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Project Approval Form

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Thesis Title: Design Patterns for Navigation within Tablet-based Digital Libraries

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Abstract

Reading habits and navigation within traditional printed media such as books and magazines has been studied extensively in the past. The research into content consumption in print lead to research into electronic document navigation and consumption. One emerging area of content consumption is the tablet.

This study contributes to the existing pool of content navigation and consumption research by assessing tablet-based content consumption through the lens of previous work in print and on the computer. The present study assesses three commonly employed methods of content navigation on tablets. The content presented falls into three categories: Text only, a combination of text and images, and Image heavy content. The results of the present study indicate the navigation methods employed by Apple’s iBooks software for eBooks and Adobe’s DPS software commonly used for tablet-based publishing apps enable users to locate content more quickly and with more confidence than the method employed by iBooks for navigating PDF documents.
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1 Introduction

1.1 Consumption of Tablet-Based Content Is Increasing

The recent advent of mainstream tablet use has brought about a number of significant lifestyle changes for information consumers. Tablets are the device of choice for "lean-back" reading for many in today’s world. Mario Garcia, of the Poynter Institute, characterized lean-back reading as the reading that takes place when a person has the time to sit back and take in the events of the day in long-form narrative. Historically, this type of lean-back reading was done with printed publications such as newspapers and magazines (Garcia, 2012).

Industry research firm Juniper Research predicts that portable-device based distribution of eNewspapers will reach $1.1 billion dollars by the year of 2016. The report points to the fact that large publishing houses such as News International have begun offering a single subscription price for access to The Times in all of the various media channels in which The Times is offered("Computers, Software; eNewspaper Sales to Tablets, eReaders & Smartphones to Hit $1.1 bn by 2016, but Publishers Face Funding Gap as Print Circulations Tumble," 2011).

Within the near future it is possible that tablets will have a broad impact in developing nations as well. An article dated December 15, 2011 from the online version of The Economist notes that the worlds most inexpensive tablet had been announced in Delhi and will be sold to students at the subsidized price of $35.00 (A.A.K, 2011). Whether this device will be a success or not remains unclear, especially in light of the widely reported failures in the One Laptop Per Child Program (OLPC). However, the article indicates that the attempts at an inexpensive tablet are being made with the OLPC challenges in mind and the devices are priced very reasonably for the Indian market.

Tablet readership is on the increase in developed nations as well. This is evidenced by a report by Adobe, a major manufacturer of content creation and distribution software for tablet devices, who indicated that in the year 2011 more than 16 million tablet-based publications were powered by Adobe’s Digital Publishing Suite (DPS). In her clarification of Adobe’s opening-day presentation at Mobile World Congress in 2012, Molly Joss sought to look at the numbers behind
Adobe’s claims about DPS. As of the publishing of Joss’ critique there were around 1,500 DPS applications live. Sixty-eight percent of that content was purchased, and 27% of the digital content was consumed by print subscribers (Joss, 2012).

Adobe has published other figures indicating the tablet-based digital magazines are important. In their paper "A Print Magazine on Any Screen: The Wired App Story", Clark and Brandt indicate that Wired magazine sells 30,000 copies of their magazine per month to readers using the iPad format. They go on to indicate that the tablet edition is a significant source of revenue for Wired’s parent company Condé Nast (Clark & Brandt, 2012).

Garcia (2012) also pointed out that dwell time, a crucial metric used in advertising sales that is based on the amount of time an individual spends consuming media, has increased with the advent of modern devices. Media dwell time has increased to over 60 minutes of daily dwell time on average from an average of 22 minutes of dwell time many years ago. These realizations are consistent with Adobe’s contention that 56% of the individuals that consume content using the DPS spend between 25 minutes and 2.5 hours per month. The report also indicates that time spent consuming content using the DPS framework applications has increased by 70% over the past year (Joss, 2012).

The figures presented above indicate tablet-based content consumption is on the rise. It is also clear that there are vibrant business opportunities available in the distribution of content for tablet-based devices. Well-designed tools are likely to be valued by content consumers on tablet-based devices and may be critical to faster adoption of tablet-based reading.

1.2 Proposed Study on Navigation Within Tablet-Based Content

There is a sizable body of research into electronic document navigation as indicated in the literature review. However, after an extensive literature review there was no published research into tablet-based document navigation from an end user and interface (Human Computer Interaction (HCI)) perspective. As such, tablet computing offers several new and unexplored navigation options for within-document as well as document library navigation. As these devices likely become increasingly adopted it is important to understand the impact they will have on the
future of document consumption and, potentially, document creation. Navigation tools are an important step in this analysis as they provide the backbone of any interaction with a document.

Due to the fact there is no published research on tablet-based document navigation it is important to understand how documents are currently being navigated on tablet devices. This is best done by examining the most commonly used commercially available software products for both content creators and distribution purposes.

Frameworks for document library navigation as well as within-document navigation already exist and are in use for digital magazine publishing in the form of Adobe Digital Publishing Suite ("Digital publishing software | Adobe Digital Publishing Suite family," n.d.) and QuarkXPress’ Quark App Studio ("App Studio - Design and Publish to Your Own iPad and Android Apps," n.d.). In contrast to commercially available solutions, both the New York Times and the Boston Globe have digital tablet-based editions of their newspapers based on proprietary development, and both use slightly different approaches for library as well as within document navigation.

There are many different navigation patterns publications on tablet devices today. It is presently proposed that these design patterns be initially characterized to provide a foundation and common terminology for subsequent analysis. The identified patterns can then be tested against several document navigation scenarios in order to quantify and qualify their usefulness with respect to information retrieval.

It is important to recognize that navigation within tablet-based document libraries comes in two broad categories. There is the within-document navigation based around non-paginated content, and there is typically a larger framework for general library and paginated content navigation. Within-document navigation for non-paginated content can take the form of tables of contents, buttons on a page, or highlighted text within an article. The design space for within-document navigation of non-paginated content can potentially be broad and unwieldy, and therefore beyond the scope of the presently proposed research. Conversely, the larger framework for general library and paginated content navigation is more concise.
The proposed study will therefore be limited in scope to the larger document navigation framework that deals with paginated content. The decision to limit the study to the larger framework for general library and paginated content navigation is specifically based on the desire to provide a precise focus on a specific content area.

In light of the cited lack of research, initial observations must be used as a guiding principle. Initial observations indicate that within-document navigation of non-paginated content is a very broad design-space.

2 Related Work

While a comprehensive review of literature pertinent to library navigation using a tablet device yielded a dearth of information, there are relevant studies in the area of navigation using other electronic media. Content presentation research has advanced substantially in recent years, but little can be found regarding tablet-based reading. Document presentation and within-document navigation are certainly important, but looking at only these areas of the document navigation experience is limiting in the context of today’s document usage.

In contrast to library-centric or document-centric research, content presentation research has advanced substantially in recent years, but little can be found regarding tablet-based reading. Tablet-based document navigation is increasingly common and is often done within the context of some type of document library. The library could be a collection of digital magazines, a group of e-books, a collection of PDFs, or a collection of disparate document types. Furthermore, each document could represent a multitude of content types: today’s documents could include text, images, videos, or even sound.

Much of the research can be traced to the seminal work of Fitts (1954), who breaks the ability of humans to acquire a specific target and interact with that target down into a simple equation based on the distance to the target, the size of the target, and the time it takes to point to the target. Fitts’ concludes that the human motor system’s "rate of performance is approximately constant over a considerable range of amplitudes, but falls off outside the optimum range (Fitts, 391)." While the study itself has nothing to do with document research, Fitts’ law is widely
recognized as foundational for future researchers examining pointing tasks similar to those required when navigating tablet-based documents.

Building on Fitts’ research are methods like rapid serial visual presentation (RSVP) (Bruijn & Spence, 2000) and speed dependent automatic zooming (SDAZ) (Igarashi & Hinckley, 2000). Both are within-document navigation methods that focus on the theoretical processing limits of the human visual system.

RSVP consists of displaying content on the screen and then switching to the next piece of content repeatedly. Effectively the user is presented with a document scrolling at a rapid and constant speed. Bruijn and Spence recommend the use of RSVP for small screen documents and for three different task types. Document browsing tasks are broken up as searching, browsing, and content modeling according to a previously developed content browsing strategy proposed by Spence in a previous paper (1999). Bruiijn and Spence indicate that RSVP may be suitable for all three browsing behaviors based on the results of their initial study.

Unlike RSVP, SDAZ will zoom the document view appropriately for the speed with which the user is scrolling the document. This is accomplished by displaying increasingly large portions of the document as the user speeds up his or her scroll. The authors of the study note that SDAZ is an effective document navigation method, but it works best when navigating through visually distinct content types (Igarashi & Hinckley, 2000).

Hoeben and Stappers (2000) took a similarly visual approach to document navigation by placing a small document thumbnail in a corner of the document. The user could glide through the document by clicking on the thumbnail and dragging. This dragging would cause a representation of the pages within the document to be presented as the user dragged the mouse. The authors conclude that this type of navigation is really best suited for exploratory browsing or magazine navigation.

Other research rooted in Fitts’ work is Cockburn, Gutwin, and Alexander’s 2006 paper, which presented a document navigation method based around space-filling thumbnails. Space filling thumbnails visually represent the document being navigated as either a full page or a series of thumbnails representing the entire document. A specific thumbnail could be selected by clicking
on it and the document would automatically jump to the page represented by the thumbnail. A user could switch between full page or space-filling thumbnail mode by pressing the middle mouse button (Cockburn, et al., 2006).

This bi-modal approach to document presentation stands in contrast to SDAZ, which gave the user a scalable view of the document they were navigating (Igarashi & Hinckley, 2000). Cockburn et al. indicated that it is possible for scrollbars to confuse the user with respect to where they are within a document from a spatial standpoint. Space-filling thumbnails are able to capitalize on a user’s spatial awareness by presenting a grid of pages. The task of re-visitation is now linked spatially within the document (Cockburn, et al., 2006).

In 2007 Guiard, Beaudouin-Lafon, Du, Appert, Fekete, and Chapuis attempt to break document navigation down into many smaller discrete tasks in their paper "Quantifying degree of goal directedness in document navigation: application to the evaluation of the perspective-drag technique" (2007). The approach taken in this paper focuses solely on content location within the document and not content types.

Two key questions drive the research of Guiard, et al. (2007):

1. "Do the users know the nature of the information they are interested in?"
2. "Do the users know the location of the information they are seeking?"

The researchers make the point that document navigation is typically made up of many different sub-tasks and Fitts’ law may not be effective in the instance that a user has many different tasks to complete. Instead they offer the Degree of Goal Directedness (DGD) as a measure of navigational complexity. The authors also point out that different contexts often require different within-document navigation strategies. Therefore, varied tasks must be used to test document navigation rather than relying solely on Fitts’ law calculations as the basis for navigation evaluations (Guiard, et al. 2007).

Until 2005, document navigation had been studied by HCI researchers in a digital realm and that research was largely governed by Fitts’ law. Marshall and Bly (2005) undertook an observational study regarding reading and within-document navigation of printed documents. Here, the
researchers indicate that paper-based document navigation is "lightweight". They then define what lightweight navigation means to the reader: when they move within an article in a way that is so unselfconscious that they aren’t apt to remember it later" (p. 230).

Marshall and Bly (2005) identify four important types of navigation within traditional print-based documents that define what makes the document navigation experience lightweight:

1. "Narrowing or broadening focus by manipulating the physical magazine"
2. "Letting one’s eyes stray to a page element out of the textual flow"
3. "Looking ahead in the text to preview or anticipate"
4. "Looking back to re-read for context"

Pearson uses Marshall and Bly’s definitions of lightweight and attempts to take a more traditional approach to electronic document navigation in the paper "Supporting Effective User Navigation in Digital Documents" (Pearson, 2010). Pearson argues that digital document navigation should be "lightweight" in nature, as was proposed by Marshall and Bly. In order to achieve this, Pearson tested the use of visual markers and post-it notes that could be placed within the electronic document for quick retrieval of information should it be required.

Pearson also indicated that the capabilities digital documents afford in terms of search should not be abandoned. Instead, she proposes that search facilities need to be more lightweight in nature. To this end she developed a series of visual indicators to aid in ranking relevance within document search results. Pearson concludes that lightweight enhancements to digital documents do improve user satisfaction (Pearson, 2010).

Alexander and Cockburn (2008) characterize digital document usage similar to Marshall and Bly’s characterization of printed document navigation behavior. Alexander and Cockburn examined the use and re-use of documents on a desktop computer using data logs of user interaction within Microsoft Word and Adobe Acrobat over the course of 120 days (Alexander & Cockburn, 2008).

Ultimately the study found that the primary method of navigation was the scrollbar or the scroll-wheel. The user interaction was characterized by the distance moved and the number of
navigation actions taken by the user. In some ways this study is a validation of document library research as it found that nearly half of all document openings were re-openings (Alexander & Cockburn, 2008). This knowledge could allow for testing practices that effectively mimic typical document browsing behavior by testing both use and re-use as the study indicates both use cases are equally likely on a desktop computer.

In a departure from the previously cited research, Guiard, Du, and Chapuis (2006) propose the use of a standardized document with which to compare navigation methods. The authors indicate that the complete works of William Shakespeare would make a suitable benchmark for multi-scale document navigation techniques. A HyperText Markup Language file is offered up for use as the standard test file going forward for document navigation tasks.

Interestingly, all of Shakespeare’s works are included in one long document. The authors indicate that typically document navigation lends itself well to Fitts’ law (1954) and almost all navigation tasks are pointing or target acquisition tasks in nature. There is no mention of Shakespeare’s complete works in document library testing though it would be suitable as it is technically many volumes in length.

Recently a paper was published at CHI 2012 indicating some of Adobe’s thought process with respect to the development of digital magazines. Clark and Brandt (2012) indicate that for the print magazine "browsing the issue as a whole is mostly a linear, horizontal experience." They then go on to point out that scrolling through a document is typically done vertically in the digital realm and this is why the decision was made to develop a system where vertical scrolling remains within an article but moving between articles is a horizontal experience (Clark & Brandt, 2012). One of the things of note here is the reference to how the design decisions were made, but no mention of any empirical testing.

Clark and Brandt (2012) also indicate that content types play into within-document navigation to some degree. They do not go as far as Igarashi and Hinckley and indicate which navigation methods are better. However, they do indicate that they had identified four content types that affect the within-document navigation. They go on to break the content types down into the following categories:
Several different proposals for document navigation have been presented including Bruijn & Spence's 2000 work on RSVP, the work of Igarashi & Hinckley with SDAZ, and the use of a document thumbnail as a navigational aid as originally proposed by Hoeben and Stappers. Almost all of the digital document navigation research up until the year 2005 was rooted in Fitts' 1954 seminal work on target acquisition. Recent approaches to document navigation have veered slightly away from Fitts' work while still referencing it or using it for contrasting purposes.

3 Methods

The research was conducted in three phases:

1. Characterization of tablet-based digital library navigation methods currently being used.
2. Development of prototypes to match the current within-document navigation options identified in step 1.
3. Evaluation of the prototypes developed in step 2.

3.1 Characterization

Documents types were chosen for characterization based on their adoption or their navigation differences with respect to other document navigation methods evaluated. Three document types were selected for evaluation based on the above criteria. These include EPUB, PDF, and Adobe DPS documents formatted for display on an iPad.
3.1.1 EPUB

Electronic books were chosen for evaluation specifically because they have a very strong presence in the publishing market. EPUB, a popular eBook format, had sales of 119.7 million dollars within the United States alone as of the 3rd quarter in 2010 (IDPF, 2014). Apple’s iBooks supports the format and is the primary means of reading eBooks on the iPad.

iBooks navigation comes in two parts: the document library, and the within-document navigation that exists to enable users to navigate the content within the electronic book.

The document library for eBooks consists of an image of a bookshelf. If there are no eBooks present on the iPad the shelf will appear empty. However, if the iPad has eBooks stored on it the bookshelf will have simulated book covers sitting on it, as seen in Figure 1. The user selects which book they would like to read by pressing the cover of the book they are interested in. Once the eBook has been selected it opens the eBook on the device and the iBooks software now changes to within-document navigation.

![Figure 1 Example of the iBooks eBook bookshelf with Shakespeare’s works on display. All navigation and content configurations had the same black cover with white text.](image)
The within-document navigation for eBooks is characterized by a few navigation options. Perhaps the most prominently featured is the scroll bar across the bottom of the page as seen in **Figure 2**. The user is given the option to select the brown location indicator, and scroll through the document in a horizontal direction. The line at the base of the page represents the entirety of the book, and the user can drag the location indicator across the line to indicate where they would like to stop navigating and begin browsing content. This method is akin to Hoeben and Stappers' (2000) concept of dragging a thumbnail through a document.

**Figure 2** Example of the scrollbar used within the ebook navigation. The scroll bar is located at the bottom of the image just above the page numbers.

Additionally, the user has the option to press the icon in the upper left-hand corner and select the table of contents view of the eBook. iBooks provides users with a table of contents, seen in **Figure 3**, that is very similar to a traditional book. In this view the user needs only press the location they would like to go to and the software will automatically take them to this location within the document. This is a very broad navigation option however, as it is only available for
larger content chunks such as chapters of a document, or in the case of the content being used in this evaluation, acts and scenes.

![Table of Contents](image)

**Figure 3** Example of the table of contents used within eBook navigation

### 3.1.2 PDF

PDF documents were chosen because they have a different within-document navigation method than eBooks on iPads, and they are one of the most ubiquitous document distribution formats in the world. The library of congress has no specific figures regarding the adoption of PDF, but it does note that it is widely adopted and recommends it for use in archival projects due in part to its widespread adoption (US Library of Congress, 2010).

iBooks document navigation for PDF comes in two parts, the document library, and the within-document navigation.

The document library for PDFs consists of an image of a bookshelf. If there are no PDF documents present on the iPad the shelf will appear empty. However, if the iPad has PDF
documents stored on it the bookshelf will have a small thumbnail of the document, as seen in Figure 4. The user selects which document they would like to read by pressing on the thumbnail of the PDF document they are interested in. Once the PDF document has been selected it opens the PDF on the device and the iBooks software now changes to within-document navigation.

![Image of iBooks PDF bookshelf with Shakespeare's works on display. All navigation and content configurations had the same black cover with white text.](image1)

**Figure 4** Example of the iBooks PDF bookshelf with Shakespeare’s works on display. All navigation and content configurations had the same black cover with white text.

The within-document navigation for PDF documents is characterized by a few navigation options. Perhaps the most prominently featured is the scroll bar across the bottom of the page as seen in Figure 5. The user is given the option to select the small thumbnail on the horizontal bar, and scroll through the document in a horizontal direction. The line at the base of the page represents the entirety of the document, and the user can drag the location indicator across the line to indicate where they would like to stop navigating and begin browsing content. This method is somewhat similar in approach to Hoeben and Stappers (2000) concept of dragging a thumbnail through a document and is similar in function to the horizontal scrolling within eBooks.
**Figure 5** Example of the iBooks PDF within-document navigation. Note the scroll bar across the bottom of the page. Small thumbnails of pages are used to represent a location within the document.

Additionally, there is an icon in the upper left-hand corner of the navigation that will bring the user to a within-document navigation method similar to Cockburn, Gutwin, and Alexander’s 2006 paper on space filling thumbnails. **Figure 6** illustrates the implementation of space filling thumbnails within iBooks. In order to select a page of content the user must press on the thumbnail they are most interested in.
Figure 6 Example of the space filling thumbnails used as a piece of within-document navigation in iBooks when reading a PDF. Note that these are individual pages with small images on them.

3.1.3 Digital Publishing Suite

DPS content was chosen for evaluation specifically because it has a very strong presence in the publishing market. As of June, 2013 DPS-based content downloads had reached 100 million total, and 6 months later the cumulative downloads had reached 150 million (Adobe Digital Publishing Suite Team, 2013).

DPS navigation comes in two parts, the document library, and the within-document navigation that exists to enable users to navigate the content within the electronic book.

The document library for DPS content consists of a blank background. If there are no DPS publications present on the iPad the background will appear blank. However, if the iPad has DPS publications stored on it the background will have a cover over top of it representing the publication, as seen in Figure 7. The user selects which publication they would like to read by
pressing on the thumbnail of interest. Once the DPS publication has been selected it opens the publication on the device and the DPS software now changes to within-document navigation.

Figure 7 Example of the within-document navigation options available to DPS users. A table of contents can be accessed by selecting the Table of Content icon indicated above and the grid navigation can be accessed by selecting the grid navigation icon indicated above

Within-document navigation in DPS can be arranged in a two-dimensional grid of pages. Typically articles appear to extend in the y-axis. The user swipes left to right to change the article he or she is reading. This unique document layout is illustrated in Figure 8.
Figure 8 Example of the grid navigation option available within DPS.

The within-document navigation available in DPS comes in three different types – table of contents, two dimensional grid, and swiping between pages as described above.

The table of contents in DPS documents can be accessed by tapping the screen once to bring up the navigation options and clicking the button indicated in Figure 7. A table of contents will slide out from the left-hand side of the iPad as seen in Figure 9. The user can then tap on the navigation point they would like to visit and the document will jump to that location.
The two-dimensional grid can be accessed by tapping the screen once to activate the navigation options and clicking the button indicated in Figure 7. Once the two-dimensional grid is activated the user can swipe through the visualization of the grid and select the article or act/scene combination he or she is interested in. Once the user has selected the navigation point they are interested in they can tap the grid in the desired location and the document will jump to that location.

3.2 Prototype Development

Once the most common navigation options had been characterized suitable documents using these navigation methods had to be developed. As indicated earlier, Shakespeare’s complete works were used to create the document library. The tasks used in the study only required a small subset of the library to be fully developed. However, it was determined that every play from Shakespeare’s work should be developed into a navigable document in the event a user accidentally selected an improper document.
Shakespeare’s complete library of plays was downloaded from MIT’s "The Complete Works of William Shakespeare," at http://shakespeare.mit.edu. All of the works are in the public domain. Only the plays were selected because their length made them suitable for document navigation analysis.

The use of 37 different plays, three different content presentations of each play, and 3 different navigation methods meant that 333 different documents needed to be created in order to complete the study as specified. An automated content transformation solution was devised in order to complete these content transformations in a timely manner. Figure 10 illustrates the basic process used for the transformations.
Figure 10 The document preparation process from initial HTML 4.0 document to finished output for all 333 documents
Several difficulties were encountered when preparing the content of Shakespeare's works for the different navigational designs. The Shakespeare content from MIT did not contain image content and was not originally in a format suitable for transformation into multiple document formats. The quantity of Shakespeare's work and the use of three different document formats for each play required the development of an automated process to transform these documents into formats suitable for distribution and consumption on an iPad.

As indicated earlier, image content was not included with the Shakespeare Content from MIT so a custom php script was written to scrape popular image sharing sites for images from each of the plays. A total of five images for each character were downloaded into a folder representing the character. These images were not necessarily of the character or usable in this research so all of the images in each character folder were evaluated using Adobe Bridge and a suitable image was tagged for use while the others were removed to avoid confusion. An action was used in Adobe Photoshop to automatically resize and crop each of the images selected for use in the study to the necessary size. Additionally, custom cover images of white text on a black background, as seen in Figure 11, were created for each of Shakespeare’s plays. These custom cover images were used regardless of content type or navigation style.

![Cleopatra](image)

**Figure 11** Example of a custom cover image. All documents regardless of navigation type or content used a black cover with the title of the play in white letters.
The acquisition of Shakespeare’s plays in HTML format required the creation of a valid xhtml file and several XSL transformations to generate the necessary documents for use on the iPad. Prior to carrying out the HTML to XML conversion the HTML documents needed to be converted into a valid xhtml document. The plays available on MIT’s site were in HTML 4.0 transitional and had elements that were not valid xhtml. This conversion from HTML 4.0 to xhtml was done using the <Oxygen/> editor and a number of custom awk, bash, sed, and perl scripts. These scripts can be found in Appendix 9.1 Document Conversion Scripts. The transformations on the converted xhtml were conducted using Saxon to process the XSL commands and transform the xhtml into the specific content structures required for each content/navigation combination.

EPUB files were then created to represent the eBook style navigation. Sigil, available at https://code.google.com/p/sigil/, was used to transform each of the xhtml files into an EPUB document. A custom cover image was added to the EPUB file, and the EPUB documents were then transferred to an iPad based on the content types contained in the document.

PDF files were created for use with the PDF style navigation as well. These PDF files were created using Adobe InDesign’s XML import tool. The xhtml representing each document was imported into InDesign and placed on the page. A custom cover image was added at the beginning of each document for use as a cover when viewed on the iPad. A PDF was then exported for use on the iPad. Each PDF was then copied to an iPad based on the content types contained in the document.

DPS documents were created for use with the DPS style navigation. These DPS files were created using Adobe InDesign’s XML import tool to import the xhtml documents into InDesign for content layout. Three accounts were created on Adobe’s DPS distribution site, one representing text content, one representing image content, and one representing text and image content. The xhtml was then placed into a document and exported to the necessary account depending on the type of content the document contained. These three accounts were then used to distribute this content to the necessary iPad by way of the Adobe Content Viewer application.
3.3 Recruitment

Participants in the study were recruited using the recruitment flyer found in Appendix 9.2 Recruitment Flyer. One-hundred and fifty flyers were printed and distributed throughout the RIT campus and the surrounding area of Henrietta, New York. Additionally, the flyer was posted on the RIT subreddit, a forum on a popular social network for college students, with a request for study participants.

Participants were required to fill out a screener to ensure they qualified for the study. The recruitment screener can be found in Appendix 9.3 Participant Screener. The screener was used to balance the participants as much as possible with respect to experience, age, gender, and student status. If an applicant qualified for the study and they were selected to take part they were contacted via email to setup a time to take part in the study. Participant demographics can be found in Table 1.

Table 1 Participant Demographics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Participants</th>
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</thead>
<tbody>
<tr>
<td><strong>Gender</strong></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>9</td>
</tr>
<tr>
<td>Males</td>
<td>7</td>
</tr>
<tr>
<td><strong>Age</strong></td>
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<tr>
<td>&gt;23</td>
<td>8</td>
</tr>
<tr>
<td>&lt;=23</td>
<td>8</td>
</tr>
<tr>
<td><strong>Tablet Use Frequency</strong></td>
<td></td>
</tr>
<tr>
<td>Daily tablet use</td>
<td>7</td>
</tr>
<tr>
<td>Weekly tablet use</td>
<td>4</td>
</tr>
<tr>
<td>Monthly tablet use</td>
<td>2</td>
</tr>
<tr>
<td>No tablet use</td>
<td>3</td>
</tr>
<tr>
<td><strong>Student/Non-student</strong></td>
<td></td>
</tr>
<tr>
<td>Student</td>
<td>8</td>
</tr>
<tr>
<td>Non-student</td>
<td>8</td>
</tr>
</tbody>
</table>
3.4 Evaluation

After the prototypes were designed a series of trials using each prototype were conducted. Each subject was asked to use each of the navigation prototypes and each of the content types. Trials were counterbalanced to negate learning effects that could be present for newer navigational modalities.

The study was conducted using a 3x3 factorial design with content type as one of the independent variables and navigation prototype as the other. The order of the trials is indicated in Table 2 with task A representing text content, task B representing image content, and task C representing image and text content. Multivariate ANOVA was calculated in accordance with standard full-factorial design practices for the times collected and Friedman tests were used to analyze the ordinal data collected using the Likert scales.
Table 2 Task Order

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<tbody>
<tr>
<td>1</td>
<td>eBook ABC</td>
<td>PDF BCA</td>
<td>DPS CAB</td>
</tr>
<tr>
<td>2</td>
<td>eBook BCA</td>
<td>PDF CAB</td>
<td>DPS ABC</td>
</tr>
<tr>
<td>3</td>
<td>eBook CAB</td>
<td>DPS ACB</td>
<td>PDF ABC</td>
</tr>
<tr>
<td>4</td>
<td>eBook ABC</td>
<td>DPS ABC</td>
<td>PDF BCA</td>
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<tr>
<td>5</td>
<td>PDF ABC</td>
<td>eBook CAB</td>
<td>DPS BAC</td>
</tr>
<tr>
<td>6</td>
<td>PDF BCA</td>
<td>eBook CAB</td>
<td>DPS ABC</td>
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<tr>
<td>7</td>
<td>PDF CAB</td>
<td>DPS ABC</td>
<td>eBook BAC</td>
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<td>PDF ABC</td>
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<td>9</td>
<td>PDF ABC</td>
<td>eBook CAB</td>
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<tr>
<td>10</td>
<td>DPS ABC</td>
<td>eBook CAB</td>
<td>PDF BAC</td>
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<tr>
<td>11</td>
<td>DPS CAB</td>
<td>eBook ABC</td>
<td>PDF ABC</td>
</tr>
<tr>
<td>12</td>
<td>DPS ABC</td>
<td>eBook CAB</td>
<td>PDF ABC</td>
</tr>
<tr>
<td>13</td>
<td>PDF ABC</td>
<td>eBook CAB</td>
<td>PDF ABC</td>
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<tr>
<td>14</td>
<td>eBook ABC</td>
<td>PDF DPS</td>
<td>eBook CAB</td>
</tr>
<tr>
<td>15</td>
<td>DPS CAB</td>
<td>eBook ABC</td>
<td>PDF ABC</td>
</tr>
<tr>
<td>16</td>
<td>eBook BAC</td>
<td>PDF DPS</td>
<td>eBook BCA</td>
</tr>
</tbody>
</table>

Users were asked to search for a specific item through three different types of content – text, images, and a combination of text and images for each of the identified navigation methods.
Participants were verbally read a task and then presented with a written form of the task to find the same piece of content regardless of navigation method being presented. Figure 12 is an example of the task presented for text content, Figure 13 is an example of the task presented for image content, and Figure 14 is an example of the task presented for the combination of images and text.

**Task A:**

I would like you to locate the text "My liege, one word." Spoken by the Duke of Aumerle in *Richard II* Act III, Scene II. The task is complete once you have located the text and pointed it out to me.

*Figure 12* Example of the task to complete when searching through text content

**Task B:**

I would like you to locate the following image of Lucio from Act III, scene II of *Measure for Measure*:

The task is complete once you have located the image and pointed it out to me.

*Figure 13* Example of the task to complete when searching through text content
Task C:

I would like you to locate Alcibiades line: "What art thou there? Speak." From Act IV, Scene III of *Timon of Athens*. The text will be below the following image of Alcibiades:

![Image of Alcibiades](image)

The task is complete once you have located the text and pointed it out to me.

**Figure 14** Example of the task to complete when searching through a combination of image and text content

The time to locate a specified target was collected to see if certain navigational design patterns are more efficient than others. A lower time would indicate a user’s ability to navigate a library/document structure more efficiently.

In order to quantify a participant’s perceived difficulty they were asked the following question: "How easy was it for you to find the information you were looking for?" The data was collected using a Likert scale with the low-end of the scale indicating very difficult and the high end of the scale indicating very easy, as indicated in **Figure 15**.
How easy was it for you to find the information you were looking for?

1 Very Difficult
2 Difficult
3 Neutral
4 Easy
5 Very Easy

**Figure 15** Example of the Likert scale used to assess a participant’s perceived difficulty when searching for a specific piece of content.

In order to quantify a participant’s certainty they were on the correct path they were asked the following question: "How certain were you that you were on the correct path to find the information you were looking for?" The data was collected using a Likert scale with the low-end of the scale indicating very uncertain and the high end of the scale indicating very certain, as indicated in **Figure 16**.

How certain were you that you were on the correct path to find the information you were looking for?

1 Very Uncertain
2 Uncertain
3 Neutral
4 Certain
5 Very Certain

**Figure 16** Example of the Likert scale used to assess a participant’s certainty they were on the correct path when searching for a specific piece of content.

Finally, participants were asked the following question: "How enjoyable was the navigation experience as you were searching for the required information?". The data was collected using a Likert scale with the low-end of the scale indicated very unenjoyable and the high end of the scale indicating very enjoyable, as indicated in **Figure 17**.
How enjoyable was the navigation experience as you were searching for the required information?

![Likert scale](image)

**Figure 17** Example of the Likert scale used to assess a participant’s certainty they were on the correct path when searching for a specific piece of content.

Additionally, qualitative data was collected in an effort to identify the subject’s feelings with respect to the content and navigation types being presented. Subjects were asked the following two questions:

1. What did you like about this navigation method and why?
2. What did you dislike about this navigation method and why?

A test script was developed to ensure participants were presented with the instructions and questions for each task in a consistent manner. The test script can be found in Appendix A4 Test Script. The test script consisted of the instructions given to the participant at the start of the test, the instructions for each task, and the questions asked upon the completion of each task.

**4 Results**

Time to locate specified content was collected and analyzed using a repeated measures ANOVA. It was found that navigation pattern when combined with image and image/text content did affect the time to locate the specified content as well as the perceived enjoyment of navigation. Post-hoc testing revealed the DPS and eBook navigation patterns yielded faster times than the PDF navigation pattern.
4.1 Time

A one-way repeated measures ANOVA was conducted to determine whether there were statistically significant differences in navigation time between the three navigation treatments presented while using text-heavy content.

Outliers were present, as assessed by the boxplot in Figure 18 for values greater than 1.5 box-lengths from the edge of the box. Outliers were present in the eBook and PDF navigation treatments. The outliers were re-evaluated for their accuracy with respect to data entry and measurement. All outliers were found to be accurately measured and recorded and have been kept in the data for the subsequent analysis.

![Figure 18](image)

**Figure 18** Outliers in text-heavy eBook, PDF, and DPS navigation treatments

A Shapiro-Wilk test for normality was conducted on the time data recorded during the navigation of text-heavy content. The eBook (p<.0005) and PDF (p=.005) treatment data were non-normally distributed while the DPS treatment data were normally distributed (p=.152). The one-way
repeated measures ANOVA is considered to be robust with respect to non-normal data and the ANOVA was run using all of the collected data.

The assumption of sphericity was met, as assessed by Mauchly’s test of sphericity, $\chi^2(2)=2.931$, $p=.231$. The navigation method presented did not elicit a statistically significant change in time with respect to text-heavy content, $F(2,28)=1.880$, $p=.171$.

A one-way repeated measures ANOVA was conducted to determine whether there were statistically significant differences in navigation time between the three navigation treatments presented while using image-heavy content.

Outliers were present, as assessed by the boxplot in Figure for values greater than 1.5 box-lengths from the edge of the box. Outliers were present in the eBook, PDF, and DPS navigation treatments. The outliers were re-evaluated for their accuracy with respect to data entry and measurement. All outliers were found to be accurately measured and recorded and have been kept in the data for the subsequent analysis.
A Shapiro-Wilk test for normality was conducted on the time data recorded during the navigation of the image treatments for each navigation design. The eBook (\(p=.002\)), PDF (\(p=.001\)), and DPS (\(p<.0005\)) treatment data were all non-normally distributed. The one-way repeated measures ANOVA is considered to be robust with respect to non-normal data and the ANOVA was run using all of the collected data.

The assumption of sphericity was not violated, as assessed by Mauchly’s test of sphericity, \(\chi^2(2)=5.531, p=.063\). The navigation treatment presented elicited statistically significant changes in navigation time, \(F(2, 28)=11.920, p<.0005\), with eBook (\(M=23.4s, SD=13.9s\)) and DPS (\(M=40.9s, SD=42.0s\)) having lower times than the PDF navigation treatment (\(M=92.0s, SD=72.3s\)). Post hoc analysis with a Bonferroni adjustment revealed that the PDF navigation treatment increased navigation time in a statistically significant manner when compared to the eBook navigation treatment (\(M=68.6s, 95\% CI[24.5,113.0], p=.003\)). PDF navigation treatment also yielded an increased navigation time in a statistically significant manner when compared to the DPS navigation treatment (\(M=51.1s, 95\% CI[5.0,97.2], p=.028\)).
A one-way repeated measures ANOVA was conducted to determine whether there were statistically significant differences in navigation time between the three navigation treatments presented while using text and image content.

Outliers were present, as assessed by the boxplot in Figure for values greater than 1.5 box-lengths from the edge of the box. Outliers were present in the eBook, PDF, and DPS navigation treatments. The outliers were re-evaluated for their accuracy with respect to data entry and measurement. All outliers were found to be accurately measured and recorded and have been kept in the data for the subsequent analysis.

![Boxplot]

**Figure 20** Outliers for the time taken within the image and text eBook, PDF, and DPS layouts

A Shapiro-Wilk test for normality was conducted on the time data recorded during the navigation of the image and text treatments for each navigation design. The eBook (p<.0005), and DPS (p<.0005) treatment data were non-normally distributed. The PDF data were normally distributed (p=.102). The one-way repeated measures ANOVA is considered to be robust with respect to non-normal data and the ANOVA was run using all of the collected data.
The assumption of sphericity was not violated, as assessed by Mauchly’s test of sphericity, \( \chi^2(2)=0.111, p=.946 \). The navigation treatment presented elicited statistically significant changes in navigation time, \( F(2, 24)=5.675, p=.01 \), with eBook (M=47.8s, SD=48s) and DPS (M=62.8s, SD=96.1s) having lower times than the PDF navigation treatment (M=131.3s, SD=102.3s). Post hoc analysis with a Bonferroni adjustment revealed that the PDF navigation treatment increased navigation time in a statistically significant manner when compared to the eBook navigation treatment (M=83.5, 95% CI[7.4,160.0], p=.03).

### 4.2 Perceived Difficulty

A Friedman test was run to determine if there were differences in a subject’s perceived difficulty between the three navigation treatments when used in conjunction with text content. Pairwise comparisons were performed (SPSS, 2014) with a Bonferroni correction for multiple comparisons. Perceived difficulty was statistically different across the navigation treatments \( \chi^2(2)=16.684, p<.0005 \). Post hoc analysis revealed statistically significant differences in perceived difficulty when searching for specific text content between the eBook navigation treatment (Mdn=4) and the PDF navigation treatment (Mdn=2) (p=.010).

A Friedman test was run to determine if there were differences in a subject’s perceived difficulty between the three navigation treatments when used in conjunction with image content. Pairwise comparisons were performed (SPSS, 2014) with a Bonferroni correction for multiple comparisons. Perceived difficulty was statistically different across the navigation treatments \( \chi^2(2)=19.633, p<.0005 \). Post hoc analysis revealed statistically significant differences in perceived difficulty when searching for specific text content between the eBook navigation treatment (Mdn=5.0) and the PDF navigation treatment (Mdn=2.0)(p=.001) as well as the DPS navigation treatment (Mdn=4.5) and the PDF navigation treatment (Mdn=2.0)(p=.008).

A Friedman test was run to determine if there were differences in a subject’s perceived difficulty between the three navigation treatments when used in conjunction with a combination of text and image content. Pairwise comparisons were performed (SPSS, 2014) with a Bonferroni correction for multiple comparisons. Perceived difficulty was statistically different across the navigation
treatments $\chi^2(2)=17.423, p<.0005$. Post hoc analysis revealed statistically significant differences in perceived difficulty when searching for a specific combination of text and image content between the eBook navigation treatment (Mdn=4.0) and the PDF navigation treatment (Mdn=2.0) ($p<.0005$) as well as the DPS navigation treatment (Mdn=4.0) and the PDF navigation treatment (Mdn=2.0) ($p=.041$).

Qualitative feedback with respect to the subject’s perceived difficulty as they were navigating the documents was collected in addition to the quantitative data. This data is useful in large part because it provides some degree of validity to the quantitative survey instrument developed specifically for this study.

Many of the subjects indicated that they had difficulty when navigating the PDF layouts because there was no easy way to tell where they currently were when navigating the document. In contrast, many test subjects found the navigation in the eBook and DPS layouts to be easier to navigate. Many users commented that the DPS and eBook layouts were "quick" and "faster" to navigate when asked why they rated the difficulty as they did.

4.3 Correct Path

A Friedman test was run to determine if there were differences in a subject’s confidence that they were on the correct path when searching for a specific piece of text content. Pairwise comparisons were performed (SPSS, 2014). There was no statistically significant difference in a subject’s confidence they were on the correct path between any of the navigation treatments, $\chi^2(2)=2.056, p=.358$.

A Friedman test was run to determine if there were differences in a subject’s confidence that they were on the correct path when searching for a specific piece of image content. Pairwise comparisons were performed (SPSS, 2014) with a Bonferroni correction for multiple comparisons. Perceived difficulty was statistically different across the navigation treatments $\chi^2(2)=18.426, p<.0005$. Post hoc analysis revealed statistically significant differences in a subject’s confidence that they were on the correct path when searching for a specific piece of content between the eBook navigation treatment (Mdn=5.0) and the PDF navigation treatment
(Mdn=3.0)(p=.006) as well as the DPS navigation treatment (Mdn=5.0) and the PDF navigation treatment (Mdn=3.0)(p=.003).

A Friedman test was run to determine if there were differences in a subject’s confidence that they were on the correct path when searching for a specific combination of text and image content. Pairwise comparisons were performed (SPSS, 2014) with a Bonferroni correction for multiple comparisons. Perceived difficulty was statistically different across the navigation treatments $\chi^2(2)=15.731$, $p<.0005$. Post hoc analysis revealed statistically significant differences in a subject’s confidence that they were on the correct path when searching for a specific combination of text and image content between the eBook navigation treatment (Mdn=5.0) and the PDF navigation treatment (Mdn=3.0)(p=.014) as well as the DPS navigation treatment (Mdn=4.0) and the PDF navigation treatment (Mdn=3.0)(p=.002).

Qualitative feedback with respect to the subject’s feeling confidence they were on the correct path as they were navigating the documents was collected in addition to the quantitative data. This data is useful in large part because it provides some degree of validity to the quantitative survey instrument developed specifically for this study.

Test subjects generally found the lack of indication as to where they were within the document important when searching through the document. Tables of contents added a feeling of certainty to both the DPS and the eBook navigation methods. Many users found the indication of where they were in the document at the top of the eBook and DPS layouts to helpful. In contrast, the PDF layouts have no indication as to what part of the document the user is in and only provides a progress bar across the bottom of the page. This caused some confusion with many users commenting that there lack of certainty was due to "no indication" of where they were in the document.

4.4 Enjoyable

A Friedman test was run to determine if there were differences in the amount of enjoyment a subject experienced when searching for a specific piece of text content. Pairwise comparisons were performed (SPSS, 2014) with a Bonferroni correction for multiple comparisons. Enjoyment
was statistically different across the navigation treatments $\chi^2(2)=18.760$, $p<.0005$. Post hoc analysis revealed statistically significant differences in the amount of enjoyment a subject experienced when searching for a specific piece of text content between the eBook navigation treatment (Mdn=4.0) and the PDF navigation treatment (Mdn=2.0) ($p=.002$) as well as the DPS navigation treatment (Mdn=3.0) and the PDF navigation treatment (Mdn=2.0) ($p=.002$).

A Friedman test was run to determine if there were differences in the amount of enjoyment a subject experienced when searching for a specific piece of image content. Pairwise comparisons were performed (SPSS, 2014) with a Bonferroni correction for multiple comparisons. Enjoyment was statistically different across the navigation treatments $\chi^2(2)=19.750$, $p<.0005$. Post hoc analysis revealed statistically significant differences in the amount of enjoyment a subject experienced when searching for a specific piece of text content between the eBook navigation treatment (Mdn=4.0) and the PDF navigation treatment (Mdn=2.0) ($p=.008$) as well as the DPS navigation treatment (Mdn=4.0) and the PDF navigation treatment (Mdn=2.0) ($p<.005$).

A Friedman test was run to determine if there were differences in the amount of enjoyment a subject experienced when searching for a specific combination of content containing both text and images. Pairwise comparisons were performed (SPSS, 2014) with a Bonferroni correction for multiple comparisons. Enjoyment was statistically different across the navigation treatments $\chi^2(2)=19.560$, $p<.0005$. Post hoc analysis revealed statistically significant differences in the amount of enjoyment a subject experienced when searching for a specific combination of content containing both images and text between the eBook navigation treatment (Mdn=4.0) and the PDF navigation treatment (Mdn=2.0) ($p<.0005$) as well as the DPS navigation treatment (Mdn=3.0) and the PDF navigation treatment (Mdn=2.0) ($p=.008$).

Qualitative feedback with respect to the subject’s feeling of enjoyment as they were navigating the documents was collected in addition to the quantitative data. This data is useful in large part because it provides some degree of validity to the quantitative survey instrument developed specifically for this study.

Most subjects found the DPS and eBook navigation treatments to be enjoyable in large part because they were able to find the content they were looking for in a manner they perceived to be
effective. Most users pointed to the clear labeling that exists in the DPS and eBook navigation structures as a reason for the increased enjoyment. Some users did find the vertical navigation employed in the DPS navigation treatment as "counter-intuitive". The PDF navigation treatment faired poorly again due in large part to the amount of scanning required to navigate the space filling thumbnails as well as the lack of indication where the subject was in the document.

5 Discussion

Statistically significant differences with respect to navigation time were found in both image content as well as the combination of images and text content when comparing the DPS navigation method with the PDF navigation method as well as when comparing the eBook navigation method with the PDF navigation method.

Clark and Brandt (2012) have indicated that content types play an important role in navigational efficiency. There were no repeated themes of content types having a significant effect on navigation times so it is unlikely that content type was a significant factor. The pattern of DPS and eBook navigation types showing a statistically significant difference when compared to the PDF navigation method is repeated frequently throughout the results of the study. Based on this repeated result it is likely the significant time difference is due to the navigation method presented and not the content types presented.

There were statistically significant results when comparing the perceived difficulty. The theme of the PDF navigation method performing poorly was repeated when analyzing perceived difficulty. Both the eBook as well as the DPS navigation types were perceived to be less difficult than the PDF navigation type across all content types.

One frequently repeated theme that appeared during the qualitative analysis was the small size of the space filling thumbnails. However, the thumbnails themselves may have been large enough but the content on each page too small to be adequately presented in a space filling thumbnail. Future work may look at what is an appropriate content size to thumbnail ratio.

A subject’s confidence that they were on the correct path may be affected by the type of content they were presented. Subjects appeared to have more confidence they were on the correct path
when navigating content composed of images as well as content that is composed of a combination of images and text. This difference in confidence is apparent when comparing the eBook navigation method as well as the DPS navigation method to the PDF navigation method. Here again, it is very likely that the navigation method played a strong role in a subject’s confidence they were on the correct path. The PDF navigation type fared poorly again when compared to the other navigation methods presented.

There were statistically significant results with respect to a subject’s enjoyment when comparing the eBook as well as the DPS navigation methods to the PDF navigation method. Test subjects reported a statistically significant decrease in enjoyment when using the PDF navigation method. It is possible that the size of the content on the page was a limiting factor when looking at a subject’s enjoyment.

6 Limitations

As previously stated, the present study was limited in scope to the larger document navigation framework that deals with paginated content. Paginated content is only one method of presenting content on a digital device and the results of this study are unlikely to generalize to other types of content presentation such as continuously scrolling content.

In addition, 16 participants participated in the study. Although this sample size was sufficient for appropriate statistical analyses, a larger sample size may have resulted in more confidence in the validity of the results. Although purposive sampling was utilized to recruit participants with different experience levels, genders, and ages, it could be argued that a larger sample would be less influenced by any potential homogeneity among participants.

There were several outliers in the recorded time data. The within-subjects ANOVA is robust with respect to outliers. However, outliers in such a small sample could be a concern. A larger sample size would have minimized the number of outliers as the larger sample would have tended toward a normal distribution.

The use of Shakespeare’s content as a library had precedent in previous work and the benefit of being readily available as well as being copyright free. It is noteworthy that it did cause some
confusion among some of the participants. The plays entitled Richard II and Richard III were often confused when searching through the library. Often the participants failed to recognize they had selected the wrong play and this would lead to a task failure.

Additionally, there was a slightly uneven distribution in the experience level of the participants. Ideally the number of users that were daily, weekly, monthly, and infrequent tablet readers would have been evenly distributed. This sample was recruited from students and residents near RIT and the ideal breakdown was not attainable. The sample is composed of more experienced users than inexperienced users and this could skew the results toward the preferences and abilities of experienced users.

7 Conclusion

The present study contributes to the study of navigation patterns in several ways. The study yielded several clear results regarding the combination of content type and navigation pattern. Additionally, important lessons regarding the testing methodology and the use of Shakespeare's work as a document library were found. The study provides several opportunities for future research.

7.1 Contributions

This study contributes to document navigation in several ways. The comparison of three different within-document navigation methods provides an understanding of the navigation methods that are effective when dealing with document navigation on tablet devices.

It is clear that some form of visual sectioning will continue to be important on tablets, and that where possible tables of contents should be used. In many instances the participants in this study exhibited difficulty where no clear sections were presented.

This research contributes a possible methodology for testing within-document navigation designs. Previous research on document navigation used Shakespeare’s works laid out in one large document. The approach of using Shakespeare’s works as a library of material on a tablet appears to be new and a viable option for the testing and characterization of document library
navigation as well as individual document navigation. The one caveat to this would be that Richard III and Richard II should not be used extensively due to the potential for confusion.

Additionally, this study required a significant amount of content preparation. The methodology and scripts used are a possible model for use in later studies. The XML that was generated for Shakespeare’s complete works may also be valuable for use in future studies that require a library of content in a different media.

7.2 Lessons Learned

The use of a pilot test prior to conducting the actual tests is important. This study did use two separate pilot trials, but these trials failed to flush out certain issues with the testing materials that would arise. A good instance of this is the understandable confusion between Richard II and Richard III when searching through the digital library. In these instances the testing materials would need to be viewed with a critical eye toward potential areas of study participant confusion.

Additionally, the development of survey instruments can be difficult and it would have been easier and potentially increased the validity of the study if a previously developed survey instrument would have been used. One potential source for test instruments and information regarding instrument validity would be the Buros Mental Measurements Yearbook. (Buros Center for Testing, 2015)

7.3 Future Research

As stated previously, this study only covered paginated content presented on tablet devices. A similar study could be conducted based on non-paginated tablet-based content such as content that scrolls continuously.

Additionally, a similar study with larger content on the page may be useful in assessing the space filling thumbnail navigation present in the PDF navigation treatment. Users frequently had difficulty identifying their location within the document when using the PDF navigation treatment and the lack of clearly designed and/or larger visual sectioning in the design was frequently cited as the culprit.
Finally, a similar study with consistent indexing and table of contents within the navigation patterns would be helpful in assessing the document content on more even terms. All three navigation treatments had significant differences in how the content was portrayed during navigation. The PDF navigation treatment relied on space filling thumbnails, the DPS navigation relied on a two dimensional grid of paginated content, and the eBook relied heavily on a scrollbar across the bottom in tandem with simulated print pages. A study that keeps these navigation patterns and presents a similar indexing and table of contents methodology would help to indicate if the space filling thumbnails used in the PDF navigation treatment really do perform poorly when compared to the other navigation treatments presented with no complicating factors.
Bibliography

http://blogs.adobe.com/digitalpublishing/2013/12/readership-metrics-open-folio-format.html

A tablet for everyone. (2011). The Economist (Online), n/a.


http://buros.org/using-mental-measurements-yearbook-review-evaluate-test


Appendix A1 Document Conversion Scripts

Image Cleanup

```
#!/bin/bash
for FILE in $1/*.jpg
do
echo $FILE
f='echo $FILE | tr '[:lower:]' '[:upper:]'
echo $f
mv $f `echo $f | sed -e "s/[0-9]/g"`
done
```

Character Sorting

```
#!/bin/bash
echo "Entering $1..."
awk 'BEGIN {print "<characters">"} >> tempfile
awk '/<b>([A-Za-z0-9[:blank:]]+)</b>/' $1/full.xml | sort -u >> tempfile
sed -e 's/</a/>/g' tempfile > tempfile1
sed -e 's/</a/>/g' tempfile1 > tempfile2
sed -e 's/</a/>/g' tempfile2 > $1/characters.xml
awk 'BEGIN {print "</characters>"} >> $1/characters.xml
rm ./tempfile*|
```

Space Removal

```
<?xml version="1.0" encoding="UTF-8"?>
<xsl:stylesheet version="1.0" xmlns:xsl="http://www.w3.org/1999/XSL/Transform">
  <xsl:output method="xml" version="1.0" encoding="UTF-8" indent="no"/>
  <xsl:strip-space elements="*"/>
  <xsl:template match="/">
    <xsl:apply-templates />
  </xsl:template>
  <xsl:template match="*">
    <xsl:copy-of select="."/>
  </xsl:template>
</xsl:stylesheet>
```
Removing Text from Image Only Content

```bash
#!/bin/bash

for PLAY in `ls -d clean_html/*`
  do
    echo "\n 1
 2
 3
 4
 5
 6
 7
 8
 9
do
 10
echo "Working on $FILE"
 11
cat $FILE | sed 's/<h4>.+</h4>\n/g' >$PLAY/dps_html/only_images/temp.html
 12
mv $PLAY/dps_html/only_images/temp.html $FILE
 13
done
```

Images and Text Content Converter from XML to XHTML

```bash
#!/bin/bash

for PLAY in `ls -d clean_html/*`
  do
    echo "-setting up the xsl file"
    DIRE=basename $PLAY
    sed "s/\$REPLACE\$/DIRE/" clean_html/digital_publishing_text_images.xsl > clean_html/dps_temp.xsl
    echo "finished altering the xsl file"
    echo "descending into $PLAY"
    for FILE in $PLAY*.html
        do
            echo "Working on $FILE"
            java -jar /Applications/oxygen/lib/saxon.jar -o $FILE.html dps_images_text.html $FILE
            echo "output $FILE.html_dps_images_text.html"
        done
    done
    rm clean_html/dps_temp.xsl
done
```
Creating a Directory Structure for InDesign DPS Content

```
#!/bin/bash

for PLAY in `ls -d clean_html/*`
  do
    echo "----------------------------------------"
    echo "Descending into $PLAY"
    echo "Working on $PLAY"
    VALUE=`echo $PLAY | cut -d'.' -f2`
    name=`basename $PLAY | cut -d'.' -f1`
    echo "Name: $name"
    mkdir /Users/gaapp/Documents/personal/thesis/shakespeare/FILE/folio/act_5[ACT].scene_5[SCENE].v.indd
    mv /Users/gaapp/Documents/personal/thesis/shakespeare/FILE/folio/act_5[ACT].scene_5[SCENE].v.indd
    done
```

Preparing Scripts to Automatically Convert XHTML to InDesign/PDF

```
#!/bin/bash

for PLAY in `ls -d clean_html/*`
  do
    echo "----------------------------------------"
    echo "Setting up the jsx file"
    echo "Finished altering the jsx file"
    echo "Descending into $PLAY"
    echo "Working on $PLAY"
    sed "s/\"FILE\"/\"$PLAY\"/g" clean_html/html_converter.js > clean_html/html_converter1.js
    osascript clean_html/html_placer.sct
    rm clean_html/html_converter1.js
    done
  done
```
Preparing Scripts to Place XHTML Content For Placement in InDesign/DPS

```bash
#!/bin/bash

for PLAY in `ls -d clean_html/*`;
  do
echo "--------------------------------------"
esetup the jsx file"
echo "finished altering the jsx file"
ed "Descending into $PLAY"
  do
    for FILE in `ls -d $PLAY/dps_html/*`;
      do
echo "Working on $WORKINGFILE"
    DIRE=basename $WORKINGFILE
    sed "$DIRE\$SFILE\$WORKINGFILE" clean_html/place_convert_html.jsx > clean_html/place_convert_html_temp.jsx
    FILENAME=$FILE$DIRE$-.indd
    sed "e\$FILENAME\$\$WORKINGFILE" clean_html/place_convert_html_temp.jsx > clean_html/place_convert_html_tempi.jsx
    osascript clean_html/html_placer.scp
    rm clean_html/place_convert_html_temp.jsx
    rm clean_html/place_convert_html_temp.indd
  done
done
```

Preparing Image Only Content For Placement in InDesign/DPS

```bash
#!/bin/bash

for PLAY in `ls -d clean_html/$1/*`;
  do
echo "--------------------------------------"
esetup the xsl file"
ed "Setting up the xsl file"
    sed "$SFILE\$DIRE" clean_html/digital_publishing_text_images.xsl > clean_html/dps_temp.xsl
    echo "finished altering the xsl file"
ed "Descending into $PLAY"
  do
    for FILE in $PLAY.html
      do
echo "Working on $FILE"
    java -jar /Applications/oxygen/lib/saxon.jar -o $FILE.html dps_text_images.html $FILE
    ~/Documents/personal/thesis/shakespeare/clean_html/dps_temp.xsl
    echo "Output $FILE.html dps_only_images.html"
    done
    done
    rm clean_html/dps_temp.xsl
done
```
Placing Text and Text/Image Content Into InDesign

```javascript
#target "InDesign-8.6"
#include "~/Desktop/extendscript/extendables/extendables.jsx"

var myDocument = app.open( File('~/Users/gaappr/Documents/personal/thesis/shakespeare/###FILE###'), true);

// A convenience function to use the script labels easily - glf, short for getLabeledFrame.
function glf( slabel ){
    // A for loop that loops through all of the items in the InDesign document and compares the
    // label you are looking for with the label assigned
    // to the item. If the label you are looking for and the label on the item match then we return it.
    for( var i=0; i<myDocument.allPageItems.length; i++ ){
        if( myDocument.allPageItems[i].label == slabel ){
            return myDocument.allPageItems[i];
        }
    }
}

var textAdjust = glf( "mainFrame" ).parentStory.characters.item(0);
textAdjust.composer = "Adobe Paragraph Composer";
textAdjust.noBreak = false;
textAdjust.recompose();
```

Placing Image Only Content Into InDesign

```javascript
#target "InDesign-8.6"

var myDocument = app.open( File('~/Users/gaappr/Documents/personal/thesis/shakespeare/shakespeare_ipad_template.indt'), false);

// A convenience function to use the script labels easily - glf, short for getLabeledFrame.
function glf( slabel ){
    // A for loop that loops through all of the items in the InDesign document and compares the label
    // you are looking for with the label assigned
    // to the item. If the label you are looking for and the label on the item match then we return it.
    for( var i=0; i<myDocument.allPageItems.length; i++ ){
        if( myDocument.allPageItems[i].label == slabel ){
            return myDocument.allPageItems[i];
        }
    }
}

glf( "mainFrame" ).place( File('~/Users/gaappr/Documents/personal/thesis/shakespeare/###PLACE###', false ) );
myDocument.save( new File('~/Users/gaappr/Documents/personal/thesis/shakespeare/###FILENAME###') );
myDocument.close();
```
Appendix A2 Recruitment Flyer

Do you read on a tablet or e-reader?

Take part in a usability study and receive a $15.00 gift card to Barnes and Nobles as compensation for your time.

The study will take approximately 1 hour. You must qualify to participate.

Tear off a tag below and fill out the survey at the address, or snap a shot of the QR code.

http://gaappr.cias.rit.edu/tabletReading/
Appendix A3 Participant Screener

tablet-based reading screener

Please fill out the following information about yourself. This data is confidential and will be used only to determine if you are eligible to take part in the study.

1. Please enter your age.

   

2. Please indicate your gender.

   ○ Male
   ○ Female

3. Please indicate which devices you typically read on.

   □ Smart phone
   □ Desktop computer
   □ Tablet
   □ e-reader
   □ Laptop
   □ Paper

4. Please estimate how frequently you read on a tablet or e-reader.

   ○ daily
   ○ weekly
   ○ monthly
   ○ I don't use a device regularly

5. Please indicate the types of content you read on a tablet or e-reader.

   □ News
   □ Books
   □ Magazines
   □ Business Documents
   □ I have never read anything on a tablet device
   □ Other: ________________________________
6. Please enter the email address you would like to be contacted at should you be selected for this study.

7. Please enter the phone number you would like to be contacted at in the event you are selected for this study.

By submitting this brief survey you are expressing interest in participation in the tablet-based reading study. If you do not wish to participate please leave this page now.
Hello and welcome. My name is Graham Anthony. Thank you for agreeing to be a part of the study on tablet-based reading. During this study you will be exploring various aspects of tablet-based reading and looking at different library designs. I will ask you to complete a series of tasks to the best of your ability.

It’s important that you realize that I am evaluating the different designs presented to you today and not your performance. If you have difficulties these are reflections of the designs presented and not of your abilities. If you have any questions please ask them at any time but be aware that I may be unable to answer them until after the study.

Please try to complete each task in a comfortable and timely manner. Please do not use any search features should they be available to you.

This session is being recorded. Before I give you the tasks, please read the consent form and sign both copies if you would like to participate in the study.

<subject reads and signs form>

Thank you.

Please hold any feedback on the library or document designs until you have completed the task. Your insights are valuable to me as I evaluate the different library designs and I will ask you for feedback after you have completed the task.

Do you have any experience with tablet devices?
What type of experience do you have with reading on a tablet device?

What type of experience do you have with Shakespeare’s work?

Please complete this brief training on how to use the tablet you have in front of you.

Do you have any questions before we begin?

Now we are ready to start the study.
Task A:

I would like you to locate the text "My liege, one word." Spoken by the Duke of Aumerle in *Richard II* Act III, Scene II. The task is complete once you have located the text and pointed it out to me.

Tell me when you are ready to start.

__________________________________________________________

Tablet State – Appropriate design open on the tablet. The library view of Shakespeare’s complete works should be visible.

Time to complete: _____:_____:_____ 

Failure:_______

Note that a task is considered a failure if it takes longer than 180 seconds to complete

Number of different page views: ________

Observations:
Please Answer the following questions about the task you just completed:

Please indicate on the scale in front of you how easy or difficult it was to find the information you were looking for.

Why did you choose that answer?

Please indicate on the scale in front of you how certain you were that you were on the correct path to find the information you were looking for.

Why did you choose that answer?

Please indicate on the scale in front of you how enjoyable the navigation experience was as you were searching for the required information.

Why did you choose that answer?
What did you like about this navigation method and why?

What didn’t you like about this navigation method and why?
Task B:

I would like you to locate the following image of Lucio from Act III, scene II of Measure for Measure:

![Image of Lucio from Measure for Measure](image)

The task is complete once you have located the image and pointed it out to me.

Tell me when you are ready to start.

Tablet State - Appropriate design open on the tablet. The library view of Shakespeare’s complete works should be visible.

Time to complete: _____:_____:

Failure:_______

Note that a task is considered a failure if it takes longer than 180 seconds to complete

Number of different page views: _______

Observations:
Please Answer the following questions about the task you just completed:

Please indicate on the scale in front of you how easy or difficult it was to find the information you were looking for.

1 Very Difficult  2 Difficult  3 Neutral  4 Easy  5 Very Easy

Why did you choose that answer?

Please indicate on the scale in front of you how certain you were that you were on the correct path to find the information you were looking for.

1 Very Uncertain  2 Uncertain  3 Neutral  4 Certain  5 Very Certain

Why did you choose that answer?

Please indicate on the scale in front of you how enjoyable the navigation experience was as you were searching for the required information.

1 Very Unenjoyable  2 Unenjoyable  3 Neutral  4 Enjoyable  5 Very Enjoyable

Why did you choose that answer?

What did you like about this navigation method and why?

What didn’t you like about this navigation method and why?
Task C:

I would like you to locate Alcibiades line: "What art thou there? Speak." From Act IV, Scene III of *Timon of Athens*. The text will be below the following image of Alcibiades:

![Image of Alcibiades](image_url)

The task is complete once you have located the text and pointed it out to me.

Tell me when you are ready to start.

_________________________________________

Tablet State - Appropriate design open on the tablet. The library view of Shakespeare’s complete works should be visible.

Time to complete: ____ : ____ : ____

Failure: _______

Note that a task is considered a failure if it takes longer than 180 seconds to complete
Number of different page views: ________

Observations:

Please Answer the following questions about the task you just completed:

Please indicate on the scale in front of you how easy or difficult it was to find the information you were looking for.

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Difficult</td>
<td>Difficult</td>
<td>Neutral</td>
<td>Easy</td>
<td>Very Easy</td>
</tr>
</tbody>
</table>

Why did you choose that answer?

Please indicate on the scale in front of you how certain you were that you were on the correct path to find the information you were looking for.

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Uncertain</td>
<td>Uncertain</td>
<td>Neutral</td>
<td>Certain</td>
<td>Very Certain</td>
</tr>
</tbody>
</table>

Why did you choose that answer?
Please indicate on the scale in front of you how enjoyable the navigation experience was as you were searching for the required information.

Why did you choose that answer?

What did you like about this navigation method and why?

What didn’t you like about this navigation method and why?
Thank you for completing the study on tablet-based reading.

Now I have a short post-test questionnaire for you to complete.

Questions after tasks complete:

1. What is important to you from a navigational standpoint when you are searching for specific items within a digital library?

2. What is important to you from a navigational standpoint when you are searching for a specific item within a document?

Do you have any final questions or comments about the study?

I ask that you refrain from discussing this study with anyone you know that has also signed up as it may affect our data. Thank you for your participation, here is your gift card. Have a wonderful day!
Appendix A5 Participant Consent Form

Tablet-based reading study

INTRODUCTION

You are invited to join a research study to understand tablet-based reading.

This research study will be used to enhance the nature of tablet-based reading in the future.

Information

You will be asked to locate several pieces of information from within a document library. Upon completion of a series of tasks you will be given a general questionnaire and asked to participate in a brief interview regarding your experiences during the search for this information. This process will be recorded.

You may stop participating at any time without penalty.

RISKS

There are no expected risks from completing this study.

Benefits

This study will provide valuable data for future designs with respect to tablet-based reading.

CONFIDENTIALITY

Your name will not be associated with the data in any way when data from this study are published. Every effort will be made to keep your research records, and other personal information confidential.

We will store any information regarding your study on a computer protected in accordance with RIT’s information security policy.

INCENTIVES

Participants will be compensated for their time with a $10.00 gift card to Barnes and Noble.

YOUR RIGHTS AS A RESEARCH PARTICIPANT?

Participation in this study is voluntary. You have the right not to participate at all or to leave the study at any time. Deciding not to participate or choosing to leave the study will not result in any penalty or loss of benefits to which you are entitled, and it will not harm your relationship with RIT or the individuals conducting the study. If you decide to leave the study, you may inform the person administering the study that you would no longer like to participate.

CONTACTS FOR QUESTIONS OR PROBLEMS?

Call the investigator at (585) 406-1831 or email at gaappr@rit.edu if you have questions about the study, any problems, unexpected physical or psychological discomforts, any injuries, or think that something unusual or unexpected is happening.
## Consent of Subject (or Legally Authorized Representative)

<table>
<thead>
<tr>
<th>Signature of Subject or Representative</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Investigator's Signature**

| ___________________________ | ___________________________ |
|______________________________|______________________________|