## Introduction

The modern era is characterized by rapid technological innovation. For example, recently new technologies such as electronic ink and electronic paper have been developed for displaying contents in ebooks; ebook readers such as the Amazon Kindle and the Sony Reader have already adopted and released eink technology (Cavanaugh, 2015). These technologies combine the advantages of classical print books and the computer screen – specifically, the portability of print books and the rewritability of the computer screen. More generally, they open wide the doors to possibilities for new forms and capabilities of ebooks that go beyond the classical form of either the print book or the computer screen. Among other advantages, they enable ebook designers to focus less on the constraints of printing techniques and physical hardware and focus more on *the nature of reading itself* in the design of ebooks. The current rapid speed of development of other innovative technologies – e.g., 3D printing, wearable computing, virtual reality, robots – should further encourage designers to think outside the box regarding the design of ebooks (e.g., Carroll et al., 2003).

This paper proposes, somewhat paradoxically, that history is a rich source of insight for modern ebook design. It reviews historical knowledge about books and reading and relates that knowledge to issues in ebook design, with the goal of providing ebook designers and researchers with design ideas. The ideas in many cases are not new in themselves, and some have been implemented in ebook devices, but others have been weakened or forgotten over time. In reviving this knowledge, we argue that in order to support optimal reading experiences in diverse modern reading contexts, it can be fruitful to re-examine and re-evaluate older forms of the book and older reading practices.

The paper first briefly surveys literature on what kinds of ebook research has been done so far and how the insights that inform the design of ebooks are usually obtained. The main body of the paper then describes and illustrates historical forms and practices associated with books and reading; discusses recently-developed ebook viewers (software) and readers (hardware) in which historical features that have been implemented, weakened, or lost; and makes recommendations for ebook designs that draw on historical insights. In concluding, we call on the imagination and creativity of ebook designers who read this paper to apply historical insights in their designs.

## Ebook Design Literature

In order to create or enhance ebook viewers and readers, ebook design researchers have tended to conduct empirical studies involving target groups of people (Koh and Herring, 2014). For example, user studies have often been conducted to identify the needs of ebook users (e.g., Adler et al., 1998; Henke, 2003; Jamali et al., 2009; Marshall, 1997; Marshall and Bly, 2005; Marshall et al., 1999; O'Hara et al., 1998; Su, 2005). User studies have also been conducted to evaluate existing or newly developed devices (e.g., Chen et al., 2008; Dyson, 2004, Dyson and Haselgrove, 2001; Egan et al., 1989; Hornbæk and Frøkjær, 2001; Malama et al., 2004; Marshall and Ruotolo, 2002; Morris et al., 2007; Öquist and Lundin, 2007; Toms, 2000; Waycott and Kukulska-Hulme, 2003; Wigdor and Balakrishnan, 2005).

Findings from these empirical studies have typically been transformed into ebook design insights by drawing ideas from the unique properties (*features* or *affordances*) of different media. For example, some research has led to new forms of ebooks through borrowing features from current

forms of print books, such as page-turning animation (e.g., Chu et al., 2004). Other designers have adopted dynamic features that are unique to digital media, such as hypertext and virtual reality in ebook design (e.g., Carroll et al., 2003; Golovchinsky and Marshall, 2000; Grasset et al., 2008; Melchior, 2001; Steichen et al., 2009). Yet another line of research has resulted in new forms of ebooks, such as interactive print books, that combine features of print books and digital media (e.g., Back et al., 2001; Guimbretière, 2003; Norrie et al., 2005; Schilit, Golovchinsky, et al., 1998; Schilit, Price, et al., 1998).

In short, design researchers have thus far usually obtained ebook design insights by borrowing features from current forms of print books, adopting dynamic features that are unique to digital media, or creating combinations of features from both print books and digital media. No ebook design research has looked beyond the properties of different media to evaluate historical aspects of books and reading as potential sources of ideas to implement in ebooks. In contrast, this paper argues that numerous useful design insights can be obtained by foregrounding historical perspectives and identifying hidden historical gems.

## Drawing Ebook Design Insights from History

In the current interdisciplinary research climate, it seems appropriate to seek out ebook design insights from various sources. In this section we trace historical aspects of books and reading back to their early days and discuss aspects that have been lost or weakened but that might still usefully inform the design of ebooks. Scholarship on the history of books (or history of the book) is itself interdisciplinary in nature, practiced by "historians, literary scholars, sociologists, librarians, and anyone else who want[s] to understand the books as a force in history" (Darnton, 2002, p. 9). More generally, Darnton characterizes scholarship on book history as "the social and cultural history of communication by print" (p. 9); it is concerned with how ideas are transmitted through print, in addition to the study of books as material objects. In the discussion that follows, we focus in particular on the evolution of the physical form of the book and the practices of reading, annotation, and bookshelving, making the case that these have especially high potential to provide insights useful for ebook design.

### *The Physical Form of the Book*

The physical form of the early book evolved from a stone, clay, or wood tablet to a scroll and to a codex (Finkelstein and McCleery, 2005; Howard, 2005). The scroll is "an early form of the book wherein the writing surface – typically papyrus – was rolled up for storage" (Howard, 2005, p. 161). The codex is a form "consist[ing] of two manuscripts or tablets that were sewn together to make the shape of a book, often with a spine and a decorated cover" (Howard, 2005, p. 159). The forces that directly or indirectly affected the evolution of the book's form include the evolution of available materials (from stone, wood, or clay to papyrus, to parchment, and to wood pulp), the evolution of printing techniques (from manual transcription by scribes to block printing, Gutenberg's movable type, and machine-press printing), and the contributions of religious and other groups (e.g., the preference of Christians for the codex) (Finkelstein and McCleery, 2005; Howard, 2005). For example, the invention of flexible papyrus enabled books in the form of a scroll, and the invention of the octavo format setting enabled pocket-size books.

To be sure, some of these early forms are reflected in ebooks. Current ebook viewers and readers, such as the Adobe Acrobat eBook Reader, Apple iBooks, and the Amazon Kindle, can be said to employ the rectangular shape of a tablet, while attempting to adopt the reading flow of a vertical scroll and/or a codex. The Adobe Acrobat eBook Reader, for example, employs an up-and-down scroll bar on the right side that enables readers to experience a continuous reading flow similar to that of a vertical scroll (see Figure 1). Like a scroll, the Acrobat eBook Reader allows the reader to read text continuously; there is no need to flip pages back and forth. The Acrobat eBook Reader can also display all contents at once if the physical space is allowed to unfold the whole scroll, or if the size of the display, such as a computer monitor or a projected screen wall, is large enough to unfold the whole scroll.

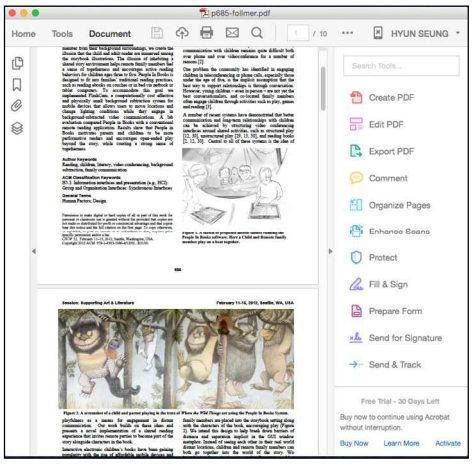


**Figure 1. Adobe Acrobat Pro DC. Source: Screenshot taken from a personal computer.**

The codex form is illustrated by Apple iBooks (Figure 2, left), which employs a page-turner that enables readers to experience a page-by-page reading flow similar to that of a codex by touching the left or the right side of the screen. The Amazon Kindle (Paperwhite version; Figure 2, right) also employs a touchscreen technology that lets readers experience a page-by-page reading flow similar to that of a codex. (All source URLs for the examples in this paper were accessed on June 30, 2016.)


**Figure 2. (Left) Apple iBooks. Source: http://www.apple.com/ibooks/; (Right) Amazon Kindle Paperwhite. Source: http://www.amazon.com/dp/B00OQVZDJM/ref=ods_fs_kp_**

Yet recent ebook viewers and readers, which were developed around 2007 when the first generation of Amazon Kindle was released, rarely employ the continuous reading flow of a *horizontal scroll*, which was more common than a vertical scroll in the early days of books (Howard, 2005). Version 3.2 of the Lexcycle Stanza Reader, which is no longer available, employed a horizontal scroll bar on the bottom (see Figure 3) that enabled readers to move to the next page and move back to the previous page, but it fundamentally adopted a page-by-page flow of reading using an animated page turner.

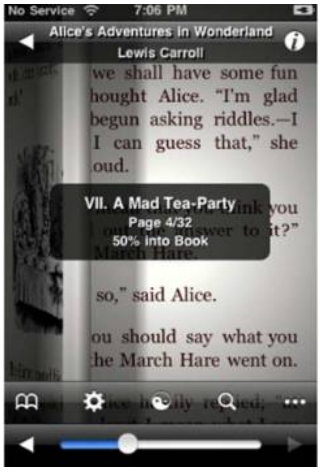


**Figure 3. An old version of Lexcycle's Stanza Reader. Source: http://www.bookrunch.com/alternatives/Stanza/**

Similarly, the Polymer Vision Readius (Figure 4), which was planned for release in 2008 (Hoffelder, 2012), but which was never released, was made of flexible epaper and employed the rollable form of a horizontal scroll, but it also employed the page-by-page flow of a codex, rather

than the continuous reading flow of a horizontal scroll. In this device, the rollable form serves only to make the size of the device more compact.

**Figure 4. Polymer Vision's Readius. Source: http://the-digital-reader.com/2012/12/02/wistorn-folds-up-polymer-vision-flexible-ereaders-are-once-again-science-fiction/**

Finally, Amazon's second generation Kindle, which was released in 2009 (Kozlowski, 2014), employed a five-way controller that lets readers navigate through contents horizontally and vertically (Figure 5). This device seems to approximate the continuous reading flow of a horizontal scroll most closely. However, the device does not let readers experience reading flow in the same way that a horizontal scroll does, because the shape of this device is still a rectangular tablet that does not allow readers to roll a portion of a scroll or view all its contents at once.

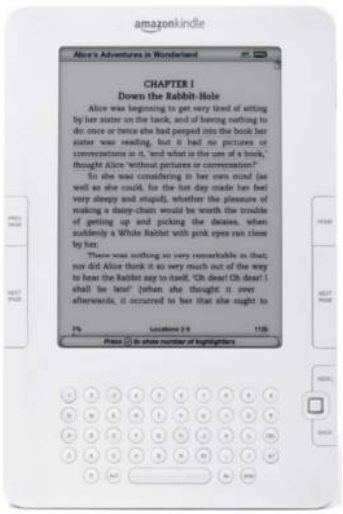


**Figure 5. Amazon's second version of the Kindle. Source: https://en.wikipedia.org/wiki/Amazon_Kindle**

As these examples illustrate, most recent ebook viewers and readers employ the *reading flow* of a vertical scroll or a codex, albeit not on the *physical forms* of the scroll or codex, which have their own distinctive reading flows. This observation prompts us to ask: What book shape provides readers with the best reading experience? Which is more optimal: the codex or the scroll? Casson (2001) and Howard (2005) identified a number of advantages of a codex over a

scroll, such as that the codex is easy to carry for travel, easy to handle (i.e., no need to use both hands), easy to retrieve from a bookshelf, easy to identify a title from a spine, and its contents (the various parts of the ebook) are easy to access. Some of the same advantages of a codex over a scroll apply to current ebooks as compared to print books: The ebook is lightweight, enabling people to carry the contents of multiple books for travel in one device; it is easy to find contents using a search facility; it is unnecessary to shelve books on a physical bookshelf; and so forth.

These advantages of ebooks notwithstanding, many people still want to read print books (in their current codex form), and some people still print out ebooks on paper to read them (e.g., Olsen et al., 2013). Just as it took a long time in the past for people to accept the codex over the scroll, due to the long history of reading with a scroll (Finkelstein and McCleery, 2005), it will take time for people to accept the ebook as a replacement for the print book (or even as a major tool for reading). History and habit aside, it seems useful to question whether the codex form of print books and the tablet form of ebook devices fundamentally provide readers with the best reading experiences. For example, when reading a print book, one must flip pages back and forth repeatedly to compare multiple contents on multiple pages. When reading an ebook, one must scroll up and down repeatedly in order to compare contents in multiple locations in the ebook. Neither form supports comparison of contents easily. Yet this activity may be crucial in contexts such as scholarly (serious) reading (Koh, 2015). For example, where there is a need to skim through an entire text effectively and efficiently, without repetitive flipping back and forth, continuous horizontal scrolling would be useful, together with features that help readers hide unwanted portions of text quickly and flexibly.

Thus even though some researchers have begun to explore new forms of ebook readers (e.g., Gomes and Vertegaal, 2015), the rectangular tablet shape of commercially available ebook readers has been little challenged, and other possible older physical forms of print books have not (yet) been proposed. Yet it may be that novel forms of the book that can produce as yet unavailable reading flows would improve ebook readers intended to create certain reading experiences.

For example, an old form of print book that allows for six ways of opening was introduced on the National Library of Sweden's Flickr page (https://www.flickr.com/photos/25300312@N08/). One can imagine that this would be beneficial in particular contexts of reading, e.g., where there is a need to skim through an entire text effectively and efficiently, without repetitive flipping back and forth (see https://flic.kr/s/aHsjsc592H for more details). Thus it seems valuable to investigate historical physical forms, re-examine and re-evaluate them, identify the beneficial properties and disadvantages of each form, and consider how these might apply to the design of ebook readers in current contexts.

*The Practice of Reading*

The practice of reading has also changed over time. It has evolved, broadly speaking, from reading aloud to silent reading, from public reading to private reading, and from intensive reading, in which "readers … typically read and re-read, memorized in whole or in parts, pondered and discussed a small number of books," to extensive reading, in which "readers devoured as much as they could, promiscuously and voraciously" (Finkelstein and McCleery, 2005, p. 113). In other words, reading aloud, public reading, and intensive reading were more

common reading practices in the past, and silent reading, private reading, and extensive reading are more common at present.

The reasons for this evolution include social and economic circumstances; for example, reading aloud took place formerly among noble people as part of their social lives and among lay people out of necessity, due to low rates of literacy and the high price of a book in earlier times (Finkelstein and McCleery, 2005). The opening of public libraries led to silent reading becoming a social norm (Finkelstein and McCleery, 2005). Silent reading is the most common current reading practice, with some exceptions, such as audio books and reading aloud to children in schools or in libraries. Technological developments have also played a role in shifting reading practices. Printing machines that allowed for the production of multiple copies of the same book led to a shift from intensive reading in the age of manuscripts to extensive reading in the age of printed books. More recently, factors such as the explosion of reading materials through the availability of free ebooks (e.g., Project Gutenberg), the digitization of printed books (e.g., Google Book Search), and the availability of blog publishing applications (e.g., Wordpress) have encouraged fast and extensive reading, rather than intensive reading. The flood of reading resources leads most readers to skim texts and read books extensively, while intensive reading is practiced mostly by people in academic settings.

How might insights from earlier reading practices help inform the design of ebooks? Some features of ebooks already enable readers to have a reading experience similar to the practice of being read aloud to in public in earlier times. Features such as text-to-speech conversion in currently available ebook viewers and readers let readers both read and hear a text; an example is the "Start Speaking" feature in Apple iBooks.

Moreover, *BuddyBooks* (Pearson et al., 2012) is a system that affords readers a reading experience that resembles the practice of public reading in small groups in earlier times. However, it limits the scope of group reading to "co-located collaborative reading, as opposed to remote reading" (p. 413), and thus is still not public. In contrast, current networked technology has the potential to support group reading among people who are located remotely; "Share with friends on Goodreads" on the Amazon Kindle is one example that leverages this potential. Yet simply connecting readers on social network sites does not seem to motivate readers to pursue collaborative reading to the same extent as in older times, when immediate, real-time exchanges of comments were possible in small groups. This is due in part to the asynchronous nature of social network sites, which does not encourage readers to get involved directly in other readers' moment-to-moment processes of reading. For example, readers are not encouraged to ask questions that require an immediate answer that would help them move from ambiguous, difficult sentences to the next sentences. *WebAnn* (Brush et al., 2002) is an educational system that supports students' reading processes by helping them to share their comments on anchored texts, but it is dedicated to asynchronous group discussion, which differs from synchronous group reading in terms of processes and outcomes, even though discussion is one important element in group reading.

In order to facilitate the practice of collaborative reading among people who want to benefit from such practice or experience the richness of offline-based group reading practice in earlier times, it would be helpful to develop convenient communication channels, as well as to expand the

boundaries of membership from readers who are acquainted with one another to anyone who is available at a given time for collaborative reading. One design possibility would be to integrate ebook devices with collaborative features that maximize the advantages of both: the convenience of synchronized communication and the possibility of networking with a broad range of people. The "Collaborate" feature in Acrobat 9 Pro, which has "Send and Collaborative Live" and "Share My Screen," illustrates the kind of collaborative features that could be integrated. When face-face conversation is needed, the Adobe ConnectNow web-conference tool, which includes a webcam facility, could be incorporated into Acrobat 9 Pro.

Given that silent reading is the conventional and prevalent reading practice, it is perhaps not surprising that none of the current ebook viewers and readers promotes or supports the practice of solitary reading aloud. Yet in the old days, the prophet Ezekiel argued that readers should read aloud to get the meaning of a text (Manguel, 1997). Reading aloud stimulates metacognition and could give readers a more positive reading experience. Thus it seems useful to re-evaluate the practice of solitary reading aloud and consider designing ebook features that encourage readers to make it one of their reading practices. For example, a feature that enables readers to add voice-activated annotations to particular phases or sentences while they are reading aloud alone might help readers save and later access their rich data about metacognition (i.e., think-aloud data) when re-reading or writing. Also, a feature that provides readers with feedback about their reading processes based on analysis of their recorded reading, similar to Biedert et al.'s (2012) gaze-based feedback about "the reading-to-skimming ratio" (p. 201), might encourage further solitary reading aloud.

In sum, while some old forms of reading practices have been implemented to some extent in currently available ebook viewers and readers, other past practices, such as public reading in groups and solitary reading aloud, have not been fully explored as potential features of ebook viewers and readers. In order to identify further reading practices that could potentially provide useful design insights for contemporary reading devices, ebook designers could investigate older forms of reading practices in different countries and at different periods in history. For example, reading in turns used to take place at house parties while some people were doing their own work, such as "embroidering and making cushion covers" (Raven et al., 2007, p. 242). This older practice could be applied to a modern context where an online group of people need to read complex texts out loud together in turns, for example, in an online study or discussion group. Similar to the idea of a reading progress percentage bar on the bottom of an ebook viewer to help solo readers recognize where they are currently and how far they need to go to complete reading, a graph that indicates reading status and progress about who is reading what parts of a text could be implemented as an ebook feature that facilitates reading in turns. Additional examples of older practices can be found in the UK RED project's database of reading experiences and practices in Britain from 1450 to 1945 (http://www.open.ac.uk/Arts/reading/UK/index.php).

*The Practice of Annotation*

Annotation, the activity of adding notes to page margins and highlighting text, is a reading practice that traditionally has been encouraged in academic settings, and it is still relevant in today's academic settings. Annotation can be traced back to the concept of *marginalia*, or "notes, commentary, and similar material written or printed in the margin of a book or manuscript" (Oxford English Dictionary, n.p.). Examples of marginalia include glosses, rubrics, scholia, and commonplace-books.

A *gloss* is “a word inserted between the lines or in the margin as an explanatory equivalent of a foreign or otherwise difficult word in the text” (Oxford English Dictionary, n.p.). The text annotations between the lines and in the margins in Figure 6 are examples of glosses in a 14th-century Italian legal digest (Reitz, 2015).

**Figure 6. Glosses. Source: http://www.bl.uk/catalogues/illuminatedmanuscripts/ILLUMIN.ASP?Size=mid&IllID=3054**

Glossaries are still relevant today. A “free-standing glossary” in a modern print book is equivalent to a pile of glosses (Jackson, 2001, p. 45). An ebook feature that directs readers to dictionaries in ebook viewers (such as the *Dictionary* and *Translate* features on Amazon’s Kindle iPhone app) could play a similar role as glosses.

A *rubric* is “an initial letter, word, phrase, title, or instruction written in red ink and/or decorative lettering, in contrast to the text written or printed in black” (Reitz, 2015, n.p.). In religious contexts, rubrics highlight terms of religious significance and are “a virtual instruction manual for who should do what when” in terms of liturgical practices (Cyrus, 2009, p. 84). Figure 7 shows an example of a rubric of “historiated initial 'D'(omine) with the Annunciation, and … putti holding the rubric, at the beginning of the Hours of the Virgin” in a late 15th-century Italian manuscript (The British Library, 2016, n.p.).

**Figure 7. Rubrics. Source: http://www.bl.uk/catalogues/illuminatedmanuscripts/ILLUMIN.ASP?Size=mid&IllID=1782**

Rubrics have recently become popular in educational settings as written guides to communicate expectations for, and to evaluate, student assignments. Jackson (2001, p. 45) has argued that a collection of rubrics is equivalent to an index in a print book, which "guides" readers to key contents of the book. Currently, in ebook viewers that emulate print books, indexes are implemented in the same manner as in print books.

A *scholium*, the singular form of scholia, is "a marginal note explaining, interpreting, or commenting on a text, especially an annotation added by a classical grammarian on a passage from a work by Greek or Latin author of Antiquity" (Reitz, 2015, n.p.). The writing around the edges in Figure 8 is an example of scholia.

**Figure 8. Scholia. Source: https://www.flickr.com/photos/ryanfb/9824214703/**

A collection of scholia can be considered equivalent to "independent commentary" (Jackson, 2001, p. 45) in modern times. In the context of ebooks, a feature that directs readers to external

sites (e.g., the *Wikipedia* feature on the Amazon's Kindle iPhone app) would function like scholia in some respects.

A *commonplace-book* is "a book with blank pages in which passages in prose or verse are recorded irregularly by its owner as ideas for future exploration or contemplation, sometimes arranged by subject." (Reitz, 2015, n.p.). Figure 9 shows an example of a commonplace book "containing poems by various authors, in various hands[, i]nclud[ing] Shakespeare[']s second sonnet" (Beinecke Rare Book and Manuscript Library, 2016, n.p.).

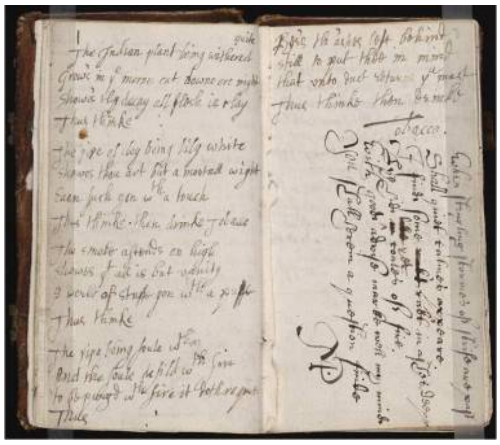

**Figure 9. Commonplace book. Source: https://commons.wikimedia.org/wiki/File:Commonplace_book_mid_17th_century.jpg**

A collection of individual sticky notes in ebook viewers that readers have added to relevant texts in the course of reading could be an example in modern times that plays a similar role as a commonplace book.

Annotation has weakened in importance over the years, due to a number of factors. These include the invention of printed indexes and footnotes, which replaced older forms of annotations; the mass production of books, which gave rise to a fear among the elite that annotations would be imitated by "lesser mortals"; and the growth of public libraries, where annotation was prohibited (Jackson, 2001, p. 73). The characteristics of marginalia have also changed, evolving from "impersonal contributions to scholarship" or "aggressive displays of disagreement" (Jackson, 2001, p. 54) intended to be shared with other scholars or students, to "typically critical (in the sense of evaluative), personal, and designed to be shared" with close friends (Jackson, 2001, p. 54), and from there to "predominantly a private affair, a matter of self expression" (Jackson, 2001, p. 73). Most current annotation practices are optional, private, and arbitrary. In other words, unlike in the past when teachers instructed students to annotate, nowadays readers add annotations of their own volition. They develop their own ways of annotating and create annotations such that they can understand their own, but cannot necessarily understand others', annotations. Thus even when different readers share common characteristics, their annotations styles may vary. For example, some readers might focus on the authors' original intended meanings (i.e., impersonal), while others might focus on their own reactions to the text, such as the inspirations they find therein (i.e., personal).

Currently available ebook viewers and readers support the annotation activities of individual readers. For example, the "Comment" feature in Acrobat Pro DC enables readers to highlight and underline text and add sticky notes. The Amazon Kindle enables readers to highlight text and share underlines with other readers. Features in Mendeley's desktop application, which is a research tool for collecting and organizing web resources, enable readers to highlight text and add sticky notes. Thus older annotation practices have already been implemented in ebook viewers to some extent. However, there remain earlier annotation practices that have been neglected, and ebook designers could benefit from exploring and reflecting on them.

For example, different functional types of annotations (e.g., impersonal, public, explanatory, editorial, commentary, social) which were written by diverse types of people in former times (e.g., scholars, editors, clergymen) were distinctive in older forms of annotation practice, but they are not clearly distinctive nowadays. Yet it could be useful to preserve these distinctions in certain contexts; for example, novice researchers could benefit from annotations done by expert researchers in an academic environment. In order to reflect such distinctions, ebook designers could consider who can be participants, what types of annotations can be added, and how multiple annotators can be engaged together. Moreover, given that one use of annotation in earlier times was as an editorial tool, e.g., to make corrections for next editions (Jackson, 2001), ebook viewers and readers could be designed as open systems, like the Public Knowledge Project (http://pkp.sfu.ca/), to enable all relevant parties, such as authors, readers, and editors, to communicate with each other through a group annotation tool, allowing all parties to benefit from each other. Authors could get feedback directly from readers; readers could clarify ambiguous passages directly with authors; and editors could get corrections directly from readers.

Further, current web technologies could allow for the implementation of private and public annotation, by adding such features as log in/out and a visible/invisible option to ebooks. It might be useful to design a feature that encourages individuals to follow a set of public annotation rules, instead of their own, idiosyncratic annotation practices. Suppose that there were a public rule that ambiguous sentences should be highlighted in red. Those red highlights might prompt other readers to make comments on those sentences in an attempt to disambiguate them. In this way, this feature could potentially engage individuals' reading processes and support them in being more active readers.

*The Practice of Bookshelving*

The practice of bookshelving is closely related to the practice of reading, in the sense that bookshelving can facilitate reading by helping readers manage multiple books effectively and efficiently. The activity of arranging books in appropriately designed spaces has historically been closely associated with the physicality of books (Brooks, 1998). Mesopotamian shelves in the 1st millennium B.C. were designed to store clay tablets side by side. Pigeonhole-like Roman bookshelves, dating back to about 79 A.D., were created to store papyrus scrolls (e.g., Figure 10).

**Figure 10. "A roman taking down a roll from its place in a library" (Clark, 1901, p. 119). Source: https://www.gutenberg.org/ebooks/26378**

Other forms of bookshelves (e.g., cupboards called *armaria*) were designed to store codex forms of books (e.g., Figure 11). Before the Middle Ages, codex books were stored horizontally on shelves in book cupboards (Suarez & Woudhuysen, 2010), with their title pages displayed outside (see the books in the cabinet in Figure 11). Later on during the Middle Ages, when the desks to which bookshelves were attached became larger and books became smaller, books were placed vertically (Suarez & Woudhuysen, 2010), with their spines on display.

**Figure 11. "Ezra writing the Law. Frontispiece to the Codex Amiatinus" (Clark, 1901, p. 3). Source: https://www.gutenberg.org/ebooks/26378**

As Polanka's (2011) book title, *No Shelf Required: E-books in Libraries*, suggests, bookshelving is no longer a relevant concern in digital environments. Nevertheless, the old practices of shelving books horizontally and vertically provide useful visual cues in selecting appropriate books according to one's purpose for reading and in recalling contents of books that were read in the past. For example, when print books are placed horizontally, displaying their covers provides readers with useful visual cues that may trigger recall of their contents. When print books are placed vertically, their thickness and size provide readers with useful visual cues about the conciseness or complexity of the contents. Currently, many websites, such as goodreads.com,

amazon.com, and barnesandnoble.com, have the ability to show individual books' front covers, but not necessarily their sizes and thicknesses. Yet the latter could facilitate quick comparison of books on similar topics when someone is deciding which books to read and in what order. Thus, the old practice of bookshelving suggests the usefulness of visually transforming ebooks into print books with book covers and spines.

In addition to storing books, arranging multiple books is another function associated with bookshelving. Unlike medieval and earlier practices of bookshelving, the more recent practice of creating cinder block shelves, especially popular in the 1970s and 1980s, provides the flexibility to expand, contract, or move book storage (Brooks, 1998). Similarly, the practice of bookshelving on Houdini's magic bookshelves in the 19th century, with secret compartments accessible only to particular people (Brooks, 1998), provided flexibility in storing books. Even earlier, Samuel Pepys's bookcases, dated about 1666, in which 3,000 books were arranged by height behind glazed doors (Figure 12), illustrate that criteria for book placement on bookshelves can be flexible according to individual preferences (Brooks, 1998; Petroski, 1999).

**Figure 12. Pepys's bookcases. Source: https://commons.wikimedia.org/wiki/File:Pepys_Library_Cambridge_interior.jpg**

Factors other than properties of books (e.g., subject, size, accession order), such as physical locations (e.g., alcoves, bookcases, position on shelves), also come into play in arranging books. These are closely related to the historical issue of fixed location versus relative location (Dunkin, 1969; LaMontagne, 1961). For example, Shurtleff's fixed location system, which was introduced in the Boston Public Library in 1852, used special call numbers to arrange books according to physical location; an example is $\frac{111}{3}$, which referred to the third book on the 111th shelf (LaMontagne, 1961). Although a fixed location system has advantages (e.g., ease of locating particular books), it makes locating books with similar subjects more difficult (Ranz, 1964). To overcome the disadvantages of a fixed location, diverse versions of a relative location system have been proposed over time, including the Dewey Decimal Classification system in 1873 and the Library of Congress Classification system in 1901 (Dunkin, 1969).

Today, reference managers, such as the Mendeley Desktop application, fulfill the role of electronic bookshelves in that they help arrange stored books. The Mendeley Desktop application offers flexibility in arranging resources within one folder according to diverse criteria such as author, title, and date added. However, it has limited flexibility in arranging resources across different folders, due to a filtering system that is limited to authors, tags, and publications.

This prevents arrangement of resources across different folders by any other criteria, such as user behaviors (e.g., level of importance, frequency of visits, degree of recent activities), which could provide readers with valuable information for the purposes of recall and retrieval. Therefore, it could be useful to increase flexibility in arranging resources for reference in reference managers by adding diverse filtering systems or utilizing diverse information visualization techniques.

In doing so, one might usefully re-assess the historical advantages and disadvantages of fixed location versus relative location (cf. Ranz, 1964, pp. 23-30) in relation to digital bookshelving. In the age of physical bookshelving, a critical disadvantage of a fixed location was that already-shelved books needed to be re-shelved and re-fixed whenever new books came in (Dunkin, 1969). However, moving digital books around by dragging and dropping is not a big issue, and thus a fixed location is no longer a disadvantage in the age of digital bookshelving. One location system or a combination of both systems could be used as new ways to arrange digital books in reference managers, depending on the individual reader's purposes for arranging books. A fixed location could be beneficial, for example, in arranging digital reference books such as encyclopedias, citation manuals, and dictionaries, enabling researchers to locate them quickly and easily.

In addition to storing and arranging books, transporting books is another function associated with bookshelving. English book chests in the 14th century are one example of a design that facilitates transporting books (Brooks, 1998) (Figure 13). Thomas Jefferson's bookshelves in the 19th century, comprising pine boxes that could be lidded for transportation and later assembled in tiers as bookcases, provide another example of a design for both transport and storage (Brooks, 1998).

**Figure 13. "Simon, Abbat of S. Albans (1167-1183), seated at his book-chest." (Clark, 1901, p. 796). Source: https://www.gutenberg.org/ebooks/26378**

Facilitating reading is another function that was closely related to the practice of bookshelving. The Zutphen lectern system in use in Holland around 1563 and the chained stall system that combined bookshelves with desks in England in the late 16th century (Brooks, 1998) are examples of designs that conveniently located places for reading next to bookshelves (e.g., Figures 14-15).

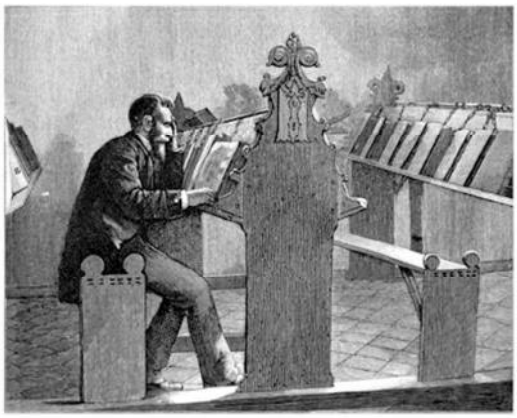

**Figure 14. "Desk in the library at Zutphen: From a photograph" (Clark, 1894, p. 47). Source: https://www.gutenberg.org/ebooks/19415**

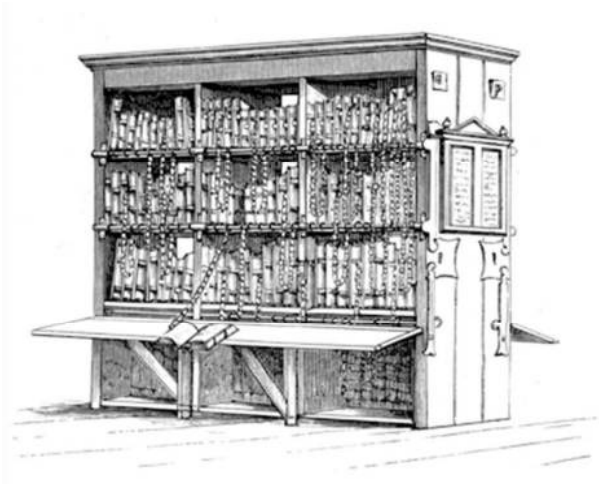

**Figure 15. "Bookcase in Hereford Cathedral" (Clark, 1894, p. 52). Source: https://www.gutenberg.org/ebooks/26378**

Napoleon's bookshelf in the 18th century, which was fitted out on his couch (Brooks, 1998), is an example of making reading comfortable. A modern example of making reading available wherever it is wanted is the niche bookshelves of Janet and Stephen Greene, journalists and publishers, which can be situated anywhere in the home, including in bathrooms (Brooks, 1998). A good example of a provision for reading efficiency is "Dr. Eliot's five-foot shelf," designed with the ideal dimensions for facilitating frequent "fifteen minutes a day" reading (Brooks, 1998, n.p.).

Today, the Mendeley Desktop application facilitates reading anywhere by providing *Synchronize* features that utilize cloud computing techniques across different devices, which can be installed anywhere at home. To make reading comfortable, this application provides *Highlight* and *Note* features. However, it seems that the Mendeley application, which was originally developed as a reference manager rather than an ebook viewer, has not yet significantly facilitated reading by encouraging users to read more books or read more frequently. Thus, it would be useful to come up with design features for reference managers that are more helpful in facilitating reading. Given that recommendation systems are already available on diverse sites, such as amazon.com

and goodreads.com, one proactive approach that could facilitate reading would be to add recommendation systems to reference managers (e.g., a prompt for a new window that shows new editions of previously added books or new relevant books), for example. This could not only support reading but also encourage further reading by stimulating readers' intellectual appetite and encouraging them to read more books.

## Conclusion

We find ourselves now at a transitional stage between classical print books and ebooks, as once we were at a transitional stage between the scroll and the codex. Some scholars believe that classical print books will be replaced completely by ebooks, while others do not. The question of whether ebooks will eventually replace print books is outside the scope of this paper, which has been concerned rather with questions such as: What are the best book forms to facilitate ease of reader manipulation and support a natural flow of reading? What are the most ideal reading and annotation practices in order to support readers' goals in reading? What can we learn from older practices such as bookshelving?

In earlier times, physical constraints, such as printing materials and techniques and physical shelving, inevitably shaped the evolution of the book. Physical constraints significantly hindered or advanced the forms and capabilities of the book. Nowadays, the rapid development of innovative technologies enables us to think about the design of ebook readers beyond physical constraints. One implication of this development is that features that constrained print books and p-reading in the past might actually improve the design of ebooks and e-reading in the present. It is possible – indeed, likely – that some advantageous properties of older forms have been sacrificed in the course of evolution. For example, the rollable scroll was replaced by the codex because the scroll was thought to be disadvantageous compared to the codex in terms of shelving in early times. However, a rollable ebook reader (hardware) that can hold many books could be advantageous compared to the large size of a tablet in terms of portability in the digital world, where physical shelving book-by-book is not an issue.

Accordingly, this paper has re-examined and re-evaluated older forms of the book and older practices of reading, annotation, and shelving, identifying historical practices that have the potential to support improved reading experiences, and suggesting ways that these could be integrated into the design of ebooks, including reference management systems. More generally, we have argued that designers should seek to develop best forms of the book and best practices of reading, annotation, and book storage beyond current knowledge or technologies. It is our hope that ebook designers will gain insights from this paper, contemplate them, and apply them to their specific contexts with imagination and creativity. Reading is a complex phenomenon; it depends on many intertwined factors. Even how to read this paper, what to take from it, and how to apply it are wide open, depending on the reader and his or her unique context.

History is vast, and this paper is necessarily based on a limited set of existing sources. In future research, it would be helpful for researchers to collect a wide range of historical data and reference books, including data and books from diverse countries, in collaboration with historians, in order to obtain the broadest possible range of design insights. At the same time, more in-depth historical investigation – for example, into whether and, if so, how, subject matter (e.g., religion) determines book forms and reading practices – could lead to interesting design

insights. Possible resources for further exploration include books and journals from the (inter)discipline of book history (e.g., Howsam, 2014; Lyons, 2009; *Book History* by Johns Hopkins University Press), as well as materials from professional organizations (e.g., *The Society for the History of Authorship, Reading and Publishing*).

Last but not least, insights could be obtained by identifying up-to-date and emerging issues in relation to ebooks and online reading and seeking out relevant historical resources. For example, accessibility has been a critical issue in ebooks and ebook readers not only from a design perspective but also from a legal perspective (Petri, 2012). A consideration of historical resources in this regard (e.g., the history of special education, the history of education of the blind, the history of education of the deaf) could suggest new insights.



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