COMPARING THE READABILITY OF TEXT DISPLAYS ON PAPER, E-BOOK READERS, AND SMALL SCREEN DEVICES

Rebecca Dawn Baker, B. S.

Dissertation Prepared for the Degree of

DOCTOR OF PHILOSOPHY

UNIVERSITY OF NORTH TEXAS

May 2010

APPROVED:

Cathleen A. Norris, Major Professor
Demetria Ennis-Cole, Committee Member
Brian O'Connor, Committee Member
Robert J. Pavur, Committee Member
Linda Schamber, Interim Chair, Library and Information Science
Herman L. Totten, Dean of the College of Information
Michael Monticino, Dean of the Robert B. Toulouse School of Graduate Studies

Baker, Rebecca Dawn. Comparing the Readability of Text Displays on Paper, E-Book Readers, and Small Screen Devices. Doctor of Philosophy (Information Science), May 2010, 50 pp., 9 tables, references, 115 titles.

Science fiction has long promised the digitalization of books. Characters in films and television routinely check their palm-sized (or smaller) electronic displays for fast-scrolling information. However, this very technology, increasingly prevalent in today's world, has not been embraced universally. While the convenience of pocket-sized information pieces has the techno-savvy entranced, the general public still greets the advent of the e-book with a curious reluctance. This lack of enthusiasm seems strange in the face of the many advantages offered by the new medium – vastly superior storage capacity, searchability, portability, lower cost, and instantaneous access.

This dissertation addresses the need for research examining the reading comprehension and the role emotional response plays in the perceived performance on e-document formats as compared to traditional paper format. This study compares the relative reading comprehension on three formats (Kindle, iTouch, and paper) and examines the relationship of subject's emotional response and relative technology exposure as factors that affect how the subject perceives they have performed on those formats.

This study demonstrates that, for basic reading comprehension, the medium does not matter. Furthermore, it shows that, the more uncomfortable a person is with technology and expertise in the requested task (in this case, reading), the more they cling to the belief that they will do better on traditional (paper) media – regardless of how well they actually do.

ACKNOWLEDGEMENTS

I would like to express my gratitude to the following individuals and entities that made this dissertation possible:

- UNT: Dr. Cathie Norris for her enthusiasm for and exceptional understanding of this topic. Dr. Robert Pavur for offering his class as well as his unmatched insight into the data itself and his unfailing steadfast support of my efforts. Dr. Demetria Ennis-Cole for making it possible for me to traverse the hurdles put in front of me during my pursuit of this degree and for giving me an opportunity to explore new areas of knowledge. Dr. Brian O'Connor for unfailing faith in my abilities and for his insightful questions that added both depth and relevance to this work. Dr. Linda Schamber for her invaluable help in navigating the labyrinth of requirements and for supporting me throughout my time at UNT. Diane Greene for making sure all the i's were dotted and t's were crossed. Student participants in the study for their time and enthusiasm.
- Family and Friends: John Baker for his love, his unquestioning support of this pursuit, and his belief in me. My parents for instilling in me the belief that I can do anything I set my mind to and providing the tools to make that possible. Dr. Joy Aswalap for her yeoman work in assisting with data collection and entry and her steadfast friendship. Dr. Abdelhak Bensaoula for setting my feet on this path.
- CA: Dr. Roman Longoria, Dr. Esin Kiris, and Joanie Norwood - for the time, money, and moral support to complete this degree.
- And God, for blessing me with the wisdom and strength to pursue and complete this effort.

TABLE OF CONTENTS

ACKNOWLEDGEMENTS iii

LIST OF TABLES v

CHAPTER 1 INTRODUCTION 1

- Reading Devices 2
- Overview of Research 4
- Summary 5

CHAPTER 2 LITERATURE REVIEW 6

- Reading 6
- Current Research 11
- Emotional Reactions 14
- Summary 16

CHAPTER 3 METHODOLOGY 17

- Formats 17
- Participants 19
- Ethical and Privacy Considerations 21
- Testing Materials 21
- Procedure 23
- Summary 23

CHAPTER 4 DATA ANALYSIS 24

- Hypothesis 1 25
- Hypotheses 2 and 3 26
- Hypotheses 4 and 5 27
- Additional Analysis 28
- Additional Observations 29

CHAPTER 5 CONCLUSIONS 31

APPENDIX DATA COLLECTION MATERIALS 34

- Demographics and Technology Background 35
- Perceived Performance 36

REFERENCES 38

LIST OF TABLES

Table 3.1 Demographics (in %) 20
Table 3.2 Technology Familiarity 20
Table 4.1 ANOVA on Perceived Performance with Device as a Factor and Controlling for Effect of Subject 24
Table 4.2 ANOVA on Actual Performance with Device as a Factor and Controlling for Effect of Subject 25
Table 4.3 Actual Performance Scores 26
Table 4.4 Perceived Performance Scores 26
Table 4.5 Perceived Performance by High and Low Technology Affinity 27
Table 4.6 Perceived Performance by High and Low Reading Affinity 28
Table 4.7 Significance of Survey Demographic Variables in Predicting Overall Perception of Performance 29

CHAPTER 1

INTRODUCTION

Science fiction has long promised the digitalization of books. Characters in films and television routinely check their palm-sized (or smaller) electronic displays for fast-scrolling information. However, this very technology, increasingly prevalent in today's world, has not been embraced universally. While the convenience of pocket-sized information pieces has the techno-savvy entranced, the general public still greets the advent of the e-book with a curious reluctance. This lack of enthusiasm seems strange in the face of the many advantages offered by the new medium – vastly superior storage capacity, searchability, portability, lower cost, and instantaneous access. Popular opinion seems to be that the smaller displays are more difficult to read, hence the public's reluctance to rush to take advantage of it (Roush, 2009). However, this assertion remains largely untested. Text display studies have focused primarily on screen and paper, with little-to-no data gathered on Portable Digital Assistants (PDAs), the Apple®[1] iPod®, e-book readers, or cell phones. A more likely reason for the slow acceptance of this medium is the emotional response elicited when abandonment of paper medium is suggested (Mangen, 2008).

With technological advances speedily removing issues of physical display (Smashwords, 2008), we are left to overcome the issues of design and desire. The book paradigm has hindered developers' ability to design good electronic displays as well as society's ability to accept them and writers' ability to take advantage of them (Nielsen,

[1] Apple Inc, http://www.apple.com/

1998). No one ever says they want to “curl up with a good screen.” The motivation to use the technology must be present before it can be accepted on a wide level – and motivation does not come from the medium, but rather from the individuals using that medium and can be as widely varied as they are. For example, the ability to make an annotation is important for education purposes but the ability to search things quickly is important for business decision-making purposes. Similarly, portability and display quality are more important for pleasure reading.

Reading Devices

Numerous devices have been created to display e-books with varying degrees of market success. The size and potential of the e-book market, in light of traditional publisher’s initiatives, independent e-publishing, and digital distribution, provides new incentives for publishers to go through the “trouble” of publishing digitally. (Fischer & Lugg, 2001; Lloyd, 2002). Acceptance of this type of media seems to have been wider in schools (Greco, Jones, Wharton, and Estelami, 2007, Buzzetto-More, Sweat-Guy, & Elobaid, 2007, Nicholas, Rowlands, Clark, Huntington, Jamali, & Olle, 2008) where the distribution of books via an electronic medium provides a definite advantage for teachers and students alike, although some reluctance remains (Young, 2006; Rowlands, Nicholas, Jamali, & Huntington, 2007; Carlock et al, 2008). The environmental movement has also speeded acceptance of these paper-less formats (Jacob, Janicke, Beise, Blazejczak, Edler, Haum, Low, Petschow, & Rennings, 2005) touting the lower ongoing physical footprint as well as the minimal impact on the environment.

Burk (2001) reviews some of the aspects of e-book evolution, starting with the introduction of the Rocket e-book (now defunct). Noting that the industry supports the development of both software (Microsoft®[2] and Adobe®[3] Systems) and hardware (Gemstar, Franklin[4], and Cytale) to enhance the reading experience through superior designs, Burk says the e-book market continues to be quite small, with the exception of institutional purchases of netLibrary titles. Digital rights management issues provide significant barriers to making the e-book form accessible. Publishers become their own worst enemy as fear of content piracy shackles the output availability. Since Burk's review, the e-book market has blossomed (Poremba, 2008; Sontag, 2008) due in large part to dedicated e-book readers such as the Amazon.com®[5] Kindle™ and Sony™[6] Reader, and to the popular *keitai shousetsu* (Wikipedia, 2009), or cell phone novels, in Japan – books that are both read and authored on a cell phone. Certainly self-publishing, supported by companies like Amazon, is much easier with e-books, and is fast becoming a popular way for new authors to be "discovered." A more recent review of e-books by Towle, Dearnlley, and McKnight (2007) acknowledges the growth of the e-book market, but confirms many of the issues Burk noted, specifically with regard to digital rights management.

Asserting that the Internet generation is the first generation in history that has been "information shifted" since birth and expects it, Levine (2002) examines this concept in terms of the portability of libraries, i.e., information. He explains that the library in 2002 is portable via e-mail, Web site, remote access to databases, Internet-

[2] Microsoft Corporation, http://www.microsoft.com
[3] Adobe Systems Incorporated, http://www.adobe.com/
[4] Franklin Electronic Publishers, http://www.franklin.com/
[5] Amazon.com, http://www.amazon.com/
[6] Sony Corporation of America, http://www.sony.com/

accessible catalogs, and instant messaging and states that the even-more portable library could now include integrated instant messaging, wireless access, e-books, MP3 files, PDA channels, Webcams, and videoconferencing, and distance education. Certainly, the interest of digitalizing libraries is a prevalent theme throughout the literature, with many studies done on the acceptance and acceptability of the e-book (Hattery, 2001, Dowdy, Parente, & Vesper, 2001, Lonsdale & Armstrong, 2001, Wilson, 2001, Gibson & Ruotolo, 2003, Costello, Lenholt, & Stryker, 2004, Clyde, 2005, Fialkoff, 2008). These studies generally suggest that library patrons are already using e-books on their computers with some frequency.

Overview of Research

This dissertation looks at the differences in reading comprehension when using paper, a dedicated e-book reader (specifically, the Amazon Kindle 2), and a small screen display (specifically the Apple iPod touch®) as well as the subject's perception of their performance in each medium, their affinity with technology and with reading, and their general technology exposure or background.

Hypothesis 1: Reading comprehension will be equal on all three, with no testable differences.

Hypothesis 2: Subjects with high technology affinity will believe they have performed better on newer technology formats, with the iPod touch being perceived as the newest format, followed by the Kindle.

Hypothesis 3: Subjects with low technology affinity will believe they have performed better on paper.

Hypothesis 4: Subjects with low reading affinity will believe they have performed better on newer technology formats, with the iPod touch being perceived as the newest format, followed by the Kindle.

Hypothesis 5: Subjects with high reading affinity will believe they have performed better on paper.

Summary

This chapter discussed the potentials of online reading as well as the development of devices used in this field. It has outlined the proposed study and the hypothesis used as a basis for that study. The potential for e-books in school settings has been well-outlined, but the emotional reaction of students to this new medium and how that may affect their performance on it remains unexplored. This dissertation seeks to close that gap, examining participant's technology and reading affinity and comparing this with their actual and perceived performance on a simple reading comprehension test using three different formats for presentation: paper, e-book reader, and small screen display device. The results of this research can inform educators about potential emotional challenges of adopting e-books and e-documents in their classrooms that lay outside the obvious financial and implementation issues.

CHAPTER 2

LITERATURE REVIEW

This chapter reviews the literature relevant to reading, online reading (including design concerns), and the effect of emotion and motivation on reading with technology. I collected the literature I have presented using electronic bibliographic databases as well as print and electronic journals. While most of the references are peer-reviewed articles, some trade magazines and informal communications, such as website reviews, are included.

Reading

Reading online has had a history of drawbacks and limitations. Physical displays have had difficulty matching the resolution and portability of paper. Traditional design techniques have difficulty translating into the online media. And slow acceptance of new presentation formats reflects a strong desire to remain with the known, visceral, and traditional format of paper.

To understand online reading, first we must understand the history of how reading is evaluated from a traditional paper medium (Tinker, 1965). Dillon (1994) discusses reading as being evaluated from two facets: process and outcome. The process of reading includes eye movement, manipulation of the text, and navigation of the physical medium. This aspect of reading has to do with the physical aspect of display and portability. The outcome of reading includes speed, proof-reading accuracy, fatigue, comprehension, and preference. This aspect of reading has to do

with the mental processing of the physical display. Most reading tests incorporate some aspects of each of these facets, but generally concentrate on one or the other.

When reviewing the literature on reading, two distinct aspects of reading measurement immediately come to the surface: readability and legibility. Readability refers to how easy it is to understand something you are reading and includes the measure of reading comprehension. Legibility refers to whether you can identify individual letters or characters. These two measures are related, but provide different foci for researchers. (Mills & Weldon, 1987; Zakaluk & Samuels, 1988)

Many readability tests in the literature are concerned more with the vocabulary presented to the reader rather than the medium in which the text is presented. Readability tests that focus on vocabulary most often use reading comprehension or speed reading tests. Chall (1995) presents a comprehensive review of the available readability formulas in this area as well as a discussion of readability measures that look at the difficulty of reading based on vocabulary and grammatical structure.

Some researchers recognize the relationship between the two ideas and have tried to separate the deployment of the text from the appearance of the page. Gropper (1991) discusses how text display affects the learnability of concepts – an interesting approach as it deals with the cognitive aspects of how we read in relation to the physical display.

The way in which we learn to read, both as a physical and a cognitive process, is a subject of much research (Robeck & Wallace, 1990). Everything from the optimal font (Boyarski, Neuwirth, Forlizzi, & Regli,1998) to the best line length (Dyson & Haselgrove, 2001) has been examined. What the research tells us is this: there are limitations, both

physical and cognitive, on reading. We can only see so much and we can only understand so much - we are limited in our ability to process information effectively. Studies (Sternberg, 1999) have shown we can see and comprehend information from about 4 characters to the left of a fixation point (the point at which your eye naturally rests on the line of text) and 14 characters to the right. That means we have, approximately, 19 characters worth of information we can process at any one time. Optimal reading speeds tend to be 90 and 130 words per minute (wpm) (Meyer, 1999). Add to this issues with lighting (we require light to see) and focal distance (differs from person to person) (Hennings & Ye,1996). It is from these limitations that we must begin our understanding of online reading.

Historically, online documentation has had numerous physical display issues (Wentorf, 2001; Bolter, 1991; Haas, 1996). Screens were consistently less-readable than paper equivalents (Nielsen, 1998) and hardware was not always readily available. Computers themselves were large and unwieldy – unlike their highly portable paper equivalent; you could not take an electronic document home or flip through it in bed. It was difficult, at best to annotate the documents (O'Hara & Sellen, 1997). Often, notes had to be made on a piece of paper that was irrevocably separate from the original document. Finally, the availability of the documents themselves was dependent on the availability (and stability) of the computer – meaning the information that would help you fix the program that just crashed was unreachable until you fixed the program that just crashed.

The opportunity to read online increases as the prevalence and availability of computers and other electronic reading devices increases. According to the

Department of Commerce (2000), there were 116.5 million Americans online at some location in August 2000; 31.9 million more than there were only 20 months earlier. In 2003, the Census Bureau reported that over half (roughly 63%) of the households in the United States had a computer.

Wilson (2001) discusses the availability of e-book readers in the UK, noting that a variety of e-book reading software can be downloaded to PDAs for free via the Internet and that some Microsoft® Pocket PCs are being sold pre-installed with the Microsoft® Reader. He places these developments in context by outlining the evolution of the portable e-book from its original conception in the 1960s through to the models available today, and on to the possible directions the design of these devices may take in the future.

Brown (2001) reviews the development of reader devices and improvement of screen technology, noting that these advancements have made reading from screens less cumbersome. Software created for e-books now provides different levels of navigation support for the manipulation of digital text, giving e-books a distinct advantage over their paper cousins. Advances in displays, both in clarity and portability (Schilit, Tanaka, and Marshall,1999, Graham-Rowe, 2007) have greatly improved the legibility of texts on screens. Features such as backlighting provide a decided advantage over the paper medium while improved editing programs allow you to annotate text easily. The introduction of commercial e-books, cyber cafes, and e-zines has made the electronic media nearly as pervasive as paper. With the introduction of portable digital assistants (PDAs) and other small screen devices such as the Apple®[7]

[7] Apple Inc, http://www.apple.com/

iPod touch® and iPhone®, electronic documents can now be positioned for optimal ergonomic comfort (O'Hara & Sellen, 1997).

Brown (2001) goes on to say:

> The parameters of e-text reading and the issues of access remain central to readers and researchers, whether the electronic text is designed and packaged as an "e-book" for portable reading devices, or resides on a server for distribution to library terminals to be downloaded to desktop PCs, laptops or tablet PCs. The power and functionality of reading software - note-taking, highlighting and indexing capabilities, robust open searching across databases - are ultimately linked to open access issues: interoperability, text standards, and digital rights management. These remain key questions for libraries, publishers and researchers.

Initially, writers and readers were unsure of what to make of the new electronic medium and the new possibilities it opened for information design (Schamber, 1996). Writers tended to fall back on the familiar book design – often with disastrous results. The potential for hypertext and the resultant design issues were only beginning to be understood (Nimwegen, Pouw, & Oostendorp, 1999; Lehto, Zhu, & Carpenter, 1995). Initial hypertext designs were actually found to be less efficient than linear equivalents (Rouet, 1992). Search engines, still in their infancy, provided more frustration than answers (Bates, 1990; Northrup, 1994). Information designers, still unsure of their role, struggled to define their discipline and acquire the necessary tools to handle the fast-growing medium (Holtzmann, 1993).

As the electronic document has slowly been accepted as a unique design challenge, researchers have moved forward to gain an improved understanding of hypertext navigability and usability (Hornbæk & Frøkjær, 2001; Toms, 2000). Recent studies have shown equal, and at times superior, comprehension for information displayed as electronic documents for younger participants (Meyer, 1999). Tools are

also being developed to support redesign and single sourcing necessary for effective online usability better understood as it applies to information design and efforts have been made to test information designs (Scanlon, 1996) and develop heuristics (Sukach, 2002). Further studies have looked at the use of layering, both within electronic documents and between electronic and paper documents, to improve readability and accessibility (Farkas,1998). As technology continues to advance, researchers have started looking at the design challenges of interactive documents (Macy, Anderson, & Krygier, 1999).

Perhaps one of the most challenging issues facing information designers is teaching ourselves and each other to think in new ways (Matson, 2001). By recognizing our current prejudices based on past experience and realizing that those experiences may not hold for new formats, we can successfully redefine and redesign information in the best way for our readers (Zimmerman, 2001).

Current Research

Research in information design and online reading struggles to keep pace with new developments that seem to appear daily. Multimedia enhancements provide new possibilities for the depth of electronic documents and the ability to provide real-time updates allows us to move toward a more interactive communication with the reader. Popular opinion continues to be that the e-book can do better (Costa, 2008).

While studies have been done on text interactions with pictures and other multimedia forms (Schriver, 1996), more work needs to be done on how people interact with text and images (Liew, Foo, & Chennupati, 2001). User participation in the text environment – allowing the reader to interact with and alter the text through their own

experiences – has already been seen, in a limited way, in message boards. As electronic communication continues to evolve, we may find new ways to define electronic documentation (Crystal, 2001).

Currently, help systems for software applications must be created so that they may be applicable to all users. This homogeneous approach limits the usability of such systems - advanced users must filter through basic answers, novice users must learn Boolean search patterns, and so on. A help system, customized to the individual user, would be more accessible and useful to users of all levels. Intelligent agents and concept-indexed databases hold the key to creating this type of customizable system. Through reasoning algorithms (Santos & Badres 1994), we can teach agents about a given user's search patterns. In this way, the agent can provide more accurate returns for future searches. As we improve our understanding of how to optimize displays and designs for reading, we in turn, begin to better understand how we cognitively process text (Meyer, 1999).

Standards are being developed in five primary areas of e-book development: e-book formats, digital audio formats, digital rights management languages, digital rights management systems, and distribution and promotion. Each of these standards has technological, economic and social aspects. Coyle (2001) describes some key e-book standards and discusses how these aspects are shaping the emerging e-book products.

Current studies on design focus on specific software formats such as Visual Book and Hyper-Text Book (Crestani, Landoni, & Melucci 2006) or display hardware,

such as the Amazon®[8] Kindle™ (Clark, Goodwin, Samuelson, & Coker 2008; Hastings, 2008; Nielsen, 2009).

A few studies focus on more generalizable design issues, such as the affect of context on e-book use (Barnard, Yi, Jacko, & Sears 2007, Morineau, Blanche, Tobin, & Gueguen 2005).

Mills & Weldon (1987) provide a thorough review of studies that compare the readability of paper and screens. This review begins by looking at the papers that have been done comparing the readability of paper and screens, then examines papers that deal with the factors that may cause the differences seen in the studies – specifically the characters in the display, the format of the display, the display contrast, and the dynamic nature of the display.

Dillon (1984) discusses the differences of paper and screen as being physical and cognitive in nature. He looks at refresh rates, angles and distances, and fixation points from a physical standpoint. Cognitively, he considers visual memory for location, searching, and experience with the media.

In Mohageg and Wagner's (2000) work, they look at what the designer needs when creating an effective interface for information appliances, such as e-book displays. They propose that designers should account for the target domain – that is, dedicated devices mean dedicated user interfaces, not the one-size-fits-all approach. They suggest that, in order to allocate function appropriately, devices must be simplified and optimized for responsiveness.

The small display size and superior resolution must be tested to optimize the potential of the PDAs and other small screen interfaces. It is not at all clear that design

[8] Amazon.com, http://www.amazon.com/

techniques that worked for standard computer displays will be scalable for the smaller screen. Current topics of research include optimal navigation of the display (Laarni, 2002, Mizobuchi, Mori, Ren, & Michiaki, 2002, Healthy Computing, 2002), fonts and display parameters (Oquist & Goldstein, 2002, Gallant, 2003, Oquist, Hein, Ygge, & Goldstein 2004, Kim & Lee, 2007, Park, Ann, Kim, Park, & Lee 2008, Strand, 2008) and information browsing design (Wobbrock, Forlizzi, Hudson, & Myers, 2002, Kim & Albers, 2002). The added advantage of ergonomic screen positioning should be considered as well when determining optimal design possibilities.

Shim (2003) experiments with the use of PDAs as a data collection mechanism in an information seeking study. No comments were made on the usability of the PDA interface, other than the eagerness of the participants to use the technology – an indication of the ready acceptance of the media.

Emotional Reactions

> Sirs, I have tested your machine. It adds a new terror to life and makes death a long felt want.
>
> *Sir Herbert Beerbolm Tree*
> *(after examining a gramophone player)*

Your desire to use something is closely related to how well you are able to use it (Norman, 2002). If you do not like a tool or find it in some way intimidating or alien, chances are you simply will not use it. Emotional reactions affect your ability to learn, your openness to new concepts, your ability to retain information, and your confidence (Schriver, 1996). Electronic documents were not, initially, very friendly. Stark black and white screen displays, cryptic messages, and a completely unfamiliar interface, made many people cling stubbornly to paper documents. As a result, a great deal of prejudice

and misunderstanding surrounds e-books and their various platforms (John & Tucker, 2003) – reactions often brushed aside by the technologically-savvy (Bergman & Haitani, 2000; Schulyer, 2003). This negative mythos combined with publisher concerns over control and publishing rights has slowed acceptance of e-books by the general populace, in spite of the economic advantages (Coyle 2001). However, an upsurge the popularity of smart phones, such as the iPhone, has had a significant impact on the public perception of e-books (Balas, 2007; Library Journal, 2008; Tennant & O'Reilly, 2008).

While your emotional reaction to a medium may slow your acceptance, motivation for reading also provides a significant contributing factor (Pumfrey 1997). Whether reading for pleasure, education, or business, can affect how the reader approaches the media. Indeed, the emotional reaction to the Kindle seems to be mixed, at best. Baker (2009) recalls one of her first experiences with the Kindle, outlining how a visceral emotional reaction can affect how you read:

> The Gluyas Williams drawings were gone from the Benchley, and even the wasp passage in "Do Insects Think?" just wasn't the same in Kindle gray. I did an experiment. I found the Common Reader reprint edition of "Love Conquers All" and read the very same wasp passage. I laughed: ha-ha. Then I went back to the Kindle 2 and read the wasp passage again. No laugh. Of course, by then I'd read the passage three times, and it wasn't that funny anymore. But the point is that it wasn't funny the first time I came to it, when it was enscreened on the Kindle. Monotype Caecilia was grim and Calvinist; it had a way of reducing everything to arbitrary heaps of words.

Slow processing time (often caused by poorly designed documents, loaded with large, unwieldy graphics) has caused significant user frustrations in the past (Shneiderman, 1984). Coupled with the limitations of the device itself, motivation to use electronic documents was very low. The acceptance of electronic documents into one of

the most popular forms – the electronic or "digital" library has been very slow for resources other than journals. (Lonsdale, & Armstrong 2001) Soon, however, overwhelmed by the sheer volume of information that rapidly became available (Wurman, 1989), users began to see the advantages in both storage and information retrieval. With the advances in electronic displays (Kuhn, 2002; Hane, 2006; McClure, 2009), e-books on mobile devices are gaining acceptance in the general market. The advantages of this form factor for educational purposes is obvious, with superior portability, lower cost per volume, and minimal environmental foot print – some studies have already shown promise in this area (Bernard, Chaparro, Mills, & Halcomb, 2002, Young, 2009). Amazon.com has initiated pilot programs to look at the effect of using e-books and learnability, specifically with the Kindle DX®, a wider screen version of the original Kindle (Young, 2009). Libraries have been a significant testing ground for the e-book (Williams, 2003), making the educational arena all the more receptive to this media, and laying the groundwork for this study.

Summary

> The man who does not read good books has no advantage over the man who cannot read them.
>
> *Mark Twain*

This chapter reviewed the literature relevant to reading and online reading, including the acceptance of the current technologies available for e-document display. This chapter provides the basis for the proposed research and a framework for understanding the importance of emotional reaction and motivation to performance.

CHAPTER 3

METHODOLOGY

To address the need for research examining the reading comprehension and the role emotional response plays in the perceived performance on e-document formats as compared to traditional paper format, this paper compares the relative reading comprehension on three formats (two electronic and one paper) and examines the relationship of subject's emotional response and relative technology exposure as factors that affect how the subject perceives they have performed on those formats. This study uses a post-test only, randomized experimental design. Testing was carried out in one of two University of North Texas classrooms on weekends (by appointment) or after class (by opportunity) with standard classroom seating (fixed height desks and chairs) and overhead fluorescent lights.

Formats

Formats that were examined included:

- Paper

  Paper used for this experiment is 8.5" X 11" stock white paper printed with black text at 600 dpi using a 12 point Arial font.

- Dedicated e-book reader (Amazon®[9] Kindle™ 2)

  The Kindle is a dedicated e-book reader device designed to appear as close as possible to a book. It uses a display that is similar to paper in

[9] Amazon.com, http://www.amazon.com/

that it uses no backlighting. Resolution of the eInk®[10] display is 200 dpi (eInk, 2009). The advantage of the Kindle over a traditional paper presentation is primarily in storage and search capabilities – one device (8" X 5.3" X 0.36") can hold up to 1500 books, each of which can be searched using the native, full-text search capabilities. Manipulation of the text in the Kindle is performed using Prev and Next buttons to flip "pages" and a small 5-way controller for navigation within text and between menus. Reading selections were provided in a 12 point Arial font.

- Small screen device (Apple®[11] iPod touch®)

  The iPod touch is a small-screen, touch device, used for games, music, personal data organization, and reading. It uses a backlit display with excellent clarity of text - 480 X 320 pixel resolution, 163 dpi (Julie, 2007) - allowing users to read text in low or no light situations. The advantage of the iPod touch over traditional paper presentation is primarily in size – one device (4.3" X 2.4" X 0.33") can easily be put in the reader's pocket. Manipulation of the text on the iPod is performed using touch screen technology. Reading selections were provided in a 12 point Arial font, which could be adjusted by the reader using the Lexcycle[12] Stanza reading application. None of the participants in this study chose to adjust the font size. A number of reading applications are readily available for e-books. Amazon.com provides an e-book reading application that lets readers view Kindle books for the PC, Mac, and iPhone. Stanza was

[10] E Ink Corporation, http://www.eink.com/
[11] Apple Inc, http://www.apple.com/
[12] Lexcycle Inc, http://www.lexcycle.com/

chosen for this experiment to ensure the application displaying the reading selection was unique to small screen devices.

Participants

One hundred six participants were tested. Subjects were University of North Texas students drawn from a level-one statistics class and were offered 5 points extra credit for their participation in the study. Two students' results had to be excluded due to failure to fill out some of the materials completely. (The surveys were provided on double-sided paper and the students forgot to turn over the paper and complete both sides).

All participants had normal or corrected-to-normal vision and normal reading comprehension (as no special dispensations for testing or class work have been requested for anyone in the study population) such that the readability of the interfaces was tested, not the visual and mental acuity of the participants. I assumed that undergraduates in a level-one statistics class would not evince any pre-existing bias either toward or against reading e-books. In addition, I assumed that having students answer questions on paper (as opposed to the format in which they read the text or in a wholly different format) would not affect the validity of the test, either by affecting their ability to recall information from a different format or by introducing a bias.

Demographics breakdown of the participants was as follows:

Table 3.1

Demographics (in %)

Demographics		%
Gender	Male	52
	Female	48
English Familiarity	English as a Second Language	22
	English as a First Language	78
Age	18-24	87
	25-32	11
	33-42	2
Grade Point Average (GPA)	2.1 – 2.9	43
	3.0 – 3.9	56
	4.0	1
Academic Level	Sophomore	19
	Junior	72
	Senior	8
	Graduate	1

Table 3.2

Technology Familiarity

Technology	I have never used one	I have seen one used	I have used one	I own one
Computer	0%	0%	1%	99%
iPhone or similar	3%	7%	40%	50%
iPod or similar	1%	1%	26%	72%
e-Book Reader	56%	17%	25%	2%
GameBoy /handheld gaming device	5%	8%	50%	37%
Blackberry/PDA	7%	12%	41%	40%

Ethical and Privacy Considerations

Before the beginning of the study, the researcher obtained approval for this study from the institutional review board. All participants were briefed on what they would be doing, provided an opportunity to ask questions, and signed an informed consent form before participating in the test. After the test, all participants were given another opportunity to ask questions and were provided with the test administrator's email address if they were interested in receiving the results of the study. Each participant was assigned a randomly generated number at the time of their session. This number was the only identifying mark used in conjunction with their demographic and performance data. To ensure anonymity, no personally identifiable data were gathered or maintained. Participation in the test was recorded separately from the demographic and performance data and provided to the professor for assignment of extra credit points.

Testing Materials

Quantitative data collection was done using a paper-based reading comprehension test that was administered after the subject read the text selection on each of the proposed formats. Text selections were taken from the McCall-Crabbs Standard Test Lessons in Reading, Book F (McCall, M. & Crabbs, L., 1979). Six passages were selected for use on the main study (Test selections: 12, 22, 23, 41, and 56). The text of these selections and the associated tests can be found in the McCall-Crabbs Standard Test Lessons in Reading, Book F (McCall, M. & Crabbs, L., 1979) and is not reproduced in this dissertation due to copyright infringement issues. Text selections were chosen randomly from the book using a lottery system. Each selection

appeared in each of three outputs (print, Kindle, and iPod touch). The text selection, the output format and the order in which the output formats were presented was randomized based on a number given to the participant at the time of the study and a number given to the output selection. If more than one participant was tested simultaneously, the order of the output format was determined by the random selection for the first participant, followed by a coin toss to determine the format for the second participant, and an assignment of the remaining format for the third participant. Font size and type was chosen in accordance with the research in this area to represent the most readable font (Bernard, Liao, & Mills 2001, Bernard, Chaparro, Mills & Halcomb 2003) although it is worth noting that considerable controversy continues to exist in this area as to whether font size, within certain bounds, has any effect on the ease of text comprehension (Sheedy, Subbaram, Zimmerman, & Hayes, 2005).

Qualitative data regarding the subject's disposition toward technology was collected using the 15 point Technology Attitude Survey - Cronbach's alpha of 0.92, reliability coefficient of 0.88 (Maag, M. 2006).

Qualitative data regarding the subject's disposition toward reading was collected using the 40 point Adult Survey of Reading Attitudes - Cronbach's alpha of 0.93, reliability coefficient of 0.87 (Smith, M. 1990).

In addition, subjects were asked to rate how well they believed they did on each of the formats and their emotional reaction to those formats using a five question survey.

Procedure

Each participant was asked to read a text selection in one format and was then given a paper-based reading comprehension test taken from the McCall-Crabbs Standard Test Lessons (McCall, M. & Crabbs, L., 1979) for that text selection. They were given three minutes to complete the test. If they completed it before the three minutes passed, they indicated this to the test administrator by raising their hand and were provided the next text selection on a different format. This process was repeated for each of the subsequent formats, with a different text selection provided on each different format.

After completing the reading and test all three formats, participants were given forms to gather data on the following items:

1) Perceived performance (see the appendix)

2) Technology attitude (Maag, M. 2006)

3) Reading attitudes (Smith, M. 1990)

4) Demographic information (see the appendix)

5) Technology exposure (see the appendix)

Summary

This chapter detailed the post-test only, randomized experimental design that was used for this study on reading comprehension on two different electronic formats as contrasted with each other and paper.

CHAPTER 4

DATA ANALYSIS

Data from the actual tests and perceived performance were analyzed using a statistical experimental design to determine the significance of the proposed hypotheses. Results from the individual reading tests, the survey on technology affinity, the survey on reading affinity, and the question regarding perceived performance were analyzed using linear regression analysis to determine relationships between the experimental variables. The results of two ANOVA experimental designs in which technology format (reading devices) and subjects were considered treatments are presented in Tables 4.1 and 4.2 with response variables being perceived performance and actual performance, respectively. A significant difference exists among reading devices for perceived performance, but not for actual performance.

Table 4.1

ANOVA on Perceived Performance with Device as a Factor and Controlling for Effect of Subject

Source	*df*	Sum of Squares	Mean Square	*F* Value	*Pr > F*	*R*-Square
Model	105	124.836	1.1889	1.25	.0866	.39
Error	206	195.441	.9487			
Corrected Total	311	320.277				
Treatments						
Device	2	10.559	5.279	5.56	.0044	
Subjects	103	114.277	1.109	1.17	.1731	

Table 4.2

ANOVA on Actual Performance with Device as a Factor and Controlling for Effect of Subject

Source	*df*	Sum of Squares	Mean Square	*F* Value	*Pr > F*	*R*-Square
Model	105	312.929	2.98	1.72	.0005	.47
Error	206	357.365	1.73			
Corrected Total	311	670.294				
Treatments						
Device	2	5.97	2.98	1.72	.1816	
Subjects	103	306.96	2.98	1.72	.0006	

Hypothesis 1

Hypothesis 1 states: Reading comprehension will be equal on all three formats, with no testable differences.

Although the two ANOVA models presented in Tables 4.1 and 4.2 had overall significance for the treatments, significant differences in type of technology format occurred only for the response variable perceived performance. A Tukey multiple comparison test with a 0.05 significance level was used to indicate where the differences occurred in type of reading device. The Tukey multiple comparison test was selected as it controls for overall Type I error (familywise error). A Tukey multiple comparison test reveals that paper and Apple®[13] iPod touch® are significantly different at the 0.05 level, but that the Amazon®[14] Kindle™ did not differ significantly from the iPod touch or paper. Using performance based on their actual score from the reading comprehension test, this analysis found no statistically significant difference in the actual reading comprehension performance betwixt the three formats. See Tables 4.3

[13] Apple Inc, http://www.apple.com/
[14] Amazon.com, http://www.amazon.com/

and 4.4 for means and standard deviations of the actual and perceived performance scores, respectively.

Table 4.3

Actual Performance Scores

Device	Mean	Standard Deviation
Paper	6.587	1.532
Kindle	6.298	1.398
iPod Touch	6.288	1.466

Table 4.4

Perceived Performance Scores

Device	Mean	Standard Deviation
Paper	4.984	1.041
Kindle	4.719	0.838
iPod Touch	4.536	1.105

Hypotheses 2 and 3

Hypothesis 2 states: Subjects with high technology affinity will believe they have performed better on newer technology formats. Hypothesis 3 states: Subjects with low technology affinity will believe they have performed better on paper.

Students were categorized as being in a high affinity group if their technology affinity was above the median score (5.47) and in a low affinity group for affinity scores below the median with observations at the median removed. As displayed in Table 4.5, the average perceived performance score for the high technology affinity group is higher than the low technology affinity group for each device. However, only for the iPod touch was there a significant difference between the two groups. Using a 0.05 significance level, a Tukey multiple comparison test was performed to determine if there were any

significant differences across devices within the high technology affinity group. There were no significant differences across devices for this group.

A Tukey multiple comparison test was also performed to determine if there were any significant differences across devices but within the low technology affinity group. Within the low technology affinity group, paper and the Kindle were significantly different from the iPod touch at the 0.05 significance level. The Kindle did not differ significantly from the iPod touch or paper. Hypothesis 2 is not supported since within the high technology affinity group, performance did not significantly differ across the technology formats. Hypothesis 3 is partially supported since within the low technology affinity group, performance on paper was significantly higher than on the iPod touch.

Table 4.5

Perceived Performance by High and Low Technology Affinity

Device	High Tech Affinity	Low Tech Affinity	t Value	Pr > |t|
Paper	5.12	4.98	0.84	.4017
iPod Touch	4.96	4.19	3.53	.0007
Kindle	4.87	4.65	1.05	.2958

Hypotheses 4 and 5

Hypothesis 4 states: Subjects with low reading affinity will believe they have performed better on newer technology formats. Hypothesis 5 states: Subjects with high reading affinity will believe they have performed better on paper.

For this study, students were categorized as being in a high affinity group if their reading affinity was above the median score (3.6) and in a low affinity group for affinity scores below the median with observations at the median removed. As displayed in Table 4.6, the average for the high reading affinity group is higher than the low

technology affinity group for each device. However, only for paper was there no significant difference between the two groups. A Tukey multiple comparison test was performed to determine if there were any significant differences across devices but within the high reading affinity group. There were no significant differences across devices for this group.

A Tukey multiple comparison test was also performed to determine if there were any significant differences across devices but within the low reading affinity group. Within the low technology affinity group, paper was significantly different from the iPod touch at the 0.05 significance level, but the Kindle was not significantly different from either paper or the iPod touch. Hypothesis 4 is not supported since within the low reading affinity group, performance on paper was significantly higher than on the iPod touch. That is, subjects believed their performance on paper was better than on the iPod touch. Hypothesis 5 is not supported since within the high reading affinity group, performance did not significantly differ across the technology formats.

Table 4.6

Perceived Performance by High and Low Reading Affinity

Device	High Reading Affinity	Low Reading Affinity	t Value	Pr > |t|
Paper	5.09	5.00	0.52	.6015
iPod Touch	4.87	4.26	2.74	.0073
Kindle	5.00	4.52	2.27	.0257

Additional Analysis

Data were analyzed using linear regression, considering survey results as compared to the perceived performance overall (taking the mean of the perception of performance on all three formats together and comparing them to the responses on

surveys for demographics, technology attitude, reading attitude, and exposure to various technologies). Reading attitude and technology attitude had a positive effect with respect to perception – that is, if the subject had a positive attitude toward reading or technology, they felt they did better on the tests overall. GPA and exposure to iPods had a negative effect – that is, if they had a higher GPA or if they had more personal exposure to an iPod, they felt they did more poorly on the tests overall. Exposure to an e-book reader had a positive relationship with perception – that is, if they had more personal exposure to an e-book reader, they felt they did better on the tests overall. See Table 4.7 for results.

Table 4.7

Significance of Survey Demographic Variables in Predicting Overall Perception of Performance

Variable	t Value	Pr > |t|
TechA	9.15	<.0001
ReadA	9.83	<.0001
GPA	7.33	<.0001
Academic_Level	0.45	0.6546
Experience with:		
Computer	2.28	0.0230
Phone	0.82	0.4101
iPod	9.23	<.0001
E-book Reader	3.13	0.0018
GameBoy	0.84	0.4016
PDA	4.01	<.0001

Additional Observations

Students were entranced by the Kindle and felt this was a very new technology. Several students asked to be allowed to “play” with the Kindle after the test had been completed and were interested in acquiring one. In contrast, nearly all of the students

had exposure to an iPhone or iPod touch and were very comfortable using them. Students were very verbal in their like or dislike of reading on the iPod touch. One student recounted a story about how reading on the iPhone (identical interface to the iPod touch) had “saved his grade” because he had forgotten to print out a copy of a paper he had to bring to read in class, but had a copy of the paper, which had been emailed to the class, on his iPhone. Another student expressed horror at the idea of trying to read anything of significant length on the iPod touch, stating they found it extremely hard to concentrate on such a small interface. Only two subjects had to be asked to turn in their papers after the 3 minute limit. Both of these subjects were using the iPod touch at the time and stated flatly that they hoped they never had to do reading on that interface for class. Interestingly, both subjects were observed using iPhones to send text messages prior to taking the test.

Overall, students were intrigued by the idea of purchasing and using books through a portable electronic medium. Many volunteered information to the test administrator that they would very much like to be able to use something like the Kindle to purchase and maintain their class books instead of the traditional paper books they currently had, especially if there was a corresponding cost reduction. Several students offered that they thought electronic books were more environmentally responsible and more ergonomic (in that they did not have to carry large, heavy books around with them.) Most students also expressed skepticism that universities would adopt electronic books in the near future, suggesting that it would be at least 10 years before the schools would “catch up to the rest of the world.”

CHAPTER 5

CONCLUSIONS

Reading is an intensely personal and emotion-filled experience for many people. The attachment or repulsion we feel toward reading is often transferred onto the medium that carries the words to us. While the data show that, objectively, there is no significant difference in basic reading comprehension based on format, subjects felt that format did affect their performance. Further, attitude – whether toward reading or toward technology – also affected how well individuals felt they performed, while having no effect on their actual performance. This is simultaneously encouraging and discouraging when considering the future of electronic reading media. It is encouraging because using electronic media for reading does not adversely affect the performance of individuals using them. It is discouraging because individuals, even technology-savvy ones, *believe* there is a difference in their performance, and as a result may be slow to adopt new media.

This study provides an initial baseline for the start of more robust comparative research in this area, by demonstrating that, for basic reading comprehension, the medium does not matter. Furthermore, it shows that, the more uncomfortable a person is with technology and expertise in the requested task (in this case, reading), the more they cling to the belief that they will do better on traditional (paper) media – regardless of how well they actually do. This preference for “the devil you know” keeps people from being objective when evaluating their own performance and leads them to the erroneous conclusion that technology is more complex or difficult than it actually is.

Confidence clearly plays a large role in self-evaluation, although not always in the way one would expect. Interestingly, individuals with higher GPAs felt they did more poorly overall – which further underlines that how we actually perform on a task and how we think we perform on a task are often unrelated.

Future studies should consider longer term comparisons, using different media over a period of days, weeks, or months and should test longer passages, preferably entire text books, for comprehension differences. Additionally, different subject pools should be drawn on to see if age or educational background would affect performance. Long term comprehension effects should also be tested to see if retention varies based on format. The results of this study provide an exciting, and much needed, first step in examining how media can affect how individuals process text and how that media affects their belief of how well they process it.

While this study clearly demonstrates the comparative performance of reading on the three chosen formats, it does not explore how remediation of text for a given format might positively or negatively affect the participants' perception of the text. When moving from illuminated manuscripts to printed books, printers retained many of the aspects of the hand-scribed manuscripts such as guidelines and illuminated letters to meet the expectations of the readers (Bolter, 2000), providing them with a familiar presentation that may or may not have been optimal for the new media. Similar remediation has occurred with the move to electronic books, including simulating the look of a turning page, providing a table of contents and index, and structuring books using chapters. The e-books we see today are our modern day incunabula – transition books that retain many of the characteristics of the previous (paper) format in order to

provide a familiar feel to the reader and to ease acceptance. This study shows that perception of the format – the emotional reaction and acceptance of it – affects how subjects believe they did in using that format. Future studies should delve into whether breaking from these familiar designs further alienate readers or improve acceptance by providing novel approaches. Certainly current trends suggest that presentations optimized for electronic media such as blogs, Twitter[15], and the like, improve acceptance and use of the media, but solid comparative studies are needed to understand the effect better.

Further, this study looks only at comprehension of short passages, not the relative advantages of searching for information in each format. While electronic texts include search engines that let readers enter text for their search, paper formats support visual page memory (the ability to locate a piece of information based on a memory of the physical, visual location of the information). Future studies should compare these types of searches, looking at both the time required to locate information and how efficient participants perceive the search to be.

It is the hope of this researcher that this work will enable a more objective evaluation of this emotionally-charged subject, both now and in the future.

[15] Twitter Inc, http://www.twitter.com

APPENDIX

DATA COLLECTION MATERIALS

Demographics and Technology Background

Gender:

- M
- F

Is English your first language?

- Y
- N

Age: _____

GPA: _____

Academic Level:

- Freshman
- Sophomore
- Junior
- Senior
- Graduate Student

Technology – Please mark your level of experience with the following technologies

Technology	**I have never used one**	**I have seen one used**	**I have used one**	**I own one**
Computer				
iPhone or similar				
iPod or similar				
e-Book Reader				
GameBoy or other handheld gaming device				
Blackberry/PDA or similar				

Perceived Performance

On a scale of 1 to 6, 1=strongly disagree and 6=strongly agree, rate your agreement with each of the following statements for each format:

Format	Question	Strongly Agree	Agree	Somewhat Agree	Somewhat Disagree	Disagree	Strongly Disagree
Paper							
	Reading the text on paper was easy.	6	5	4	3	2	1
	I was able to read the text quickly on paper.	6	5	4	3	2	1
	I performed well on the test I took after reading the text on paper.	6	5	4	3	2	1
	I found it difficult to understand the text on paper.	6	5	4	3	2	1
	I enjoyed reading the text on paper.	6	5	4	3	2	1
iPod		**6**	**5**	**4**	**3**	**2**	**1**
	Reading the text on the iPod was easy.	6	5	4	3	2	1
	I was able to read the text quickly on the iPod.	6	5	4	3	2	1
	I performed well on the test I took after reading the text on the iPod.	6	5	4	3	2	1
	I found it difficult to understand the text on the iPod.	6	5	4	3	2	1
	I enjoyed reading the text on the iPod.	6	5	4	3	2	1

Kindle		6	5	4	3	2	1
	Reading the text on the Kindle was easy.	6	5	4	3	2	1
	I was able to read the text quickly on the Kindle.	6	5	4	3	2	1
	I performed well on the test I took after reading the text on the Kindle.	6	5	4	3	2	1
	I found it difficult to understand the text on the Kindle.	6	5	4	3	2	1
	I enjoyed reading the text on the Kindle.	6	5	4	3	2	1

REFERENCES

Baker, N. (2009). A new page. *New Yorker* Retrieved from http://www.newyorker.com/reporting/2009/08/03/090803fa_fact_baker

Balas, J. (2007). Of iPhones and Ebooks: Will they get together? *Computers in Libraries, 27*(10), 35-38.

Barnard, L., Yi, Ji Soo, Jacko, J.A., & Sears, A. (2007). Capturing the effects of context on human performance in mobile computing systems. *Personal Ubiquitous Computing, 11*, 81-96.

Bates, M. (1990). Where should the person stop and the information search interface start? *Information Processing and Management, 26*(5), 575-591.

Bergman, E., & Haitani, R. (2000). Designing the PalmPilot: A conversation with Rob Haitani. In E.Bergman (Ed.) *Information appliances and beyond* (pp 82-102). San Francisco, CA: Morgan Kauffman.

Bernard, M., Liao, C. H., & Mills, M. (2001). The effects of font type and size on the legibility and reading time of online text by older adults. *Proceedings from CHI '01: Extended abstracts on human factors in computing systems.* (pp. 175-176) New York: ACM. http://doi.acm.org/10.1145/634067.634173

Bernard, M., Chaparro, B., Mills, M. , & Halcomb,C. (2002). Examining children's reading performance and preference for diVerent computer-displayed text. *Behaviour & Information Technology*, *21*(2), 87-96.

Bernard, M., Chaparro, B., Mills, M. & Halcomb, C. (2003). Comparing the effects of text size and format on the readability of computer-displayed Times New Roman and Arial text. *International Journal of Human-Computer Studies*, *59*(6), 823-835.

Bolter, J. D. (1991). *Writing space: The computer, hypertext, and the history of writing*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Bolter, J. D. (2000). *Writing space: Computers, hypertext, and the remediation of print*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Boyarski, D., Neuwirth, C., Forlizzi, J. & Regli, S. (1998). A study of fonts designed for screen display. *Proceedings of the ACM SIGCHI '98: Conference on human factors in computing systems*. (pp 87-94) New York: ACM. doi: http://doi.acm.org/10.1145/274644.274658

Brown, G. J. (2001). Beyond print: Reading digitally. *Library Hi Tech Journal*, *19*(4), 390-399.

Burk, R. (2001). E-book devices and the marketplace: In search of customers. *Library Hi Tech Journal, 19*(4), 325-331.

Buzzetto-More, N., Sweat-Guy, R., & Elobaid, M. (2007). Reading in a digital age: e-Books are students ready for this learning object? *Interdisciplinary Journal of Knowledge and Learning Objects*, *3*, 239-250.

Carlock, D. M., & Perry, A.M. (2008). Exploring faculty experiences with e-Books: A focus group. *Library Hi Tech Journal*, *26*(2), 244-254.

Cell phone novel (2009). In *Wikipedia*. Retrieved from http://en.wikipedia.org/wiki/Cell_phone_novel

Chall, J. S., & Dale, E. (1995). *Readability revisited: The new Dale-Chall readability formula*. Cambridge: Brookline Books.

Clark, D., Goodwin, S., Samuelson, T. & Coker, C. (2008). A qualitative assessment of the Kindle e-book reader: Results from initial focus group. *Performance Measurement & Metrics, 9*(2), 118-129.

Clyde, L. A. (2005). Electronic books. *Teacher Librarian*, *32*(5), 45-59.

Costa, D. (2008). E-book readers can do better. *PC Magazine, 27*(3), 66.

Costello, B., Lenholt, R. & Stryker, J. (2004). Using Blackboard in library instruction: Addressing the learning styles of Generations X and Y. *Journal of Academic Librarianship*, *30*(6), 452-460.

Coyle, K. (2001). Stakeholders and standards in the e-book ecology: Or, it's the economics, stupid! *Library Hi Tech Journal, 19*(4), 314-324.

Crestani, F., Landoni, M., & Melucci, M. (2006). Appearance and functionality of electronic books: Lessons from the visual book and hyper-text book projects. *International Journal of Digital Libraries, 6*(2), 192-209.

Crystal, D. (2001). *Language and the Internet.* Cambridge: Cambridge Press.

Dillon, A. (1994). *Designing usable electronic text: Ergonomic aspects of human information usage*. Southport, England: Taylor & Francis.

Dowdy, J., Parente, S., & Vesper, V. (2001). *Ebooks in the academic library*. Paper presented at the Sixth Annual Mid-South Instructional Technology Conference, Murfreesboro, TN. Retrieved from http://frank.mtsu.edu/~itconf/proceed01/21.pdf

Dyson, M., & Haselgrove, M. (2001). The influence of reading speed and line length on the effectiveness of reading from the screen. *International Journal of Human Computer Studies, 54*, 585-612.

eInk (2009). *High resolution displays: Specifications*. eInk Retrieved from http://www.eink.com/products/matrix/High_Res.html

Farkas, D. (1998). Layering as a safety net for minimalist documentation. In J. Carroll (Ed.), *Minimalism: Beyond the Nurnberg funnel*. (pp. 247-274), Cambridge: MIT Press.

Fialkoff, F. (2008). Beyond the Kindle. *Library Journal, 133*(12), 8.

Fischer, R., & Lugg, R. (2001). E-book basics. *Collection Building, 20*(3), 119-122.

Gallant, M. W. (2003). *Evaluation of electronic text display modes for small screen devices.* Unpublished master's thesis. San Jose, San Jose State University.

Gibson, M., & Ruotolo, C. (2003). Beyond the web: TEI, the digital library, and the e-book revolution. *Computers and the Humanities, 37*, 57-63.

Graham-Rowe, D. (2007). Electronic paper rewrites the rulebook for displays. *Nature Photonics, 1*, 248-251.

Greco, A., Jones, R., Wharton, R., and Estelami, H. (2007). The changing college and university library market for university press books and journals: 1997-2004. *Journal of Scholarly Publishing*, 265-269.

Gropper, G. L. (1991). *Text displays anaylsis and systematic design*. Englewood Cliffs, New Jersey: Educational Technology Publications.

Haas, C. (1996). *Writing technology: Studies on the materiality of literacy*. Mahwah, NJ: Lawrence Erlbaum Associates.

Hane, P. (2006). Trials: The new e-book readers. *Information Today, 23*(10), 22-24.

Hastings, J. (2008). The Kindle, iLiad reviewed. *School Library Journal, 54*(2), 18-19.

Hattery, M. (2001). The PDA: Its place in the library. *Information Retrieval and Library Automation, 36*(12), 1-7.

Healthy Computing (2002). *PDA ergonomics*. Retrieved June 7, 2009, from Healthy Computing, Web site: http://www.healthycomputing.com/mobile/pda/index.html

Hennings, L., & Yes, N. (1996). Interaction of screen distances, screen letter heights, and source document distances. *Interacting with Computers, 8*(4), 311-322.

Hornbæk K. & Frøkjær, E. (2001). Reading of electronic documents: The usability of linear, fisheye, and overview + detail interfaces. *Proceedings of the SIGCHI conference on human factors in computing systems* (pp. 293 – 300). New York: ACM. http://doi.acm.org/10.1145/365024.365118

Hotzmann, J. (1993). Ready fire!! Aim??? *Proceedings of the 11th annual international conference on systems documentation* (pp. 117-134). New York: ACM. http://doi.acm.org/10.1145/166025.166048

Jacob, K., Janicke, M., Beise, M., Blazejczak, J., Edler, D., Haum, R. Low, T., Petschow, U., & Rennings, K. (2005). Potentials for substituting paper by electronic media. In W. Franz (Ed.), *Lead markets for environmental innovations* (pp. 179-203). Mannheim, Germany: Physica-Verlag.

John, N. R., & Tucker, D.C. (2003). 10 myths about PDAs. *Computers in Libraries, 23*(3), 26-30.

Julie (2007). *Apple iPod Touch*. Retrieved from http://the-gadgeteer.com/2007/09/21/apple_ipod_touch/

Kim, L., & Albers, M. (2002). Web design issues when searching for information using handheld interfaces. *Technical Communication, 49*(3), 314-329.

Kim, Y., & Lee, W. (2007). The design and evaluation of a diagonally splitted column to improve text readability on a small screen. In J. Jacko (Ed.), *Human-computer interaction. Interaction platforms and techniques* (pp. 384-393). Berlin/Heidelberg: Springer.

Kuhn, R. (2002). Displays for mobile communications enabling new markets and applications. *Wireless Personal Communications, 22*, 199-212.

Laarni, J. (2002). Searching for optimal methods of presenting dynamic text on different types of screens. *Nordic Conference on Human-Computer Interaction*, *31*, 219-222.

Lehto, M., Zhu, W., & Carpenter, B. (1995). The relative effectiveness of hypertext and text. *International Journal of Human Computer Interaction, 7*(4), 293-313.

Levine, J. (2002). Information shifting. *Internet Librarian*, 128-141.

Library Journal (2008). In eBook race, iPod Touch is a contender. *Library Journal,* 133(13), 13.

Liew, C., Foos, S. & Chennupati, K.A. (2001). User study of the design issues of PROPIE: A novel environment for enhanced interaction and value adding of electronic documents. *Journal of Documentation, 57*(3), 377-426.

Lloyd, S. (2008). A book publisher's manifesto for the twenty-first century: How traditional publishers can position themselves in the changing media flows of a networked era. *Library Trends, 57*(1), 30-42.

Lonsdale, R., & Armstrong, C. (2001). Electronic books: Challenges for academic libraries. *Library Hi Tech Journal, 19*(4), 332-339.

Maag, M. (2006). Nursing students attitudes towards technology. *Nurse Educator*, *31*(3), 112-18.

Macy, S., Anderson, E. & Krygier, J. (1999). Interactivity and meaning. In R. Jackobson (Ed.), *Information design* (pp. 293-299), Cambridge: MIT Press.

Mangen, A. (2008). Hypertext fiction reading: Haptics and immersion. *Journal of Research in Reading, 31*(4), 404-419.

Matson, R. (2001). Re-Forming information: A case study in teaching content encapsulation. *Proceedings of the 19th annual international conference on computer documentation* (pp. 116-121). New York: ACM. doi: http://doi.acm.org/10.1145/501516.501540

McCall, M. & Crabbs, L. (1979). *McCall-Crabbs standard test lessons in reading Book F*. New York: Teachers College, Columbia University.

McClure, M. (2009). Turning a new page in ebooks. *Information Today 26*(4), 1, 18-19.

Meyer, B. (1999). Importance of text structure in everyday reading. In A. Ram, & K. Moorman (Ed.),*Understanding language understanding* (pp. 227-252). Cambridge: MIT Press.

Mills, C. B., and Weldon, L.J. (1987). Reading text from computer screens. *ACM Computing Systems, 19*(4), 330-358.

Mizobuchi, S., Mori, K. , Ren, X., & Michiaki, Y. (2002). An empirical study of the minimum required size and the minimum number of targets for pen input on the small display. In G. Goos, J. Hartmanis, & J. van Leeuwen (Ed.), *Human computer interaction with mobile devices* (pp.184-194). Pisa, Italy: Springer.

Mohageg, M., & Wagner, A. (2000). Design considerations for information appliances. In E. Bergman (Ed.), *Information appliances and beyond: Interaction design for consumer products* (pp. 28-51). San Francisco: Morgan Kaufmann Publishers.

Morineau, T., Blanche, C., Tobin, L., & Gueguen, N. (2005). The emergence of the contextual role of the e-book in cognitive processes through an ecological and functional analysis. *International Journal of Human Computer Studies, 62*(3), 329-348.

Nicholas, D., Rowlands, I., Clark, D., Huntington, P., Jamali, H. & Olle, C. (2008). UK scholarly e-book usage: A landmark survey. *ASLIB Proceedings, 60*(4), 311-334.

Nielsen, J. (1998). *Electronic books - A bad idea*. Retrieved June from http://www.useit.com/alertbox/980726.html

Nielsen, J. (2009). *Kindle 2 usability review*. Retrieved from http://www.useit.com/alertbox/kindle-usability-review.html

Nimwegen, C., Pouw, M., & Oostendorp, H. (1999). The influence of structure and reading-manipulation on usability of hypertexts. *Interacting with Computers, 12*, 7-21.

Norman, D. (2004). *Emotional design*. New York: Basic Books.

Northrup, M. J. (1994). The fate of indexes in an online world. *Proceedings of the 12th annual international conference on systems documentation: Technical*

communications at the great divide (pp. 182-189). New York: ACM. doi: http://doi.acm.org/10.1145/192506.192562

O'Hara, K., & Sellen, A. (1997). A comparison of reading paper and on-line documents. *Proceedings of the SIGCHI conference on human factors in computing systems* (pp. 335-342). New York: ACM. doi: http://doi.acm.org/10.1145/258549.258787

Oquist, G., & Goldstein, M. (2002). Towards an improved readability on mobile devices: Evaluating adaptive rapid serial visual presentation. In G. Goos, J. Hartmanis, & J. van Leeuwen (Ed.), *Human computer interaction on mobile devices* (pp.23-32). Pisaro, Italy: Springer.

Oquist, G., Hein, A., Ygge, J., & Goldstein, M. (2004). Eye movement study of reading on a mobile device using the page and RSVP text presentation formats. In S. Brewster, & M. Dunlop (Ed.), *Mobile human-computer interaction - Mobile HCI 2004* (pp. 108-119). Berlin/Heidelberg, Germany: Springer.

Park, K., Ann, S., Kim, C., Park, M., & Lee, S. (2008). The effects of hangul font and character size on the readability in PDA. In O. Gervase, B. Murgante, A. Lagana, D. Taniar, Y. Mun, & M. Gavrilova (Ed.), *Computational science and its applications - ICCSA 208* (pp. 601-614) Berlin/Heidelberg, Germany: Springer.

Poremba, S. (2008). Take a look at today's vibrant ebook market. *EContent, 31*(2), 32-38.

Pumfrey, P. D. (1997). Assessment of affective and motivational aspects of reading. In R. Beech and C. Singleton (Ed.), *The psychological assessment of reading* (pp. 160-175). London: Routeledge.

Robeck, M., & Wallace, R. (1990). *The psychology of reading: An interdisciplinary approach*. Hillsdale, New Jersey: Lawrence Erlbaum Associates.

Rouet, J. (1992). Cognitive processing of hyperdocuments: When does nonlinearity help? *Proceedings of the ACM conference on hypertext* (pp.131-140). New York: ACM. doi: http://doi.acm.org/10.1145/168466.168508

Roush, W. (2009). *E-book readers on the iPhone? They're not quite Kindle slayers yet*. Retrieved from http://www.xconomy.com/national/2009/01/23/e-book-readers-on-the-iphone-theyre-not-quite-kindle-slayers-yet/

Rowlands, I., Nicholas, D., Jamali, H., & Huntington, P. (2007). What do faculty and students really think about e-books? *ASLIB Proceedings, 59*(6), 489-511.

Scanlon, T. (1996) *Making online information usable*. Retrieved from http://www.uie.com/articles/online_information/

Schamber, L. (1996). What is a document? Rethinking the concept in uneasy times. *Journal of the American Society for Information Science, 47*(9), 669-671.

Schilit, B. G., G. Tanaka, K. and Marshall, C. (1999). As we may read: The reading appliance revolution. *Computer*, *32*(1) 65-73.

Schriver, K. (1996). *Dynamics in document design: Creating text for readers* New York: Wiley & Sons.

Schuyler, M. (2003). PDA avoidance: They'll get you eventually! *Computers in Libraries, 23*(3), 32-33.

Sheedy, J., Subbaram, M., Zimmereman, A., & Hayes, J. (2005) Text legibility and the letter superiority effect. *Human Factors*, *47*(4), 797-815.

Shim, W. (2003). Using handheld computers in information seeking research. *Journal of Education for Library and Information Science, 44*(3-4), 258-265.

Shneiderman, B. (1984). Response time and display rate in human performance with Computers. *Computing Surveys, 16*(3), 265-285.

Smashwords (2008). *Smashwords Launches Public Beta of Breakthrough Digital Publishing Platform for Authors, Poets and Screenwriters*. Retrieved from https://www.smashwords.com/press/release/2

Smith, M. Cecil (1990). Adult survey of reading attitudes. *Journal of Research and Development in Education*, *3*(2), 156-161.

Sontag, S. (2008). Re-kindling a love of books. *IEEE Spectrum,* 45(7), 25.

Sternberg, R. (1999). Perception. In *Cognitive psychology* (pp. 109-152), Fort Worth: Harcourt Brace College Publishers.

Strand, L. (2008). Legibility on a podcast: color and typefaces. In T. Sobh (Ed.), *Advances in computer and information sciences and engineering* (pp. 265-267). Netherlands: Springer.

Sukach, R. (2002). Identifying information design heuristics. *Proceedings of the 49th Annual STC Conference*. Retrieved from http://www.stc.org/confproceed/2002/PDFs/STC49-00031.pdf

Tennant, R., & O'Reilly, T. (2008). Does Amazon's Kindle have a future? *Library Journal, 133*(12), 13.

Tinker, M. A. (1965). *Bases for effective reading*. Minneapolis: University of Minnesota.

Toms, E. (2000). Understanding and facilitating the browsing of electronic text. *International Journal of Human Computer Studies, 52*, 423-452.

Towle, G., Dearnlley, J., & McKnight, C. (2007). Electronic books in the 2003-2005 period: Some reflections on their apparent potential and actual development. *Publishing Research Quarterly, 23*(2), 95-104.

United States Census Bureau (2003). *Internet and computer use data*. Retrieved from http://www.bls.census.gov/cps/computer/2003/sdata.htm

United States Department of Commerce. (2000). *Falling through the net toward digital inclusion: A report on Americans' access to technology tools.* Retrieved from http://search.ntia.doc.gov/pdf/fttn00.pdf

Wentorf, D. (2001). Printed pages vs. web pages: The documentation dilemma. *Proceedings of the 29th annual ACM SIGUCCS conference on user services* (pp, 204-209). New York: ACM. doi: http://doi.acm.org/10.1145/500956.501005

Williams, J. (2003). Taming the wireless frontier: PDAs, tablets, and laptops Home on the range. *Computers in Libraries, 23*(3), 10-18.

Wilson, R. (2001). *Evolution of portable electronic books*. Retrieved from http://www.ariadne.ac.uk/issue29/wilson/

Wilson, R. (2001). Designing a readable e-book. *Library Association Record 103*(1), 40-41.

Wobbrock, J., Forlizzi, J., Hudson, S., & Myers, B. (2002). Novel input, output, and computations: WebThumb: Interaction techniques for small-screen browsers. *Proceedings of the 15th annual ACM symposium on user interface software and technology* (pp. 205-208). New York: ACM. doi: http://doi.acm.org/10.1145/571985.572014

Wurman, R. (1989). *Information anxiety.* New York: Doubleday.

Young, J. (2006). Even with improved screens, e-book devices not ready for college. *The Chronicle of Higher Education, 53*(17), 33-37.

Young, J. (2009). How Kindle could change the textbook market. *Chronicle of Higher Education, 55*(36), A4.

Young, J. (2009) 6 lessons one campus learned about e-textbooks. *Chronicle of Higher Education, 55*(39), A18.

Zakaluk, B. L., & Samuels, S.J. (1988). *Readability: Its past, present, and future*. Newark, Delaware: International Reading Association.

Zimmerman, M. (2001). Technical communication in an altered landscape: What might be. *Technical Communication, 48*(2), 200-205.