Dillon, & Spiro, 1996). Nonetheless, Spiro and his colleagues (Spiro, Feltovitch, Jacobson, & Coulson, 1992) reported that presenting information as hypertexts to more mature and capable learners such as medical students resulted in increased ability to apply that information to a diagnosis, but decreased recall of factual information when compared to students reading conventional texts. The theory guiding their research was cognitive flexibility theory, which postulates that learning content in ill-structured domains such as performing a medical diagnosis or making decisions about teaching children will be enhanced when knowledge is deconstructed and then reconstructed flexibly in relation to specific cases. Presenting information in hypertextual formats has been considered to be a logical means for instantiating this theoretical orientation (Shapiro & Niederhauser, 2004) and perhaps in creating more active comprehension and learning (cf. Niederhauser, Reynolds, Salmen, & Skolmoski, 2000; Shapiro, 1998).

Some work has indicated that computer-based reading might affect readers' comprehension strategies, at least in the short term, although that work has not focused specifically on using the audio-visual capabilities of computer-based texts. For example, Tobias (1987, 1988) inserted questions in online texts that required review of previously presented material when readers answered a

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question incorrectly. That is, the computer made access to texts contingent on readers demonstrating that they had comprehended the text presented previously, thus illustrating the unique capabilities of digital forms of reading to manage and perhaps shape comprehension processes. However, he found that mandatory review, while increasing learning of information targeted by the inserted questions, decreased learning of other potentially important information, which reflected a phenomenon evidenced in the literature investigating the effects of inserting questions in conventional printed texts. He speculated that under conditions of mandatory review, readers focus their review on quickly finding portions of the text that allow them to answer the question correctly, thus increasing recall of that information at the expense of other information. Extending his work, Reinking, Pickle, and Tao (1996) investigated the possibility of overcoming this limitation by providing high school readers with the same or a different question after mandatory review. They found that indeed readers devoted more time to reviewing paragraphs containing information relevant to an inserted question when they received the same question, but that they more equally distributed their review time across several paragraphs when they received a different question after mandatory review.

In a similar vein, Hegarty, Carpenter, and Just's (1991) work illustrates how digital texts employing animation might compensate for readers lacking requisite cognitive skills for comprehending textual information. They reported one study (Carpenter, Just, & Fallside, 1988) in which they measured eye movements and comprehension of participants who read a text explaining the operation of a machine and viewed an accompaning diagram of the machine. In one condition a printed text presented a conventional static diagram on a page. In another condition, the text was presented on a computer screen and the accompanying diagram was animated to show the movement of the machine. All readers attended to the animated graphical representation longer, but the comprehension of readers assessed to be of low mechanical ability, and presumably less adept at imaging the machine's operation, increased significantly when reading the online animated version. However, these examples of altering or supplanting cognitive processing, because they involve short-term interventions, illustrate mainly the potential effects *of* a medium, in this case computer-based reading, to alter or supplant strategic aspects of acquiring information as opposed to more long-term effects *with* media that might generalize to other texts and contexts for reading (see Salomon, Perkins, & Globerson, 1991).

A different line of research has investigated reading comprehension among young children interacting with digital versions of popular children's stories that include a variety of audio-visual effects not possible in the printed versions of these stories. "Talking Books," or "CD-ROM stories" have been extensively researched although the scope of that research extends into the area of decoding described in the previous section (i.e., stories that include the pronunciation of unfamiliar words; e.g., see Chera & Wood, 2003; McKenna, Reinking, & Bradley, 2003) and the area of building interest and motivation as described in the subsequent section of this chapter. An obvious benefit of these stories is that young children with little or no independent reading ability can interact with them without the assistance of an adult or more competent reader.

The relation between pictures and story content in printed texts has been a topic of research for many years. For example, Beck and McKeown (2001) found that pictures inconsistent with the story led children to misunderstand stories. However, digital stories complicate this issue. For example, many online stories include sound effects and animations, many of which are incongruent with the story line. Further, many of these stories implicitly or explicitly encourage children to access story events in an order not consistent with the original printed version. Do such multimedia versions of the stories interfere with story recall? Do they compare less favorably with adult-assisted reading of

printed versions? Do they generate more interest and motivation in reading by encouraging more playful explorations of story content? These are the type of questions that have been researched.

Research thus far does not provide a clear answer to these questions, although some clarifications of contradictory findings are beginning to emerge. It is clear across the available studies that children become engaged in playful interactions with these stories, which are likely to be motivating (e.g., Cordova & Lepper, 1996; DeJong & Bus, 2003). What is not clear is the extent to which these playful explorations enhance or inhibit story understanding particularly when compared to conventional printed stories that adults read to children. For example Ricci and Beal (2002) found that comprehension was not affected by animations unrelated to the story. Likewise Cordova and Lepper (1996) concluded that animations may increase motivation and interest and therefore may increase comprehension. On the other hand, James (1999) found that children didn't navigate through an entire story, seemed distracted by pictorial details, and became engrossed in less relevant and entertaining animations after an initial pass through the story. Similarly, DeJong and Bus (2002) found that children in their study did not recall the structure of electronic stories as well as children who listened to adults read the same story to them. Further children reading electronic stories explored the story in a seemingly random order focusing more on appealing animations.

A few studies suggest some explanations for these inconsistent or contradictory findings. For example, Labbo and Kuhn (2000) applied the concept of considerate and inconsiderate texts (considerate in relation to being sensitive to readers' attempts to understand) to evaluating the effects of talking books. That is, they distinguished between electronic stories that provided audio-visual effects that were congruent or incongruent to the plot of the stories they accompanied. They found that texts they deemed to be considerate (i.e., with special effects congruent with the story) supported understanding as determined by story retellings, which they attributed to a weaving of affective responses, cognitive processes, and metacognitive activity. In a more recent study, DeJong and Bus (2004) found evidence suggesting that the effects of talking books may be related to a child's level of cognitive development. That is, kindergarten children who had reached a stage of development where they had a distinct sense of story beyond attending to pictures were not distracted from story comprehension even when, using Labbo and Kuhn's terminology, there were many effects incongruent to the story.

Comprehension instruction in schools also includes developing the ability to critically evaluate textual information, although this aspect of reading instruction typically receives short shrift in classrooms, at least beyond skill work such as distinguishing between fact and opinion or beyond discussing propaganda techniques. That conclusion can be confirmed by a quick scan of leading textbooks aimed at preparing reading teachers, which include little, if any, attention to this area of comprehension. Computer-based activities have played some role in expanding attention to this neglected area. For example, the ready juxtaposition in digital environments of historical texts representing differing viewpoints in the work of Stahl et al. (1996) cited previously in this section illustrates some of the possibilities.

One example of the possibilities for using multimedia in developing a critical stance toward textual information is illustrated by the work of Myers, Hammett, and McKillop (1998). They engaged students in developing multimedia documents comparing and contrasting images of Pocahantas in various media ranging from the Disney animated version to Elizabethan paintings. Students' work, which presumably involved much reading and viewing of textual materials and visual images, also explored related themes pertaining to spiritual images related to Native American and Christian religions and environmental themes. Myers et al. (1998), writing from the perspective of critical pedagogy, concluded that children who were engaged in these activities exhibited more "resistant" processing of information consistent with a critical pedagogy, which includes

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Building Interest in Reading

Reading educators and researchers have always considered building interest in reading and creating conditions that promote a enjoyment of reading to be an important aspect of reading instruction. However, this aspect of reading instruction moved closer to the mainstream of the curriculum when Stanovich (1986) introduced the theoretical point of view he termed *Matthew Effects* after the biblical gospel that includes the line "the rich get richer and the poor get poorer." He argued that much of the widening discrepancy across the school years between children of low and high achievement in reading could be accounted for by the fact that children who initially perform poorly in reading are less motivated (or expected) to read and thus read less, thus compounding their lack of achievement. Children who, on the other hand, experience initial success are likely to read more and thus become better by virtue of their increased practice, background knowledge, and so forth.

Relatively few applications and even fewer studies have explored the possibilities of using computer-based multimedia formats to increase motivation to read and the amount of reading that children do, thus, presumably, in light of the Matthew Effects, addressing the gap in achievement between good and poor readers. Labbo's (1996) work is at least indirectly related to this area of instruction, because her work focused on the audio-visual aspects of young children's playful interactions with computer-based texts. Using a semiotic framework, she analyzed the way children constructed and used texts created with a commercial program that combined drawing and illustrating tools with word processing functions, which is consistent with the now widely accepted view that drawing is a precursor to playful writing and more advanced forms of literacy. Based on her analysis of children's experimentation with and interaction about these texts, she introduced an overarching construct she termed *screenland*, which entailed several cognitive metaphors for the way children engaged with this multimedia environment: screen as landscape, playground, stage, canvas, and paper. However, an important element of the activity was the promotion of personally meaningful self-expression and presumably interest and motivation, which the computer-based multimedia activities seemed to promote. Also relevant to the overall focus of the present chapter, Labbo raised the question of the extent to which such early experiences with multiple symbol systems might lay a foundation for subsequent literacy development that accommodates a broader range of symbolic elements. She asked, "Is it possible that having opportunities to use depictive or transformative symbolism to represent ideas allow children to make associations with typographic and linguistic forms of meaning making?" (p. 381).

Another study addresses more directly the issue of how multimedia might transform conventional instructional activities toward increasing elementary students' independent reading. Reinking and Watkins (2000) investigated engaging teachers and students in developing multimedia book reviews as an alternative to the conventional book report that is a pervasive, but largely ineffective, approach that many teachers employ to inspire more reading in elementary and middle schools. Using Hypercard, a tool that allows for the flexible integration of pictorial and audio information in menu-driven and nonlinear formats, children developed a template that allowed them to develop personal and creative responses to the books they had read. Further, these multimedia book reviews were compiled into a searchable database that other students, teachers, and parents might choose to investigate. Using mixed methods within the methodology of a formative experiment they found that, across two years, in nine fourth- or fifth-grade classrooms in three schools effects varied considerably depending on contextual factors (e.g., administrative and professional climate of the school). Further, increased reading was mediated in unexpected ways such as students' interacting about books incidentally in the context of helping each

other use the technological options available to create multimedia texts. Overall, the amount of reading increased and attitudes toward in-school and out-of-school reading remained constant. The latter finding was noteworthy because attitudes toward reading are known to decline steadily during the elementary grades (McKenna, Kear, & Ellsworth, 1995).

One relevant, but untested, theoretical perspective related to multimedia is directly relevant to this area of increasing engagement in reading and motivation to read. Reinking (2001) has argued that reading in multimedia environments is inherently more engaging than reading in print environments. Based fundamentally on the argument that printed and digital texts are theoretically distinct and separate media, he presented four theses in support of that conclusion: Multimedia texts are inherently (a) interactive, thus passive reading is less likely; (b) less difficult because they make various types of assistance available to readers, and they may be designed to determine if a reader is having difficulty and to respond accordingly; (c) tend to be less serious and philosophical and more playful, rhetorical and concrete; and (d) meet a wider range of social needs (e.g., chat rooms on the Internet). This theory suggests a variety of testable hypotheses. For example, do multimedia reading environments that possess all or various configurations of these qualities lead to more extensive reading, more persistence in reading difficult content, greater comprehension, heightened interest in textual topics (e.g., more off-line reading), more strategic reading, more communication with others about one's reading, and so forth when compared to conventional printed texts?

Implications and Future Directions for Research, Theory, Instruction, and Instructional Design

The focus of this chapter has been on research and theory pertaining to the use of computer-based multimedia materials and activities that might apply to teaching reading in the elementary school and middle school where reading is an identifiable component of the language arts curriculum. The relevant research base is broad yet shallow with relatively few studies conducted by mainstream literacy researchers interested in teaching reading in schools (Kamil et al., 2000; Kamil & Lane, 1998). Whereas the literature is replete with articles addressing the importance of technology to literacy instruction and lamenting the shortage of research, there is a paucity of research studies to guide the field in this area. Disturbingly, many of the calls for more research come from writers in the field of literacy who have themselves published little relevant empirical research. Consequently, much of the research relevant to using digital technologies in reading have been conducted by educational psychologists and instructional designers who are typically focused more on how readers process multimedia texts, how comprehension and learning of specific texts might be enhanced, or how screens might be designed to increase ease of use (e.g., Walker & Reynolds, 2000). They typically conduct studies of mature readers, mainly college students (see Lawless, Mills, & Brown, 2003 for an exception). Although informative, findings and implications from these studies are not directly applicable to younger children and classroom teaching.

Thus, one clear implication of the existing literature is that there is much room for more research that focuses on how computer-based, multimedia materials and activities might enhance the teaching and learning of reading in the elementary school and middle school. Among literacy researchers, there is a need to focus more attention on conducting rigorous empirical investigations published in mainstream, peer-reviewed journals. Among educational psychologists and other researchers, there is an opportunity to focus more attention on how multimedia might contribute to teaching reading and learning to read in schools. Although research is logistically more difficult to conduct in school settings, the

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benefits of knowing how developing readers process multimedia materials and how those materials might contribute to enhancing reading achievement and comprehension are likely to be greater theoretically and practically than knowing how to effect improvements in reading and learning among readers at a later stage of development. One way to address these challenges to researchers inside and outside the community of literacy researchers would be to form interdisciplinary research teams that include researchers who are well grounded in the pedagogy of reading and intimately familiar with the environments of classrooms and schools.

On the other hand, the current research base related to multimedia and learning to read is theoretically rich – much richer now, that is, than it was characterized in earlier reviews focusing on computer applications to reading and writing, which judged many studies to be atheoretical, horserace-like comparisons. For example, the current literature makes use of general theories such as the cognitive flexibility theory (Spiro et al., 1992); dual-coding theory (Sadoski & Paivio, 2001); semiotics (Labbo, 1996); theories of media, multimedia, and instructional design (e.g., Mayer, 2001; Salomon, 1979), and anchored instruction (Cognition and Technology Group at Vanderbilt University, 1994). It also includes more specific theories pertaining to reading pedagogy (e.g., the role of phonological development, e.g., see Wise & Olson, 1995), theories of how digital media comprise a new medium of reading and writing (Reinking, 1992, 1997), and theories about integrating technology into instructional contexts (e.g., Bruce & Rubin, 1993; Labbo & Reinking, 1999; Karchmer, 2001). That theoretical diversity reflects the many, sometimes competing, goals that literacy instruction entails and the many factors and variables that figure into designing instructional experiences to achieve those goals. Theoretical diversity, however, makes it sometimes difficult to synthesize strong recommendations for developing and implementing multimedia instructional interventions and activities that might enhance reading development. Nonetheless, a few at least tentative conclusions and recommendations emerge from the existing literature.

Currently, the deepest research base pertaining to multimedia and learning to read involves using synthesized or digitized speech to assist young readers acquire basic decoding skills. Using the capability of a computer to provide beginning readers assistance in the form of audio pronunciations of words and word parts under various conditions clearly seems to benefit decoding skills at least as much as adult-led activities using conventional printed materials. Further, young children do not seem to have difficulty recognizing and understanding high-quality pronunciations synthesized by the computer (Olson et al., 1986a). These conclusions are important given that computers may expand opportunities to children reading independently when an adult or other knowledgeable reader is unavailable to provide individual assistance with any word in a text.

However, the research is less clear on what the optimal conditions are for providing such assistance and what category of beginning readers might most benefit. There is some evidence that for such multimedia materials to be effective, children must have attained a stage of reading development where they have achieved a basic understanding that letters represent sounds (e.g., McKenna et al., 2003; Olson & Wise, 1992). However, the majority of research in this area has focused on children experiencing difficulty in learning to read. Despite gaps in the research, there seems to be no reason for designers of multimedia materials for young children to be cautious about making available the pronunciations of particular words in the text. Ideally perhaps, from a pedagogical point of view and consistent with the empirical uncertainty of the research, such applications would provide a teacher with various options for tailoring what words are available for pronunciation, what additional feedback might be included (e.g., phonics analogies), along with a tracking of children's selections.

The research base pertaining to how multimedia materials and activities might

contribute to developing general comprehension ability (as opposed to enhancing comprehension of specific texts) and interest in reading is more diverse and typically less well developed, although the research in these areas showcases some interesting and innovative possibilities. Paralleling the findings related to decoding words, there is consistent evidence that providing readers of online texts with immediate access to the meanings of unfamiliar words enhances readers' meaning vocabularies and perhaps also readers' comprehension and their propensity to investigate words' meanings (Reinking & Rickman, 1990). Further, explanations that include video may be particularly helpful with some concepts (Kinzer & Risko, 1988; Miller & Gildea, 1987). However, this line of research has been dormant for many years, perhaps because it is relatively easy to conceptualize and implement such assistance and the demonstrated benefits seem logical and intuitive. Designers of instructional materials would seem well advised to include assistance with potentially difficult vocabulary employing the full range of media effects at their disposal (e.g., the written definition of an unfamiliar musical instrument might be accompanied by a sample of its sound, or a video clip showing someone playing it). In fact, organizations such as the Center for Applied Special Technology (http://www.cast.org/) have spearheaded the development of such types of textual assistance for online learning materials and lobbied for its use to assist students with a variety of disabilities.

Nonetheless, the research investigating young children's explorations of digital stories suggests caution in providing too much multimedia assistance if the goal is to promote story understanding. That caution seems particularly warranted for multimedia effects not directly related to the plot (Labbo & Kuhn, 2000) and for young readers who do not have a well-developed sense of story (DeJong & Bus, in press). Online versions of stories supplemented with multimedia effects do, however, seem to be motivating (Cordova & Lepper, 1996; DeJong & Bus, 2003), although it is unclear to what extent young children may benefit from interacting with an adult during story reading or how online children's stories might be presented to duplicate the positive benefits of adult–child interactions during conventional storybook reading. Another possibility, yet to be investigated, is the extent to which engaging online multimedia reading materials might stimulate more interest and engagement in reading in general, including conventional printed materials.

Other important areas of teaching reading and learning to read are less well researched. Specifically, there have been few computer applications developed and researched aimed at helping readers to become more strategic in their approach to reading and to assume a more critical stance toward what they read, perhaps because using multimedia in service of these goals requires more complex theoretical perspectives and more divergent thinking and innovation to develop computer-based applications. Further, measuring fundamental changes in these aspects of reading is difficult requiring perhaps a commitment to long-term and longitudinal studies. The research suggests, for example, that students' familiarity with conventional printed texts and how they are typically used as authoritative sources of information across years of schooling may supercede the potential effects of a more critical and evaluative stance (e.g., Stahl et al., 1996). However, the few studies reviewed in the previous section of this chapter suggest some promising directions for designers and researchers, particularly those willing to make a long-term commitment to pursuing the possibilities afforded by multimedia formats and juxtaposing diverse texts in digital environments.

Likewise, little research has investigated how multimedia might generate more interest in and motivation to read. However, a few studies suggest that computer applications employing diverse media may contribute to teachers' attempts to address this goal in classrooms (Labbo, 1996; Reinking & Watkins, 2000). One theoretical point of view has been offered to argue that multimedia environments for reading are inherently

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more engaging than reading in print-based environments (Reinking, 2001), but this theory has yet to be investigated empirically.

Several issues are important for the future of research on how multimedia applications affect teaching reading and learning to read. First, more researchers and educators need to expand their conceptions of literacy to include multimedia forms of reading and writing and to accept that these forms have implications for virtually every aspect of teaching reading and learning to read. Although there have been continual calls to do so (e.g., Lemke, 1998; Leu & Reinking, 2004; Reinking, 1995), the field has been slow to respond. It seems difficult for literacy researchers and educators to abandon conventional print-based ideas and topics centered in the alphabetic code. For example, the concept of textual difficulty in terms of decoding and comprehension is central to long-standing conceptions of reading pedagogy (e.g., matching readers to texts in terms of difficulty). However, what makes a text difficult when readers have the option of hearing the pronunciation of a word they cannot decode or seeing a video that explains the meaning of an unfamiliar word?

A second and related issue is determining what skills and orientations reading teachers might teach to develop students' abilities to read multimedia texts, particularly on the Internet, which is increasingly a mainstream context for reading. What strategies are students using and what strategies are useful in processing multimedia information on the Internet? What criteria might be used to evaluate the reliability of such information? These and similar questions for the most part await empirical investigation among elementary and middle school students. Preliminary work has attempted to provide a theoretical orientation within which these questions might be framed in relation to developing literacy in schools (Leu, Kinzer, Coiro, & Commack, 2004).

A third issue revolves around the following question: How might promising instructional activities related to multimedia forms of reading be integrated into the language arts curriculum and instruction? This question is critical given the investment of many educators in traditional models of schooling and conventional print-based literacy, the consequent slow pace of technology integration in teaching reading (see the International Reading Association, 2001), and the potentially radical changes in curriculum and instruction implied by digital access to multimedia sources of information (see standards established by the International Society for Technology in Education, 2002).

Research has established convincingly that simply making available new applications and activities involving computer-based technologies does not alone insure that they will be integrated effectively into instruction or that they will be used to promote new visions of language arts instruction. For example, Bruce and Rubin (1993) found that teachers used a computer-based application designed specifically to promote reading and writing for authentic purposes but they used it in a way that addressed their commitment to more conventional instructional goals and that was contrary to its intended purposes. Likewise, research has consistently shown that effective integration of new technologies in schools is related to teachers' beliefs about technology and about instruction and to a host of contextual factors that affect teaching and learning in schools (Ertmer, Addison, Lane, Ross, & Woods, 1999; McGee, 2000; Windschitl & Sahl, 2002; Zhao, Pugh, Sheldon, & Byers, 2002). One framework has been proposed for facilitating integration among literacy educators who as a whole are likely to be invested in printed materials (Reinking et al., 2000). Another dimension to facilitating integration of multimedia materials and activities into literacy instruction is to engage preservice teachers in exploring possibilities in programs of teacher education.

In the final analysis, knowing how multimedia might affect learning to read is not enough to insure that it will. We need research and methodologies that allow us not only to understand the implications and possibilities that multimedia forms of communication suggest for learning to read, but

that also allow us to understand how we can effectively use that knowledge to effect positive changes in how it is taught in schools. Formative experiments contextualized in authentic school settings have been shown to be well suited for studying how technology can transform instruction (e.g., Reinking & Watkins, 2000). In the end, because learning to read takes place in schools, knowing how multimedia interacts with learning to read is as much about understanding schools as it is about understanding how multimedia changes texts and how students read them.

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