Media-rich Paper: Enhancing Reading Comprehension through Touch User Interface Technology

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Abstract
The current paper summarizes the problem of K-12 students' comprehension of text. In an effort to improve reader understanding the publishing industry has adopted numerous research-based recommendations to facilitate learning by including visual elements that supplement text: graphic organizers; pictures; graphics; and digital audio and video supplements. Numerous research studies support the supplementary use of visual/video and audio adjunct elements to support students' learning of content. Despite these improvements a major dilemma remains: How can text seamlessly intertwine with digital content? Separately packaged video, audio and computer programs fail to connect a reader immediately to digital content *during* the actual text-based reading process. One possible technological solution to this problem is Touch-User-Interface (TUI) paper-to-digital content books. *Media-rich Paper* consists of paper pages, exactly like those contained in a book, except that the paper lies on top of touch-sensitive panels programmed to connect instantly to the digital realm via a companion computer. Such a seamless connection might improve reading comprehension for all learners. A dual *call* is articulated for: (1) the development of this technology specifically for improving reading comprehension; and (2) the technical evaluation of the affect of TUI/*Media-rich Paper* on reading comprehension achievement.

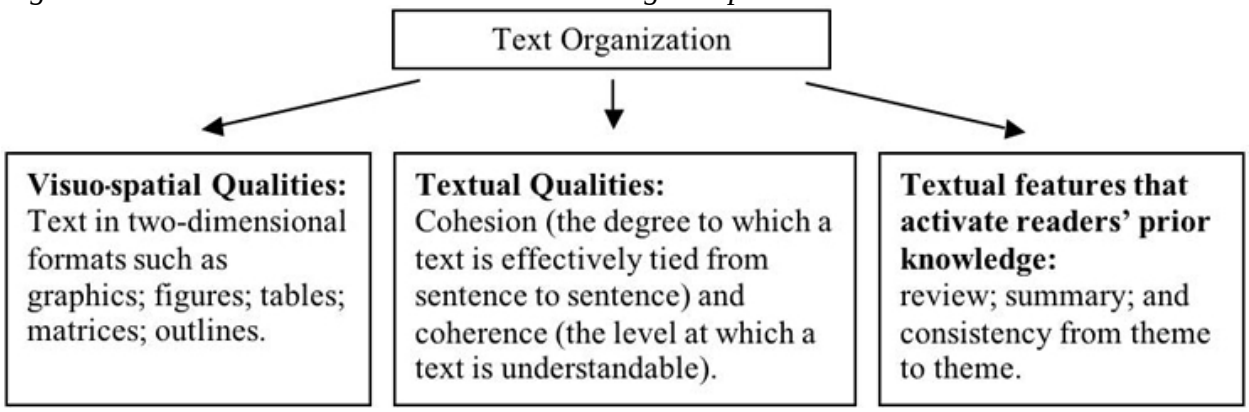
The Age-Old Problem: Reading for Understanding is Not Easy

Decade after decade since the late 1980s national assessment results consistently reveal that K-12 students in the United States suffer from low reading scores, particularly when those scores are compared to other industrialized nations (Congressional Record 1987). Reading has been defined as constructing a mental representation of textual information and its interpretation (Van Keer 2004). A significant segment of poor reading performance can be attributed to those students classified as: (a) behaviorally disabled or educationally disabled, (b) coming from homes where English is a second language (ESL), (c) a bilingual family. These students struggle with reading performance and therefore the learning of content taught in the classroom (NCES 2004). The general educational issue of learning to read thus becomes a pressing issue for students classified and placed in special educational settings.

From Traditional Paper to Reading for Understanding with Hypermedia

Traditional paper texts have undergone extensive improvements in the last two decades as paper publishers have responded to the reading research by including visual qualities to aid in comprehension. Figure 1 summarizes these changes.

Figure 1. Textual Features That Facilitate Reading Comprehension.



Textbooks are the traditional way by which teachers convey information to students to supplement lecture. As educators struggle to improve instructional methods in the hopes of increasing learners' conceptual understanding and knowledge, many of these methods rely heavily on the use of text-based material. Newly developing technologies, namely hypermedia, have gained support in educational settings.

Beginning in the mid 1990s, researchers following the introduction of newly developed multimedia and hypermedia computer environments revealed how hypermedia enhances learning. In Ayersman's (1996) comprehensive review on the effects of hypermedia on learning he found that learning is enhanced through the use of multiple meaning-based symbol systems in multiple contexts. Ayersman found that hypermedia supported higher-order thinking by incorporating a wide array of information and content in the digital realm. Learner motivation and self-efficacy were found to be present in increasing levels, compared to purely text-based information. Takyioshi (1996) linked the process of writing, or the active creation of knowledge, with reading in hypermedia, thus pointing to a recursive process of understanding, analyzing, and re-learning information in non-linear formats. Other studies on the application of hypermedia (hyperlinked text, audio, video and graphics) learning technologies in classrooms have demonstrated increased student motivation (Mott and Klomes 2001), and found that students

labeled as high performers on standardized literacy achievement tests were positively correlated with student high performance in hypermedia-authoring (Mott, Etsler and Drumgold 2003). It is important to note that Mott and Klomes (2001) found that younger children (ages 6-8) preferred the concrete material of paper to hypermedia when producing narratives in a writing curriculum. Presently, there is no indication in the research literature that hypermedia environments, whether reading or writing, are inherently superior to paper-based materials in terms of contributing to higher achievement. Numerous studies have revealed that higher levels of student motivation and dispositions toward learning occur when students interact with hypermedia in a way which experimentation and discovery processes are supported (Coiro 2003). Higgins and Boone (2003) further discerned that special education students' reading comprehension was positively affected via student interaction with hypermedia presentation as measured with a reading comprehension aptitude test. It is possible that a new technologically-driven solution might be sufficient to bridge traditional text with hypermedia.

Seamless Reading: A Technological Bridge for Paper Texts and Hypermedia

While the use of computer-based materials increases, traditional textbooks and linear paper materials continue to be effectively used. It may be that neither paper-based nor computer-based information, both seemingly effective means of instructional design, provides the optimal mechanism for education and training of struggling readers with special needs. However, the two approaches can be synthesized into a seamless new technology that utilizes both paper and hypermedia. *Media-rich Paper* represents an integration of these technologies.

Figure 2. Child Combining Paper with Digital Media

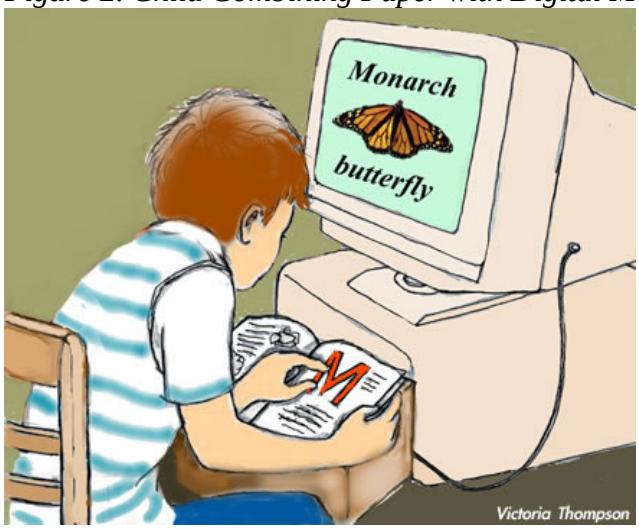
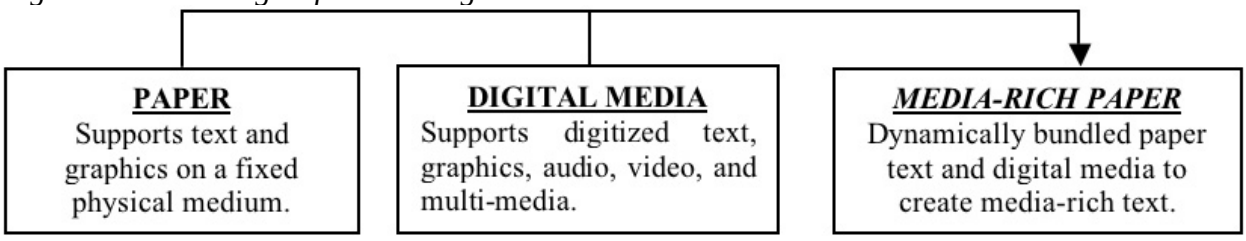


Figure 3. Combining Paper with Digital Media.



Touch-User-Interface and *Media-rich Paper* Technology Description

Media-rich Paper is enabled when traditional paper is placed on top of a touch sensitive interface. The reader touches any part of the page and an infrared signal instantly links from the coordinate to the digital realm via a companion computer. Thus traditional texts become digitally-enhanced paper capable of facilitating a wealth of activities. See Figure 4. *Media-rich Paper* Possibilities.

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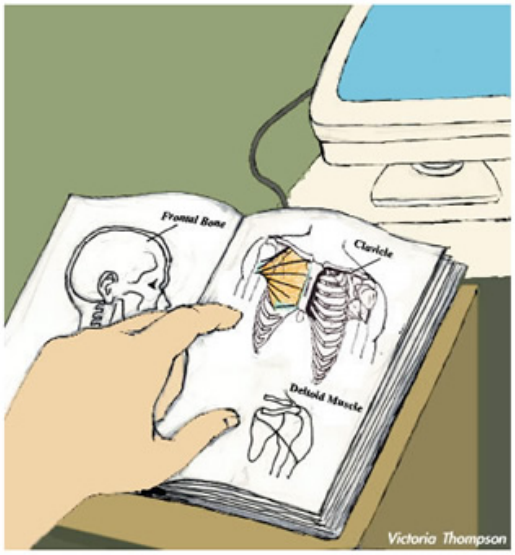
A *Media-rich Paper* book would function similar to an infrared remote control. In this case a person touching a grouping of words or graphics on paper activates digital media.



Media-rich Paper joins two separate entities: paper and digital. This is critically important due to the overwhelming consensus developed in expository reading research. Dynamic strategies such as re-reading, glossing (notes in margins that underline main points), scanning, and mathemagenic behaviors are strategies employed by textbook readers to gain comprehension (Rothkopf 1982). These strategies, while valuable, quick, and efficient, are not practical with most digital media. Envision quickly and purposefully thumbing though text looking for one important piece of information. *Media-rich Paper* gives students three options of one inclusive volume instantly at their fingertips. In the digital realm we scroll, click, scan, and search in hopes of finding that idea or passage on one of the hundreds of more or less linked pages.

From GUI to TUI

Graphical user interface (GUI) technology from the early 1960s proved to be a most desired computer operating environment and style (Preece, Rogers, and Sharp 2002). GUIs allow users freedom of choice in how to carry out computer operations (Schneiderman 2003). *Media-rich Paper*, while similar to GUI, supports icon driven navigation by linking digital pieces of information from traditional paper text. Thus, instead of using a mouse or other mechanical input device, a reader can point a finger to the text or graphic on paper to choose to follow a link to digital content. This technology, Touch User Interface (TUI), makes any text or graphic on paper function as a GUI icon that links paper with digital media.

TUI technology is quite commonly used. For example, when we cook popcorn in the microwave, we touch the “popcorn” button that relays a signal to the microwave processor to cook the corn

for a preset amount of time. *Media-rich Paper*, like TUI technology, has the potential to be a ubiquitous technology that seamlessly connects paper to the digital world in virtually every possible arrangement. A computer by design and intent should provide efficient and effective ways for completing any conventional task. Interfacing paper with the digital world further extends the way in which we use technology. Presently a commercial product implementing *Media-rich Paper*, called SmartPaper, is a device limited to less than 60 pages of paper text. (Barkaloo and McMahon, 2004).

While seamless connections of paper text to digital information should aid in student learning, there are, to date, no studies to confirm this. There is, however, evidence that the combination of multi-sensory activation of text and graphical imagery, (Pavio 1969) as well as current hypermedia computer-based environments (Takyoshi 1996), can increase the level of comprehension in learners. One can speculate that the act of reading seamlessly connected to digital content is likely to be enriched because the learners can process a multitude of meaning-based symbol systems in addition to text.

Media-Rich Paper and Comprehension of Text

Historically, understanding has often been evaluated through the examination of a learner's reading comprehension. With computer technology, namely hypermedia, that has changed due to the nature of the environment in allowing the "reader" to also "write" via the self-selection of information and see text-based information as graphics and images. Reading comprehension can happen from (a) text alone; (b) hypermedia environments; and (c) reading with paper text and digital media.

Media-rich Paper and Hypermedia

In many states in the United States, when a new driver applies for a license, the state department responsible for motor vehicle administration requires the viewing of a DVD/video addressing the dangers of driving while intoxicated. Research on driver education addressing consequences of driving while intoxicated has supported the use of a wide-array of training materials versus solely lecture (Turrisi and Jaccard 1991). The DVD/video invariably contains interviews of law enforcement personnel, images, and graphic depictions of the potential consequences for engaging in the operation of a vehicle while influenced by alcohol or other identified substances. Additionally, potential drivers must pass a written test, with the aid of a booklet that addresses the rules of the road. Why are new drivers exposed to information in these multiple formats? Clearly, text on paper and digital information function to facilitate learning in powerful ways. Through the inclusion of paper and digital information in the above example, a bridge to individual learning styles improves learning by adding multi-modal elements that strengthen comprehension through the use of verbal/textual and spatial representations which ultimately make complex information easier to comprehend.

A related and similar technology to both hypermedia and *Media-rich Paper* is the Whiteboard. Although not paper, the whiteboard extends the hypermedia environment by offering a concrete physical surface for learners to manipulate with touch and pen marking capabilities. This is accomplished via the use of the computer image projected onto a touch sensitive "board." Wickall (2004) describes how deaf and hard-of-hearing students share information with their classmates and teacher using the interactive Whiteboard. While remaining seated students and teacher can see the computer with content information on the Whiteboard while viewing sign

language from their teacher. Through this type of TUI, students see, discuss, and manipulate text and graphical elements as a community of learners.

Potential Uses of *Media-rich Paper* Books

Virtually any body of knowledge, could theoretically benefit from experiencing information in multiple formats. *Media-rich Paper* could connect to Whiteboards for whole class discussion while still allowing individual students to self-select information to display on their own computer. Providing all learners with multiple formats to comprehend text should increase comprehension. (Pavio 1969; Banotai 2004; Takyoshi 1996). Figures 5 and 6 show examples of the way in which *Media-rich Paper* can function.

Figure 5. Potential Media-rich Paper Phonics Book-Sample Page for Emergent Readers in Kindergarten.

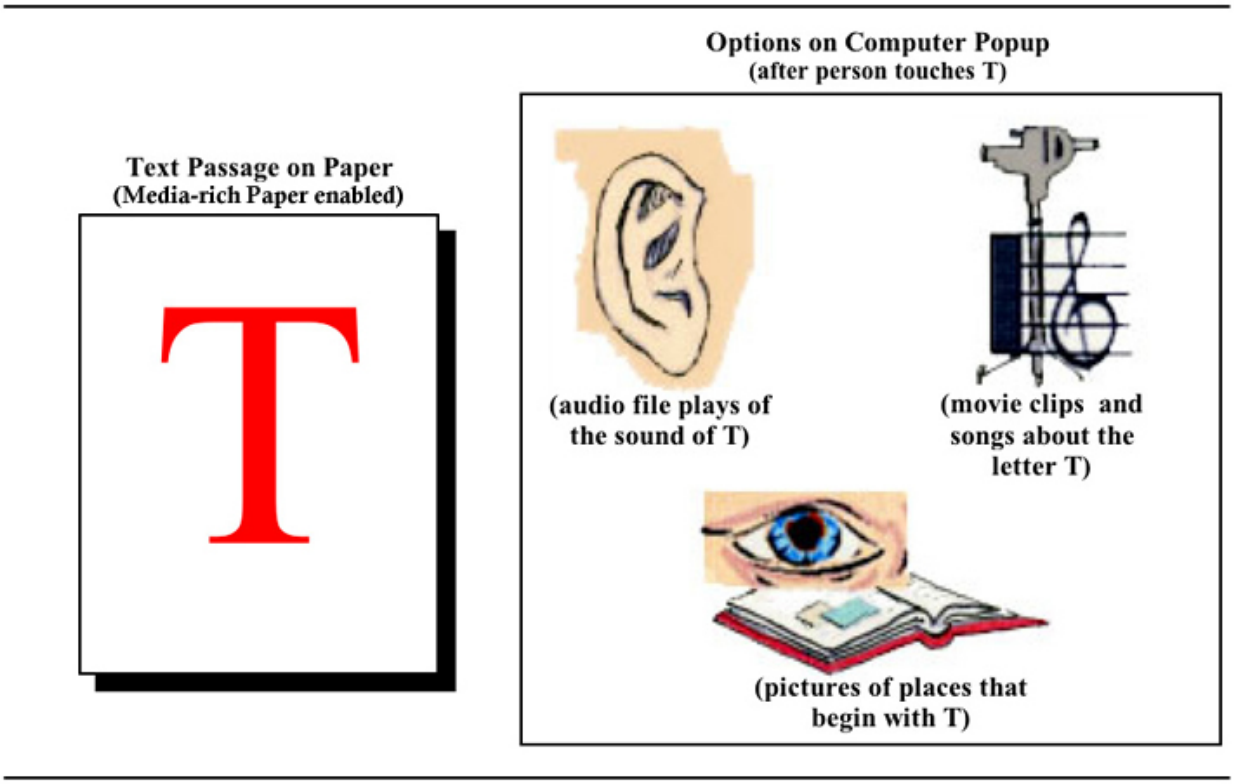
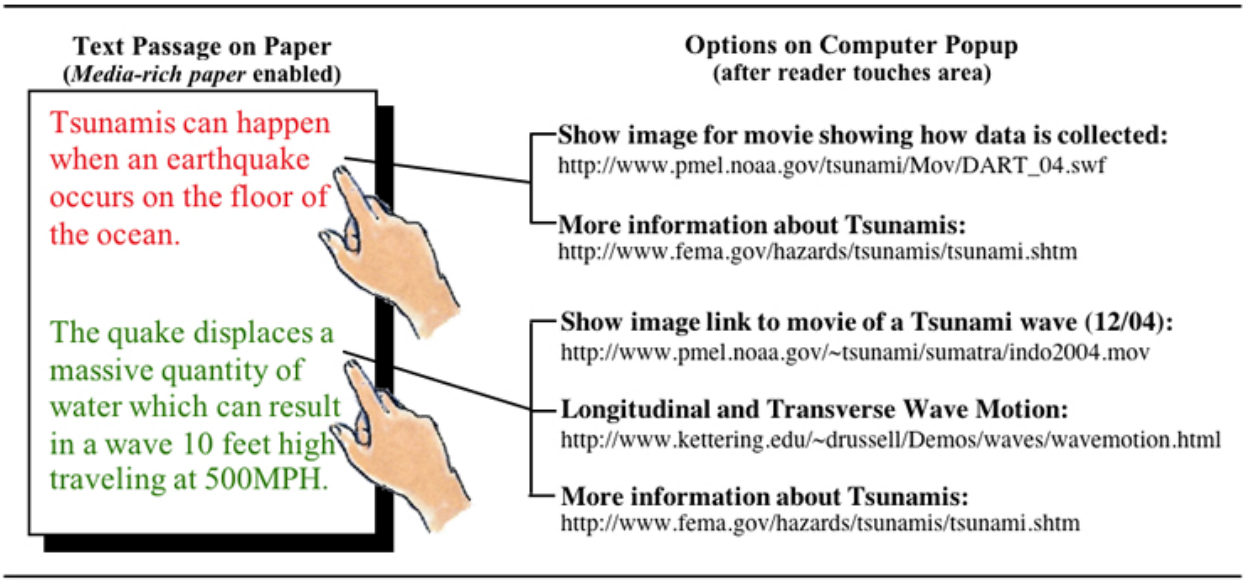


Figure 6. Potential Media-rich Paper Textbook Model for a Science Passage about Tsunamis.



Future Considerations

The synergistic seamless combination of paper with digital media presents a potentially powerful avenue for delivering and facilitating content through two research-based modes and environments of instruction: text comprehension and hypermedia effects on learning. *Media-rich Paper* has the potential to support reading comprehension in a multifaceted manner, textual and multi-media. Pavio (1969) research showed how both text and visuals increased comprehension. With *Media-rich Paper*, texts extend beyond static visuals towards dynamic sights and sounds, revised texts, and 3-D graphics. The opportunities for extending the text become a function of the user.

There exists an acute and perpetual societal need to improve reading comprehension for all individuals. As agencies struggle to raise reading comprehension, there is clearly demonstrated need to pair new dynamic technologies that can foster comprehension to traditional text reading. Researchers should begin critically and technically to evaluate *Media-rich Paper* technologies to determine their effectiveness. If found to be effective, researchers should focus on the best means of implementing this technology into learning environments.

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Biographies

Michael S. Mott is an Assistant Professor of Literacy and Early Childhood Education at Purdue University Calumet. He holds a PhD in Curriculum and Instruction from Mississippi State University and a Master of Science in Early Childhood and Elementary Education from Bank Street College of Education. Prior to his arrival at Purdue, Mott was the Coordinator and Assistant Professor of Early Childhood Education at Governors State University and the Director of the Four College Child Care Initiative. Current interests include the research, development and application of *Media-rich Paper* texts toward the improvement of teaching and learning literacy in K-12 and higher education. Mott is a former New York City Public School teacher and presently has teaching licenses in Mississippi and New York.
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Vicki Thompson is a graphic artist who received her training at the Philadelphia University Museum School of Art. She earned bachelor's and master's degrees in education at Indiana University. Thompson taught Art at Junior High and Middle School for twenty-six years. She also taught Computer Graphics to all ages of students, and was the presenter at several conferences on Computer Graphics. Her school system sent her to London, England, to present at an international conference on computers. Along with her drawing and painting skills, she is a published author of fictional novels.

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