

Ebooks, Ereaders, and Ebook Device Design

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INTRODUCTION

Ebooks (also: e-books), as a new type of electronic resource, have become an important component of academic libraries, due in part to their potential to enhance teaching and learning (Vasileiou, Hartley, & Rowley, 2009). Along with this, research in library and information science has focused on the adoption (Wexelbaum & Miltenoff, 2012) and design (e.g., Tees, 2010) of portable ebook readers (or ereaders) for academic use, e.g., as regards their usability, the quality of graphic display, and the availability of annotation tools. This chapter defines key concepts related to the design of ereaders and other ebook devices: ebook, ebook device, etext, hypertext, and interaction design. It also summarizes research concerning the design process for ebook devices, organized in terms of user research, design alternatives and building prototypes, and evaluation (cf. Rogers, Sharp, & Preece, 2011). It concludes by identifying directions for future research that take into account the emerging reading practices associated with new digital technologies.

BACKGROUND

Ebooks and Ebook Devices

The term *ebook* (also: *electronic or digital book*) is commonly used in contrast with paper or printed books. Beyond that, it has no consensus definition: It is sometimes used to refer to electronic text in the special form of the digital medium (e.g., Feather & Sturges, 1997; Hughes, 2003) and at other times to the software or hardware used in devices for reading such text. The more precise term *ebook device* refers to an ereading appliance that comprises three components: *etext* (including *hypertext*), *ebook software*, and *ebook hardware*. Ebook devices include not only *ereaders* (or *ebook readers*), which are portable devices designed solely for reading, but also any devices with *ebook software*, such as laptops and desktop computers. In the design literature, the term *ebook* is sometimes used to refer to an *ebook device*. The focus of this chapter is the design of *ebook devices* intended for *ereading*. Ebook content and *ebook device* design for specific applications such as *elearning* are outside the scope of the chapter.

Etext and Hypertext

Ebooks involve *etext*, text that is displayed on a computer screen or other electronic device. Etext can be either a component of an ebook (e.g., Anderson-Inman & Horney, 1997; Vasileiou et al., 2009) or a broad category that subsumes ebooks (e.g., Bellamy et al., 2001). *Hypertext*, a term coined by Ted Nelson, is a type of etext (Dillon 2004; Willett 2004) that is more than text, in that it contains nodes and links to text and other types of media (McKnight et al., 1996).

In 1945, Vannevar Bush envisioned the prototype of hypertext, the Memex machine, which would enable all intellectual products – books, records, and communications – to be linked to each other by utilizing the principle of association or human cognitive capability (Bush, 1945). Bush's vision inspired two projects in the early 1960s: Ted Nelson's Xanadu system, which envisioned that a new document could be created by linking or bridging existing documents that are mutually exclusive (Nelson, 1974), and Douglas Engelbart's On-line System (NSL), which was the first to implement hyperlinked text, diagrams, email, and source code (Engelbart & English, 1968), although Engelbart did not use the terms 'hypertext' or 'hyperlink.' The early 1980s also saw a number of experimental hypertext and hypermedia programs, many of whose features and terminology were later integrated into the World Wide Web (Cailliau & Ashman, 1999).

History of the Ebook

More directly relevant to the modern ebook device, in 1968, Alan Kay's Dynabook was proposed as "the first prototype of a computer hardware device for reading books online" (Henke, 2003, p. 22). Around the same time, Andries van Dam at Brown University, with assistance from Ted Nelson, started the Hypertext Editing System (HES) and the File Retrieval and Editing SyStem (FRESS) projects; FRESS was used in several courses for reading primary texts online, for annotation, and for online discussions. The term 'electronic book' is thought to have been used first by van Dam (Reilly, 2003). The invention of the ebook is also sometime attributed to Michael Hart at the University of Illinois, who in 1971 launched Project Gutenberg, an initiative designed to create electronic copies of books and make them replicable (Hart, 1992).

In the late 1980s, the idea for the World Wide Web, "the all-time, ultimate e-book" (Lambert et al., 2005, p. 85), was proposed by Tim Berners-Lee. Around the same time, Sony's Data Discman, "the first handheld electronic book reader," was released in 1990 (Lambert et al., 2005, p. 84). In 1998, Gemstar released the Rocket eBook, which resembles a paper book in form and function (Henke, 2003). More recently, the Sony reader and the Amazon Kindle launched a new generation of ebook devices in 2004 and 2007, respectively, that use an epaper technology

(Gibson & Gibb, 2011; Golovchinsky, 2008; Nikam & Rai, 2009). Unlike backlit computer displays, epaper displays reflect light like ordinary paper, making them easier to read. Since then, many other ereaders have been released into the market. These include Barnes & Noble's Nook, the iRex iLiad, Samsung's Papyrus, and the Hanlin eReader (for more examples, see Gibson & Gibb, 2011; Zimmerman, 2011).

Design Principles of Ebook Devices

Some ebook design researchers claim that Alan Kay's Dynabook concept, although intended as a computer for children, was the ideal ebook device (e.g., Golovchinsky, 2008; Marshall, Price, Golovchinsky, & Schilit, 2001). The design principles that Kay (2000) proposed for Dynabook were that it should enable children to read, write, draw, play with ideas, access ideas in other places, and communicate with other children. In other words, Kay envisioned Dynabook as a dynamic medium that was interactive, unlike static printed books.

Kay (2002) was inspired for his user interface design by concepts from Jean Piaget's theory of cognitive development (Piaget & Inhelder, 2000), Seymour Papert's work with LOGO, a programming language (LOGO Foundation, 2011), and Jerome Bruner's multiple mentality model (Bruner, 1966). Papert's argument, which was built on Piaget's theory, was that children are able to learn even difficult concepts (e.g., math) when knowledge is presented to them in a form (e.g., images) that is consistent with their cognitive development stage (e.g., the visual stage). Bruner's multiple mentality model holds that human mentality consists of three separate modes of representation – enactive, iconic, and symbolic. Combining these approaches, Kay (2002) came up with the idea that “[d]oing with images makes symbols” (p. 128) as a primary principle of user interface design. That is, people should start by doing concrete things with images and move on to making abstract symbols through them (Kay, 2002). This principle was later concretized into the Graphic User Interface (GUI). Kay (2002) was also influenced by McLuhan's book *Understanding Media* (1964), with its famous quote, “The medium is the message.”

Unlike Kay, however, most other ebook device design research has not grounded its designs in explicit reading or learning theories; rather, it has been based mostly on empirical studies, especially those conducted from the perspective of interaction design.

Interaction Design

Ebook designs have been proposed by researchers in different disciplines, including education, computer science, and library and information science. The research described below was carried out by scholars of human-computer interaction, a field that spans these disciplines with design as

its primary focus, and that has a strong interest in ebook design. *Interaction design* is "the practice of designing interactive digital products, environments, systems, and services" (Cooper, Reimann, & Cronin, 2007, p. 160).

In the context of ebook devices, interaction design involves defining attributes or properties of components in an ebook device to shape or affect the reader's measurable and non-measurable reading experience from one or more design perspectives. These design perspectives include the Technology-Centered View, in which the goal is "mak[ing] technology useful, usable, and pleasurable to use"; the Behaviorist View, in which interaction design is regarded as defining "how products behave and provide feedback based on what the people engaged with them are doing"; and the Social Interaction Design View, in which interaction design is about "facilitating communication between humans" (Saffer, 2010, p. 5; see also Rogers, Sharp, & Preece, 2011). Most ebook designs proposed thus far fall in Saffer's first two categories; little has yet been done from the Social Interaction Design View.

MAJOR RESEARCH DIRECTIONS IN EBOOK DEVICE DESIGN

Rogers et al. (2011) proposed that four basic activities are involved in the process of interaction design: establishing requirements (through user research), designing alternatives, building prototypes, and evaluation. Ebook device design generally follows this process. In the following subsections, ebook device design research is organized into three sections: user research for establishing requirements for design, conceptual and physical designs that include both designing alternatives and building prototypes, and evaluation.

User Research on Ebook Devices

One basic activity of interaction design is establishing requirements through understanding the users of a design (Rogers et al., 2011). A number of studies have used survey techniques to understand readers' needs and preferences for specific design features of ebook devices. For example, Henke (2003) used surveys that included questions about both paper book features (e.g., table of contents, index) and ebook features (e.g., search tools, hypertext links) to determine which design features would improve ebook devices. The study found that readers preferred features that derive from paper book metaphors. Similarly, Jamali, Nicholas, and Rowlands (2009) conducted a broad range of surveys about ebooks, including questions about their advantages and disadvantages. The survey participants identified the key advantages of ebooks as ease of access and searchability, and the disadvantages as having to read from the screen and the inconvenience of printing.

Other scholars have focused on understanding how people achieve a high level of reading and reading-related practices in their workplaces. Adler et al. (1998) conducted a diary study and structured interviews with 15 diverse office/business workers in order to understand office workers' daily reading practices in print and digital environments. The findings with regard to reading practices included non-linear, concurrent reading with multiple documents, and writing while reading. In order to facilitate the development of annotation tools in a digital library, Marshall (1997) focused on the practice of personal annotation. She found that individuals' paper-based annotations were telegraphic (e.g., underlines, highlights, symbols) or explicit (e.g., brief notes between lines and in margins), and they functioned as memory aids, reflection notes, and aids for directing future attention or tracing the reading process. Similarly, O'Hara, Smith, Newman, and Sellen (1998) studied students' record-keeping practices in the context of a digital library. They found that students recorded "paraphrased content, verbatim information, readers' thoughts and ideas in response to a text, and bibliographic information" (p. 235) using note-taking, annotating, and photocopying. In the context of information retrieval, Su (2005) investigated the reading practice of browsing and proposed footnote tracing, citation searching, virtual shelf browsing, and content browsing aids as desirable search features for ebook devices.

In contrast to studies focusing on the reading practices of individuals, Marshall, Price, Golovchinsky, and Schilit (1999) investigated a reading group's reading practices in terms of the members' analytic reading strategies, how they identified and marked references, and their use of annotation(s). They found that individual members used diverse reading strategies for group discussion, such as skimming, re-reading, and annotation, and built on their group's efforts to identify further relevant references.

Design of Etext/Hypertext Software and Ebook Hardware

Two other basic activities of interaction design are designing alternatives and building prototypes based on the findings of established requirements (Rogers et al., 2011). This section reviews research on conceptual and physical design that includes these two activities. Ebook researchers have designed ebook devices by closely emulating the properties of printed books, leveraging the capabilities of digital technology, and/or integrating the advantages of paper books and digital technology into a single design. Each of these approaches has its advantages, as described below.

Some ebook developers have introduced new software designed to resemble a printed book in terms of static presentation (e.g., a three-dimensional look), behaviors (e.g., page turning), and experience (e.g., intimate, tangible contact with hands and fingers). For example, Chu, Witten, Lobb, and Bainbridge (2003) designed a device that had the three-dimensional shape of a printed

book with animated page turners. Beyond the importance of visual presentation resembling printed books, Mangen (2008) emphasized the importance of readers' immersive and haptic experience with "the material substrate of the text" (p. 405) in reading hypertext fiction.

Other researchers, consistent with Saffer's (2010) Behaviorist View, have proposed new software designed to maximize the unique capabilities of etext/hypertext, such as dynamic text presentation, interactivity with text, and manipulation of ebook devices (e.g., via a stylus), in order to create new reading experiences with new digital media. For example, Melchior (2001) proposed a "wiping" technique (p. 2), which involves gradually transitioning to a next page by dimming the previously-read text and revealing the new text line by line, in order to help individuals read more efficiently on a small screen. In order to maximize the advantages of hypertext, Golovchinsky and Marshall (2000) proposed diverse interactive types of hypertext in an ebook device, including a pre-defined reading path, a randomly-generated reading path, and a reader-generated reading path. Relatedly, Steichen, Lawless, O'Connor, and Wade (2009) highlighted the notion of informational hypertext that supports learning by generating more advanced adaptive and personalized hyperlinks in an ebook design. Carroll et al. (2003) moved beyond the constraints of small digital devices and increased interactivity by introducing a virtual reality system that enables readers to interact with flying text projected onto walls.

Hardware is another important component of design. Hardware refers to the system or means via which contents are displayed, such as paper, ebook portable devices, and computer screens. Some researchers have proposed novel forms of hardware designed to enhance ebook devices by incorporating the advantages of printed books into a digital format. Years before Apple's iPad, for example, Schilit, Golovchinsky, and Price (1998) and Schilit, Price, and Golovchinsky (1998) introduced a pen-based tablet computer, called "XLibris," that enabled users to take notes with a stylus by adding handwriting capability, which is an advantage of printed books.

Other designers have proposed the inverse: novel forms of ebook hardware designed to enhance printed books by incorporating the advantages of ebooks. An example is the "Listen Reader" proposed by Back et al. (2001), which is a type of electronically-augmented printed book that enables readers to have a multimodal reading experience involving text, graphics, and sounds. Guimbretière (2003) introduced "Paper Augmented Digital Documents" – paper documents augmented with features that enable users to synchronize writing input between a printed book and a computer. Norrie, Palinginis, and Signer (2005) proposed another version of interactive paper that is designed to enable users not only to capture their writings, but also to interact with features in a printed book with an electronic pen (e.g., going to a URL by pointing at an active area with the

pen). Similarly, Grasset, Dunser, and Billinghamurst (2008) introduced a visually-augmented “mixed-reality” book containing virtual content (e.g., a three dimensional pop-up object).

Evaluation of Ebook Devices

The last basic activity of interaction design identified by Rogers et al. (2011) is evaluating prototypes/devices for usability, in keeping with Saffer’s (2010) Technology-Centered View. Content, text presentation (software), and hardware are important factors that should be taken into account when evaluating ebook devices.

As regards content, some researchers (e.g., Malama, Landoni, & Wilson, 2004) have used a single text to test and compare usability across diverse types of text formats (software) and hardware. However, most researchers have used multiple texts that are the same or similar in genre (e.g., newspaper articles, scientific articles) as a control variable (e.g., Hornbæk & Frøkjær, 2001; Morris, Brush, & Meyers, 2007), although other researchers (e.g., Chu, Bainbridge, Johns, & Witten, 2004) have used multiple texts that varied in genre, text length, and complexity.

In order to understand what properties of software contribute to the design of good ebook devices, researchers (e.g., Chu et al., 2004; Dyson & Haselgrove, 2001; Wigdor & Balakrishnan, 2005) have examined the effects of static properties such as line length, adherence to a print book metaphor, and text orientation on reading processes and outcomes. Other researchers (e.g., Hornbæk & Frøkjær, 2001; Öquist & Lundin, 2007) have examined how different forms of dynamic presentation affect reading-related quantitative and qualitative outcomes. Other studies (e.g., Egan et al., 1989; Henke, 2003) have evaluated the effects of dynamic (interactive) design features such as hypertext, menus, and search tools. These studies found that different types of software (text formats and features) give rise to different types of quantifiable and qualitative benefits in reading (e.g., increased reading speed, satisfaction), depending on the purposes for reading and the types of devices used. For example, a medium line length (55 characters per line) produces better outcomes in terms of both reading speed and comprehension, but comprehension can be achieved with more extreme line lengths, depending on how one scrolls (Dyson & Haselgrove, 2001).

In order to understand what hardware as a whole and what specific properties of hardware contribute to the improvement of ebook devices, researchers (e.g., Dillon, 1992; O’Hara & Sellen, 1997; Marshall & Ruotolo, 2002; Waycott & Kukulska-Hulme, 2003) have compared one medium to another (paper versus digital) or examined the appropriateness of one particular hardware type, such as small handheld devices and Personal Digital Assistants (PDAs), in particular contexts. Other researchers (e.g., Chen et al., 2008; Morris et al., 2007) have examined the effects of specific

properties (e.g., size and ratio) on reading outcomes. As with the software designs mentioned above, different types or properties of hardware produce different reading benefits depending on different types of reading. For example, although students identified limitations, such as the small screen size, of handhelds such as Pocket PCs for academic reading, they reported using the devices for reading secondary, shorter materials (Waycott & Kukulska-Hulme, 2003).

Finally, the Electronic Books ON-screen Interface (EBONI) project¹ developed comprehensive design guidelines for etextbooks (or digital or electronic textbooks), taking into account content, software, and hardware. Although its focus is on textbooks, this has been referred to as “an ebook evaluation model” (Wilson, 2002, “Article Type,” para. 2) or “a general ebook evaluation model” (Wilson & Landoni, 2001, p. 2).

FUTURE RESEARCH DIRECTIONS

While some people, including students, still prefer to read on paper and do not want to read from an electronic screen (Hillesund, 2010; Wexelbaum & Miltenoff, 2012), people’s reading habits and practices are changing. Moreover, younger generations of readers who have been exposed to new digital media might take advantage of properties of ebooks in different ways than would older generations accustomed to printed books. For example, younger readers accustomed to clicking hyperlinks or scrolling might not appreciate a software feature that emulates page-flipping from printed books. Ebook researchers thus need to understand the unique properties of print and digital media, and apply them selectively to the design of ebook devices, taking into account the emerging reading practices that are associated with new digital technologies.

Ebooks that are dedicated to reading (as opposed to content learning) currently mainly display static textual content, with some static images. However, ebook authoring software (e.g., Apple’s iBooks; Inkling Systems’ Habitat) is available that enables users to add multimedia and interactive content easily, and new forms of ebook devices have been developed in combination with new technologies such as virtual and mixed reality and interactive paper. Given these developments, ebook designers need to take into account diverse forms of ebook content, ranging from static text to multimedia and interactive content, in keeping with the requirements of different kinds of readers and advances in new digital technologies.

Readers’ interactions with ebook devices are currently limited to their fingers, through touch-screen technology and keyboards. For example, readers flip through pages and look up words in a dictionary by touching or typing with their fingers. Text 2.0 (<http://text20.net>) is a

¹ <http://ebooks.strath.ac.uk/eboni/index.html>

project that enables readers to interact with texts, even with part of a word, through their eyes using eye movement tracking technology. This project suggests that ebook designers need to explore new forms of interaction with ebook devices, by applying new technologies such as new voice, visual, haptic, and tactile technologies.

Social media have already begun to affect readers' behaviors and practices. For example, people share their bookmarks via social bookmarking websites such as Delicious, share reading recommendations via Facebook apps (and check Facebook while reading), and can view other readers' textual highlights on Amazon's Kindle. User research is needed to shed light on these and other emerging social reading practices. In addition, natural, ethnographic research is needed over longer periods of time and in diverse contexts, including transportation contexts, because portable devices such as mobile phones and tablet PCs, in concert with cloud computing (e.g., Dropbox), enable people to continue reading seamlessly on any device, at any time, anywhere.

From a theoretical perspective, ebook device researchers might usefully focus their research by adopting one or more perspectives on design from the outset; their research might also benefit from drawing more explicitly on design principles (cf. Lidwell, Holden, & Butler, 2010) and reading theories (cf. Tracey & Morrow, 2012). Finally, collaboration across different disciplines is needed in order to arrive at more comprehensive understandings of reader behaviors and more usable ebook designs.

CONCLUSION

Ebook researchers and practitioners, including schools, libraries, and other agencies with an interest in understanding the potential of ebook devices as primary or secondary (text)books, might benefit from the literature reviewed in this chapter in their selection or design of ebook devices appropriate for use in academic and other settings. Meanwhile, it is certain that this literature will continue to expand as ereader designs evolve and ebooks and ereaders become increasingly pervasive.

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ADDITIONAL READINGS

Books

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Journals

Journal of the American Society for Information Science and Technology
 The Electronic Library
 Program: Electronic Library and Information Systems
 Library Hi Tech
 Technical Services Quarterly
 The International Journal of the Book
 Journal of Research in Reading
 Scientific Studies of Reading
 Reading Research Quarterly
 Journal of Adolescent & Adult Literacy
 Innovations in Education and Teaching International

Computers & Education

Educational Technology Research and Development

International Journal of Distance Education Technologies

Journal of the Learning Sciences

TechTrends

International Journal of Human-Computer Interaction

International Journal of Human-Computer Studies

Ergonomics

International Journal of Industrial Ergonomics

Journal of Experimental Psychology

Computers in Human Behavior

Conferences

Annual Meeting of the Association for Information Science and Technology (ASIS&T)

iConference

Joint Conference on Digital Libraries (JCDL)

International Reading Association (IRA) Annual Convention

The EdMedia World Conference on Educational Media and Technology (EdMedia)

Hawaii International Conference on System Sciences (HICSS)

International Conference on Advanced Learning Technologies (ICALT)

The ACM SIGCHI Conference on Human Factors in Computing Systems (CHI)

The HCI International Conference (HCII)

Websites (Associations, magazines, blogs, databases, etc.)

International Reading Association (<http://www.reading.org/>)

American Library Association (<http://www.ala.org/>)

Digital Content & Libraries ([http://www.ala.org/transforminglibraries/ebooks-digital content](http://www.ala.org/transforminglibraries/ebooks-digital-content))

The Association of American Publishers (<http://publishers.org/>)

The Book Industry Study Group (<http://www.bisg.org/>)

Publishing Perspectives (<http://publishingperspectives.com>)

No Shelf Required (<http://www.libraries.wright.edu/noshelfrequired/>)

TeleRead (<http://www.teleread.com/>)

The Digital Reader (<http://www.the-digital-reader.com/>)

Ebook Reader (<http://ebookreader.com/>)

NN/g Nielsen Norman Group (<http://www.nngroup.com/>)

The ACM Digital Library (<http://dl.acm.org/>)

IEEE Computer Society Digital Library (<http://www.computer.org/portal/web/csdl>)

IEEE Xplore Digital Library (<http://ieeexplore.ieee.org/Xplore/guesthome.jsp>)

JSTOR (<http://www.jstor.org/>)

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The term ebook (e-book, or digital or electronic book) has no consensus definition in the literature. However, different terms refer to distinctive elements. Etext (or digital text) is defined as text in digital formats. Ebook software, as opposed to ebook hardware (i.e., the physical component of a device), refers to a computer software program (e.g., Adobe Acrobat Reader; the web-based software at NetLibrary). An ebook device or ereading device (e.g., a computer screen; the Amazon Kindle) refers to a reading appliance that includes the other three components: etext, ebook software, and ebook hardware. An ereader is a portable device, excluding laptops and tablet computers, that is designed solely for reading. An electronic textbook is a special form of ebook that is dedicated to student learning.