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THESIS SERIES

KIMBERLY ANNE SHEEN

A Cognitive Ergonomics Design Framework for Future Electronic Textbooks

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1999–2020 THESIS SHOWCASE

Many universities are shifting from the use of physical textbooks to electronic textbooks. Yet, there is a lack of research that examines whether this type of textbook can meet students' task requirements. Within the context of Engineering and Design disciplines, this research investigates: (1) the role of student characteristics in the perception of future electronic textbooks; (2) the supporting tasks that students perform whilst reading both types of textbooks and how they differ; (3) the crucial aspects and components for future electronic textbooks; (4) the discrepancies between students and professors' perceptions, and (5) the necessary changes that need to be made based on the above needs and desires and the required changes based on these needs and desires. Utilising the findings from a survey and the result of the Hexagon-Spindle Model, this study proposes a framework that serves as a guide for designers and content creators to design future electronic textbooks that meet students' academic reading task needs and grow with technological advances.

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A COGNITIVE ERGONOMICS DESIGN FRAMEWORK FOR FUTURE ELECTRONIC TEXTBOOKS

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Ph.D

The Hong Kong Polytechnic University

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School of Design

A Cognitive Ergonomics Design Framework for Future Electronic Textbooks

Kimberly Anne Sheen

A Thesis Submitted in Partial Fulfillment of the Requirements

for the Degree of Doctor of Philosophy

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CERTIFICATE OF ORIGINALITY

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Kimberly Anne Sheen

ABSTRACT

Many universities around the world are shifting from physical textbooks to electronic textbooks. Yet there is a distinct lack of research on whether this type of textbook can even meet students' task requirements. To address this gap, investigation into how student characteristics play a role in the perception of future electronic textbooks, what supporting tasks students preform whilst completing readings in both types of textbooks and how it differs, what aspects and components students and professors feel are necessary for future electronic textbooks, what the discrepancies between students and professors' perceptions are, and how changes based on these needs and desires will be utilized and accepted were undertaken. While focus was on students, professors were included as they choose the readings and at times author the textbooks.

The area of research described in this work is constructivist and followed a naturalistic paradigm. A mixed qualitative and quantitative approach was utilized. A survey, focus groups, interviews, and experiment were used to understand the academic reading task and student needs. The survey identified discipline as having significant association with components of electronic textbooks. Based on the findings, the Engineering and Design disciplines were chosen to be investigated due to their similarities in goal, yet differences in mindset and process. Investigating similar yet different disciplines, allow for a better understanding of how differences in disciplines change academic needs. Following this, focus groups and interviews were used to identify student and professor perceptions. Professor and student opinions were mirrored within disciplines and the perceptions and needs changed between disciplines. Overall, current electronic textbooks were found to require an interactive and discipline specific design. Following this, an experiment was conducted to investigate current components in electronic textbooks and screen size. It was found that students took fewer notes and highlighted less when using an electronic textbook and that the iPhone size negatively affected student perception of the reading task.

Data from the focus group sessions and experiment were analyzed using the Hexagon-Spindle Model and in-app components were identified as necessitating designs that better support the academic reading task. All data gathered was then analyzed together and holistic cognitive ergonomics guidelines emerged in an overarching design framework. To validate the framework, two prototypes were produced. Students then evaluated these prototypes for perceived usefulness and ease of use. Iterations to the framework were then made to create the final framework. The framework can be utilized by designers and content creators to design future electronic textbooks that meet the students' academic reading task needs and grow with technological advances. The findings from the individual methods also provide insight on the effects of electronic textbooks and an understanding of how students are currently interacting with and perceive physical and electronic textbooks. This information can be useful to professors teaching courses and textbook designers.

LIST OF PUBLICATIONS ARISING FROM THIS WORK

Refereed Journal Papers

Sheen, K. A., & Luximon, Y. (2015). Relationship between Academic Discipline and User Perception of the Future of Electronic Textbooks. *Procedia Manufacturing, 3*, 5845-5850.

Sheen, K.A., & Luximon, Y. (2016). Student Views on Academic Reading and its Future in the Design and Engineering Disciplines. *International Journal On Advances in Life Sciences, 8*(3&4), 257-266.

Sheen, K. A., & Luximon, Y. (2017). Student perceptions on future components of electronic textbook design. *Journal of Computers in Education*, *4*(4), 371-393.

Journal Paper entitled: *Effect of Component and Screen Size of Electronic Textbooks on Reading Performance, Behavior, and Perception* under review at International Journal of Human-Computer Studies.

Refereed Conference Papers

Sheen, K. A., & Luximon, Y. (2015, August). The Future of Electronic Textbooks from a User Perspective. In *International Conference on Learning and Collaboration Technologies* (pp. 704-713). Los Angeles, CA: Springer International Publishing.

Sheen, K.A., & Luximon, Y. (2016, April). Focus Group Study on Student Perception of Electronic Textbooks. In *ACHI 2016, The Ninth International Conference on Advances in Computer-Human Interactions* (pp. 110-115). Venice, Italy: IARIA.

Sheen, K.A., & Luximon, Y. (2016, July). Academic Professor Perception of the Future of Electronic Textbooks. In *Advances in Physical Ergonomics and Human Factors* (pp. 165-173). Orlando, FL: Springer International Publishing

Sheen, K. A., Luximon, Y., & Zhang, J. (2017, July). Reading Task Investigation of the Kindle app in Three Mediums. In *International Conference on Applied Human Factors and Ergonomics* (pp. 357-364). Los Angeles, CA: Springer International Publishing.

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Chapter 1. Introduction

1.1 Overview of Chapter

This chapter introduces the proposed research's background, identifies the scope of the research, outlines the aims and objectives, and then presents the main research questions. Finally, it outlines the significance of the research.

1.2 Research Background and Approach

Over the past few decades, tertiary educational institutions have started to shift to electronic textbooks from the physical counterparts. Some institutions have instituted fully bookless libraries (D'Orazio, 2014) whereas others have only a few classes implementing them (Brunet et al., 2011). The current research and discussion on this subject tends to be superficial and neglects to take into account many facets of academic reading, such as the mobility of students while reading (Dominick, 2005) and the use of many different tools to assist them while completing their readings. This move towards electronic textbooks may alter how students approach their academic readings, the activities they use to support those readings, and affect their mindset while approaching their readings. The effects of these changes require investigation while still taking into account the entire academic reading task, student and professor perception, and the various mental models. If these changes are not identified and investigated, this could negatively affect the students' abilities to complete their degrees to the standard they wish or cause undue stress during their studies. Without investigating the task and perceptions, designers may struggle to design an appropriate textbook that will be adopted by universities and be well received by the students.

While there is current research on task of academic reading and electronic textbooks, these two topics do not tend to converge nor do they focus on user perception and the task appropriateness of the components of textbooks, which are vital in the adoption of the textbooks and their intended outcome of sharing information, leaving an obvious gap in research. The distinct lack of research on whether this type of textbook can even meet students' task requirements, which often include things such as highlighting and notetaking among others (Fairbairn & Fairbairn, 2001), may affect academic progress. To address this gap, investigation needed to be undertaken in several areas: how student characteristics play a role in the perception of future electronic textbooks, what supporting tasks students preform whilst completing readings in both types of textbooks and how it differs, what aspects and components students and professors feel are necessary for future electronic textbooks, what any discrepancies between students and professors' perceptions are if they exist, and how changes based on these needs and desires will be utilized and accepted. Past research has shown that perceived usefulness is key to the acceptance of new technology (Davis et al., 1989; Yi & Hwang, 2003; Park, 2009) and that intuitive displays are essential to the user experience (Shneiderman, 1998; Sharp et al., 2007; McFall, 2005). Thus, the findings presented in this work provide crucial recommendations that informed a set of design guidelines presented in a framework for future electronic textbooks to better support students' tasks, facilitate the adoption of the electronic textbooks, and minimize any design issues related to the differences in students and professors' understanding of electronic textbooks.

In order to uncover the habits and perspectives of both professors and students, which are fundamental to this research, an exploratory investigation was undertaken. This area of research is constructivist in nature due to the many realities related to electronic textbooks constructed by the various disciplines. The methodology used in this work follows the naturalistic paradigm and the derived form of inquiry allowed for conclusions to be drawn, which were both meaningful and provided an in-depth understanding of the situation. A mixed methodology was employed in this work as the qualitative research allows for an understanding of the created realities, but it does not allow for generalizability of findings that are provided by quantitative research. The research presented in the later chapters is more meaningful, descriptive, and in-depth due to this. The distinct methods and models that were employed in this research were an Internet survey, focus groups, interviews, an experiment, the Hexagon-Spindle Model, and modified Technology Acceptance Model (TAM) evaluation of prototypes developed based on the framework derived from the literature and previous methods.

This study aims to advance the current discussion, highlight what students need to complete their reading tasks from a cognitive ergonomics perspective, and provide a design framework based on these results. The design framework was based on the task requirements and preferences toward components in electronic textbooks in relation to their appropriateness to the reading task. This framework was designed by investigating the preference trends and academic reading task without tying it to specific technology so as to create longevity for this research's applications.

1.3 Objectives

To holistically approach this subject, investigation into how university students approach their academic readings and the subsequent requirements needed to be undertaken with an emphasis on perception. Past research on student perception has been collected after the design and production of electronic textbooks. To this day, publishers and academic staff are still deciding the future of electronic textbooks with limited input from the student users before or during design. Focus is most often placed exclusively on the current technology, overall market potential, and the business of education (Tian & Martin, 2013) rather than the students.

To holistically comprehend what is in store for the future of electronic textbooks, the subject matter needs to be researched from a cognitive ergonomics viewpoint of students. The International Ergonomics Association (2014) defines cognitive ergonomics as "concerned with mental processes, such as perception, memory, reasoning, and motor response, as they affect interactions among humans and other elements of a system." Thus the research presented was focused on the cognitive aspects such as perception, memory, reasoning, performance, and the student task of academic reading. Special emphasis was placed on perception and how that relates to the task of academic reading. Perception plays a vital role in the adoption of new technologies based on the Diffusion of Innovations Theory (DOI) (Rogers, 2003; Dearing, 2009).

To approach this research, the following objectives were met:

1) Discover the student perceptions of electronic textbook components and the association with student characteristics.

2) Discover which supporting tasks students use during their academic reading and how it differs in physical and electronic medium.
3) Determine what, if any, discrepancies there are between student and professor perception of aspects of future electronic textbooks.
4) Determine whether the changes based on the perception of the components' ability to support the academic reading task would allow students to feel they can successfully complete their reading task and gather an understanding of if these changes would be accepted by students based on the perceived usefulness and ease of use.
5) Create a design framework used for the creation of electronic textbooks.

1.4 Research Questions

Five research questions were investigated during this study to meet the objectives outlined in the previous section. Shortened labels for future reference of the research questions across this thesis are noted in brackets after each question. They have been arranged into three overarching questions as follows:

1. *What are the relationships between student characteristics and academic reading? (Relationships between characteristics and reading)*

    a. *How do student characteristics play a role in the perception of future electronic textbooks? (Characteristics role in perception)*

    b. *What tasks do students preform whilst completing readings in both their physical and electronic textbooks to support their learning of the material and how does this differ? (Student tasks)*

2. *What components need to be in future electronic textbooks based on the academic reading task? (Components based on task)*

    a. *What aspects and components do students and professors feel are necessary to be included in future electronic textbooks? (Aspects and components necessary)*

    b. *What are the discrepancies between students and professors' perceptions of components and aspects of future electronic textbooks? (Student-professor discrepancies)*

3. *Would changes based on these needs and desires be considered useful in relation to the academic reading task and would the changes be accepted by the students? (Usefulness and acceptance)*

1.5 Research Significance

Results from this study are applicable to not only the academic discussion but also the wider publishing industry. Firstly, findings shed new insights on the effects of electronic textbooks on academic reading and assist in informing the general academic discussion. This research also illuminates the habits and behaviors students exhibit while doing academic reading in both physical text and electronic text. A perception of the needs of students in completing their academic reading task was also found which can be utilized when planning courses. In regard to industrial applications, by using the guidelines presented in this work in the design of the textbooks, electronic textbook designers may create a better educational tool, especially when accounting for the association between the components and the two disciplines studied. It will also provide educators and content creators an understanding of what students feel they need to complete their academic readings, which can be used to create a supportive educational tool that would be better accepted by students. Finally, by presenting the components outside of the restrictions of a specific piece of technology, yet taking into account the effect of layout on cognitive load, will allow for more flexibility in the future technological applications and longevity of the academic findings.

1.6 Overview of the Thesis

The content of the thesis is as follows (see Figure 1.1 for the flowchart of the research): Chapter 1 introduces the work and presents its objectives and significance. Chapter 2 is a review of the literature surrounding academic reading, electronic textbooks, and the factors related to the acceptance and adoption process of technology. In addition, it outlines the research rationale for this work. Chapter 3, then, presents the research methodology that was used in this study. Chapter 4 outlines the first study conducted in this research, the Internet Survey, which investigated student characteristics relationships with electronic textbooks and which components students feel are necessary in their future electronic textbooks to meet the academic reading task. It then discusses the narrowing of the research topic to two disciplines. It is this chapter, which meets objective 1 and helps to inform research questions 1: Relationships between characteristics and reading, 1A: Characteristics role in perception, 2: Components based on task, and 2A: Aspects and components necessary. Chapter 5 is a review of the second study, in-depth focus groups, conducted with students of the engineering and design disciplines regarding their academic reading habits in both electronic and physical textbooks and their views on the necessities of future electronic textbooks based on their academic reading task. This study meets objectives 1 and 2 and assists in informing research questions 1: Relationships between characteristics and reading, 1B: Student tasks, 2: Components based on task, and 2A: Aspects and components necessary. Chapter 6 outlines the results from the third study, the foil to the focus group sessions, professor interviews, which investigated professor perceptions of electronic textbooks and which components are necessary for student academic reading tasks. This study met objective 3 and research questions 2: Components based on task, 2A: Aspects and components necessary, and 2B: Student-professor discrepancies. Chapter 7 presents the final study, which was an experiment conducted on current electronic textbooks to investigate changes in reading behavior, perceptions of aspects, and identify any changes in comprehension and recall when moving from paper to the electronic medium. This study met objective 4 and helped to inform research questions 1B: Student tasks and 2: Components based on task. Following that, Chapter 8 presents the findings which met objectives 4 and 5 and research question 3: Usefulness and acceptance. It starts with a short discussion of the findings of the methods and how they fit together, introduced the ergonomics issues and solutions that were identified using the Hexagon-Spindle Model, and the development of the guidelines from the previous methods. It then presents the validation of the guidelines through two prototypes and a modified Technology Acceptance Model (TAM) questionnaire and the final iteration based on those findings. Finally, Chapter 9 presents the final conclusions, limitations, future work, and outlines the major points of significance.

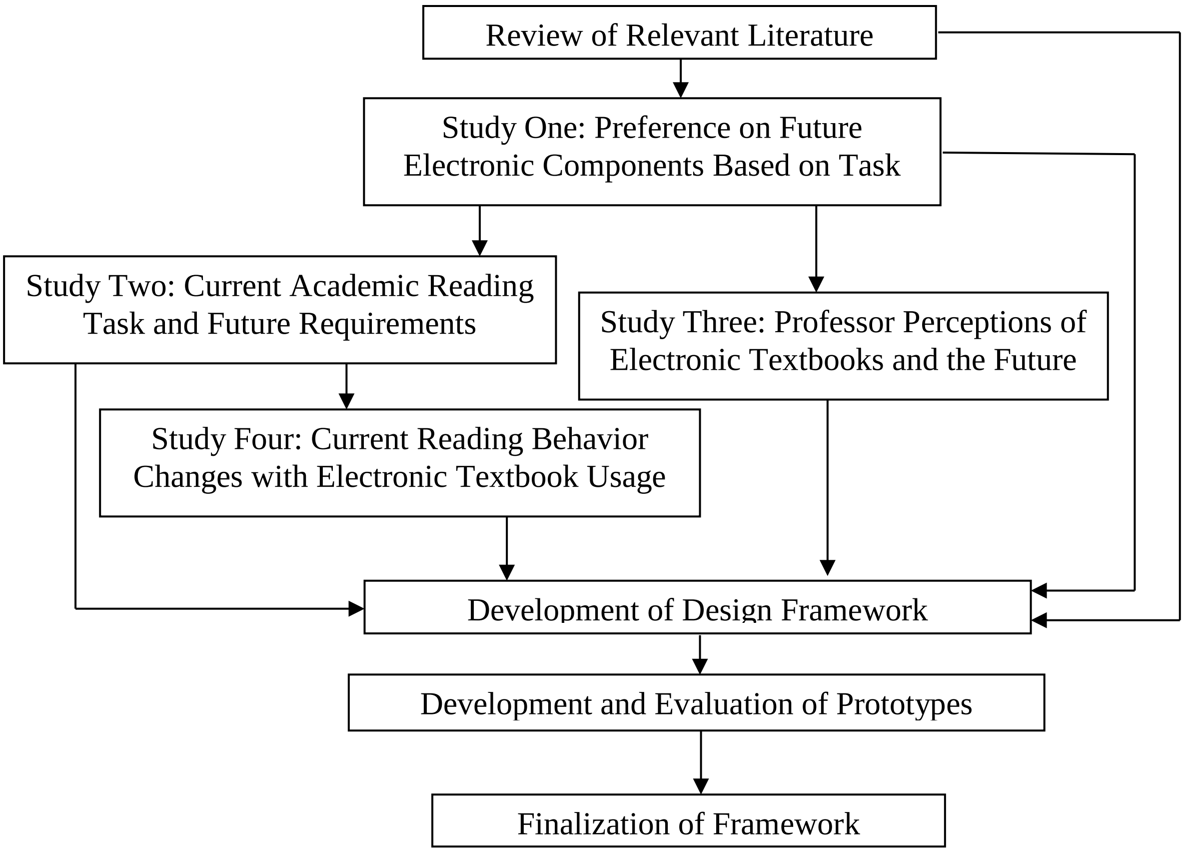


Figure 1.1 Flowchart of research.

Chapter 2. Literature Review

2.1 Overview of Chapter

This chapter outlines the relevant literature surrounding electronic textbooks and their users. It starts with an overview of the terminology associated with academic readings. Following that, it introduces an acceptance model that outlines the reasoning why technology is adopted and applies the importance to students and electronic textbooks. After this, it introduces the task of academic reading and outlines how it is different cognitively than other reading. Then it outlines the past research undertaken related to electronic textbooks, including users' perceptions and the effect electronic textbooks have on user performance skills. Finally, an overview of electronic textbook usage in universities is presented along with research on the future of electronic textbooks. The chapter concludes by outlining the research rationale and research questions.

2.2 Terminology

2.2.1 Textbooks

The official definition for a textbook is "a book about a particular subject that is used in the study of that subject especially in a school" (Merriam-Webster.com, 2015). The definition of textbook used in this research will be the same as the dictionary usage.

Figure 2.1 The epic poem Beowulf commonly used as a literature textbook (Rebsamen, 2004).

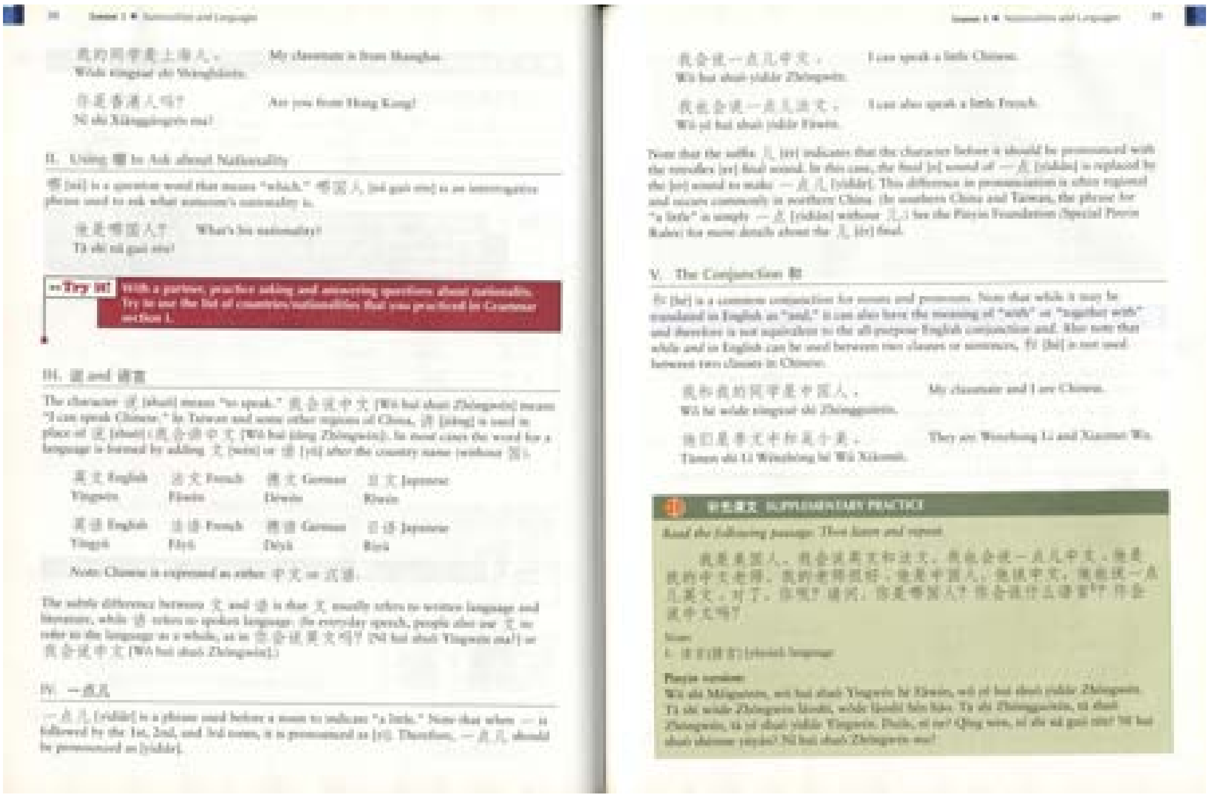


Figure 2.2 Example of a Chinese language textbook (Wu et al., 2011).

While textbooks have been used for centuries, they tend to be hard to define because of their diverse nature, which is directly related to the differences in the academic fields. In fields such as English Literature it can often be difficult to identify what is a textbook (see Figure 2.1), yet in the hard sciences or languages, a textbook is easily identified through the layout and terminology (see Figure 2.2). While much research has gone into the design of physical textbooks, design recommendations cannot remain the same and research in this area needs to start from the beginning (Hartley, 1990).

2.2.2 Electronic Textbook

When discussing electronic textbooks, researchers have come to a general conclusion of how an electronic textbook is defined. This definition is commonly stated as an equivalent of a printed version of a textbook (Gu et al., 2015). There are some confounding factors to this definition, as e-textbooks do not necessarily have to have a physical textbook equivalent and have the ability to integrate multimedia and components that allow for a more interactive experience (Gu et al., 2015; Choi et al., 2011; Lee et al., 2013; Reynolds, 2011). Still, one can go back to the stated dictionary of a textbook and change book into electronic book as many of the electronic textbooks currently available on the market do not take advantage of these technological advances or have limited rich multimedia assets (Ibanez & Delgado Kloos, 2012).

For this dissertation, electronic textbooks will be defined as a study aid, which conveys information necessary for students' studies and understand of a subject. While the word text is a root to the term textbook, the amount of text necessary to convey information may change based on the subject and complimentary learning components should be used to assist in conveying the message. Thus, the official definition used in the scope of this research is “an electronic book used to present and study the principles of the chosen subject with limited rich multimedia assets such as video or images.”

While the creation of electronic learning materials in other ways such as eLearning Platforms may be an option in the future, they require considerable amounts of additional work and are often generated by automated mining processes or by assembly from professors (Walling, 2014; Gu et al., 2015). In addition, open source webpages may be copyright free, yet questions of the validity and credibility of the material may arise. Also, platforms such as Blackboard or Moodle may have issues related to copyright when professors who assemble their own material choose to upload a copyrighted PDF file. The lack of oversight in some of these cases may negate some of the benefits created. This method is also not the more widely recognized definition of electronic textbook, which is the actual scope of this research. Instead, this research uses the “widely recognized method of developing e-Textbooks, which is also the easiest way, […] to digitize existing printed books as replacement textbooks, especially in the context of higher education” (Gu et al., 2015). Major publishers such as Pearson, Wiley, and McGraw-Hill are producing this type of electronic textbook and are available on devices such as those made by Apple and Amazon (op. cit.).

While there are dozens of electronic textbook formats, only five are considered mainstream and are the most common formats (Gu et al., 2015). These five are PDF, EPUB, HTML, TEXT, and CHM. While many of these formats are researching ways to use the benefits of technology, most do not support multimedia or advanced components. In fact, scholars such as Gu et al. (2015) are calling for requirements in this are to be developed and instituted, especially foundations. While their group is attempting to create some requirements, their requirements differ in direction from the ones later presented in this dissertation as they are focused more on the technical specifications rather than the content required for the academic reading task. Similarly, other projects for etextbook standardization have been created, but are related to one specific format (Hoel, 2013; ISO/IEC JTC 1/SC 34, 2013) or are too general (Arenas & Barr, 2013; Belfanti & Gylling, 2014) and disregard the holistic nature of content and technology that the guidelines presented later in this thesis acknowledge.

2.2.3 Nomenclature

The definitions that will be used to describe various terms and concepts throughout this work are defined as follows:

"Academic readings" are readings assigned for the course students are completing or are otherwise necessary to complete the coursework.

"Physical textbooks" "physical readings", or "physical texts" are textbooks, printed or copied chapters, or printed PDFs assigned for the course students are completing or are otherwise necessary to complete the coursework.

"Electronic textbooks", "electronic readings" and "electronic texts" include electronic textbooks and electronic PDF textbooks read on any electronic device including mobile and stationary. See Figure 2.3 for an example of an electronic textbook.

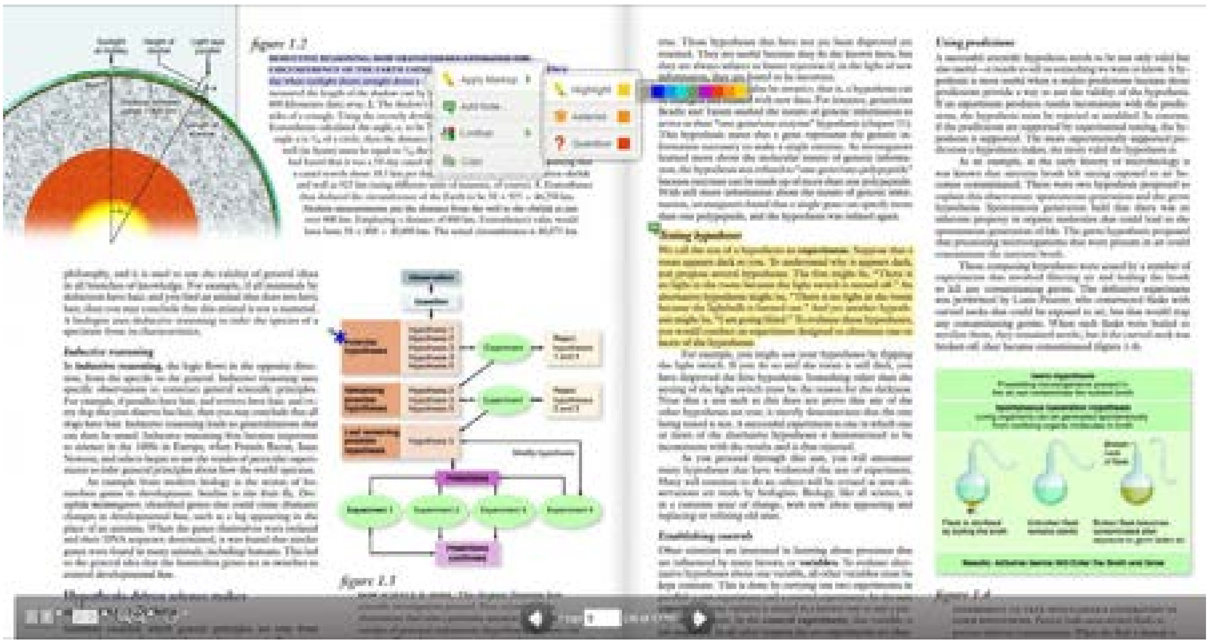


Figure 2.3. Example of a standard electronic textbook (Sadon & Yamshon, 2011).

2.2.4 Textbook Metaphor

The textbook metaphor (see Figure 2.4) stemmed from the World Wide Web and the external and internal hyperlinks that were developed for it (Bush & Cameron, 2011). It wasn't until 1994 when Catenazzi and Sommaruga developed the hyper-book model that the textbook metaphor truly came into existence. Designing with this metaphor keeps the main properties of the physical book like orientation and navigation central to design while adding additional peripheral components from the World Wide Web such as hyperlinks (Catenazzi & Sommaruga, 1994). Landoni et al. (2000) believe that using the physical book as a design metaphor while creating electronic textbooks will be easily understood and accepted by the students using it. While standard textbooks do not have additional components to assist during reading, highlighting and bookmarking are still considered appropriate in this design metaphor. While technology has advanced from the hyper-book, most of the electronic textbooks designed today still use the textbook metaphor.

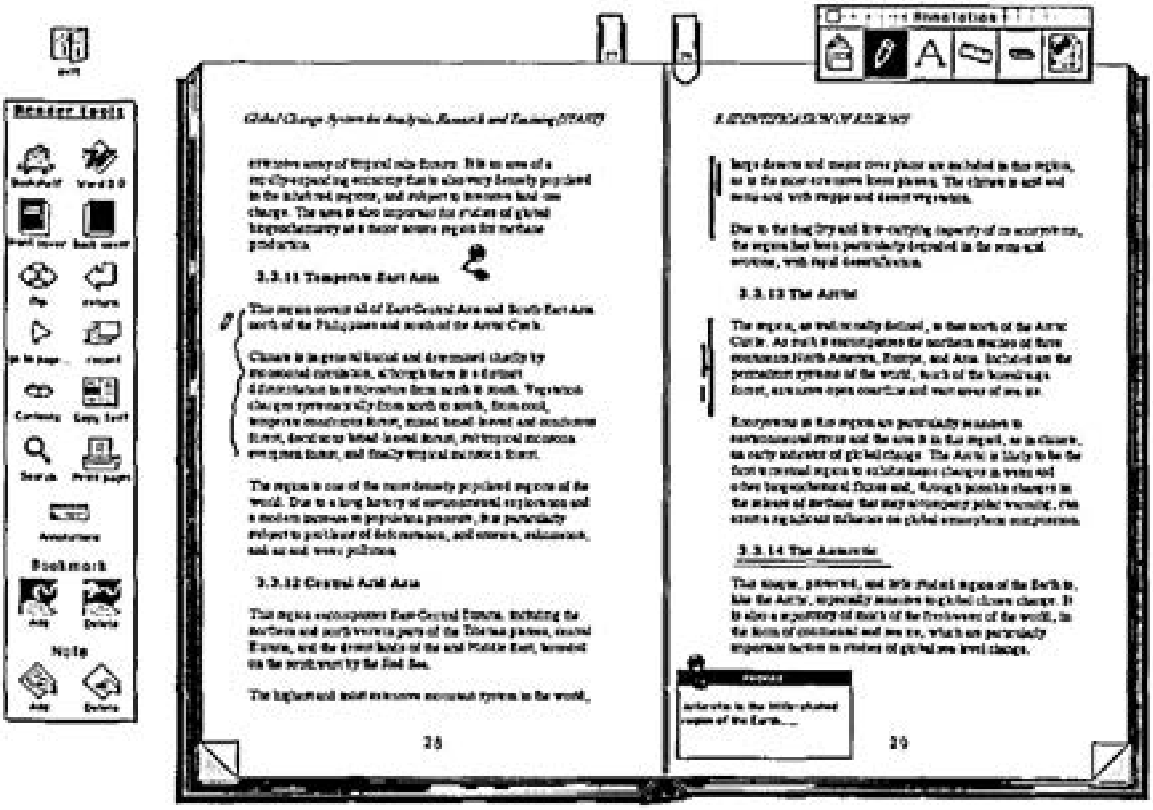


Figure 2.4. Figure of the hyper-book as proposed in Catenazzi and Sommaruga's 1994 article.

2.3 Technology Acceptance Model (TAM)

The technology acceptance model (TAM) was a significant concept utilized in this work. The originators of TAM postulate that all other variables which influence the acceptance of technology are mediated by the perception of usefulness and ease of use for the user (Davis et al., 1989). This model is frequently utilized in the prediction of how useful the technology is considered in regard to the required tasks, to explain user acceptance of the technology, and predict how difficult the user will find the system (see Figure 2.5). Moreover, the model is often modified for different purposes. For example, Yi & Hwang (3003) modify the model to examine new technology's variables of enjoyment, self-efficacy, and learning goal orientation and associates them with the acceptance and adoption of said new technology by the target user group (Yi & Hwang, 2003). In Yi & Hwang's paper, they place enjoyment under TAM's category of ease of use.

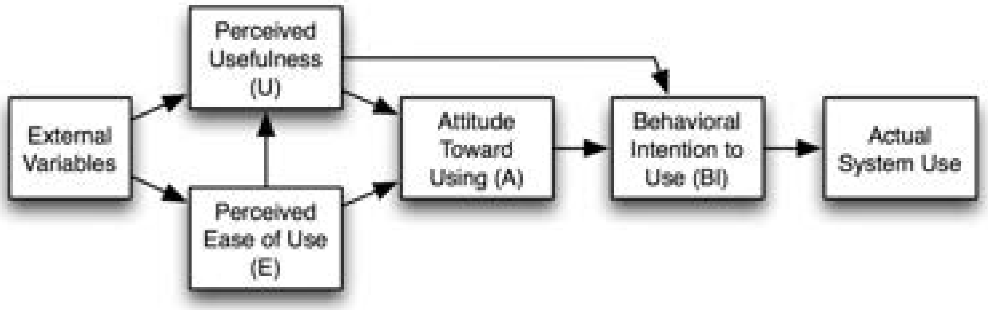


Figure 2.5. Figure of TAM as described in Davis' article (1989).

Self-efficacy is related to a person's personal judgment of their ability to perform a required task and will have a positive effect on ease of use. Enjoyment was also a focus of Yi & Hwang (2003), in the context of the personal enjoyment while using the system by a user outside of the value of the system. They hypothesized that enjoyment has a positive effect on ease of use, usefulness, and self-efficacy. Learning goal orientation can be placed into two types in HCI research, but the more related type to electronic textbooks and academic reading is the user's approach of a task to learn new things or increase their competence level. Learning goal orientation has a positive effect on self-efficacy. Overall, the ease of use has a positive effect on behavior intention, and usefulness has a positive effect on behavior intention; behavior intention then has a positive effect on actual use. Overlooking these variables can be detrimental to the user acceptance of technology, such as electronic textbooks.

TAM is commonly used to evaluate current aspects of technology and anticipate how the users will accept it. As this work looks towards the future of electronic textbooks, TAM cannot be applied in the standard way. Instead, the principles of TAM will be used to focus the findings from the various methods employed in this research. Thus, the framework developed will be developed after taking into consideration the main variables identified in TAM. Additionally, the TAM questionnaire employed later on will be modified to only investigate the two most important factors: perceived usefulness and perceived ease of use.

2.4 Task of Academic Reading

There are distinct differences between academic reading and activities such as leisure reading. For example, leisure reading is relaxed in nature and does not require the full concentration of the reader. Whereas academic reading requires high levels of concentration on the part of the reader so that material may be fully comprehended and recalled at a later day (Phillips & Phillips, 2007). This recall is vital to the task of academic reading because of the academic performance measures such as papers, discussion sessions, and exams (Simpson & Nist, 2000). To prepare for these measures, students often employ different types support activities, such as annotating in textbooks. No one support activity nor firm rule on what activities help to engage students in their reading has been shown to be more effective than others (Brown, 1982; Fairbairn & Fairbairn, 2001).

There are two approaches to reading: the surface approach and deep approach (Bowden & Marton, 2003). The surface approach only provides a student with a superficial understanding of the subject that is often based on the questions they anticipated being tested on. Whereas the deep reading approach allows students to read the material closely and then relate it to their current knowledge. See Table 2.1 for more information about the goals students have while doing these two types of reading. Academic reading is most commonly associated with deep reading because students are normally required to come to their own conclusions based on the inferences they have made from the material (Wolf, 2010). Students engage in this way by actively constructing meaning by questioning, analyzing, and probing the information conveyed in the text (Wolf & Barzillai, 2009).

Surface Approach	**Deep Approach**
Reading quickly	Reading Slowly
Finding select information	Finding meaning of entire text
Keep in short term memory	Making deep connects for long term memory
Intending to reproduce information	Intending to understand and draw conclusions from information

Table 2.1. Goals for Surface Approach to reading versus Deep Approach.

While electronic textbooks, with their myriad of additional features, may assist in this through these features, they may also cause distractions, which disrupt deep reading. This can be things that seem innocuous such as movement in the surrounding environment or noise. Interruptions such as things hinder engagement with the text. While this is true for both print and electronic text, there are additional distractions inherent to digital texts such as their non-linear nature. Things like hyperlinks or embedded media require a decision to be made regarding continuing reading or not. While these may seem vital to enhancing the text, components like hyperlinks are a distraction to the reader (Mark, 2009).

In addition to the distractions the components add to the reading process, the physical technology utilized with reading an electronic textbook offers its own set of distractions. When reading on a computer, phone, or tablet a student may be tempted to switch tasks. This is especially an issue with phones because of the notification feature from any app ranging from email to Instagram. When a student switches their task of reading, they will lose time and not be able to give their reading the appropriate level of concentration needed to read deeply (Aamodt, 2009). This leads to a dichotomy in electronic textbooks where the additional components, which support understanding, may also lead to a distraction, which reduces a reader's ability to approach their studies appropriately.

2.5 Electronic Textbooks

For decades, research on electronic textbooks has been undertaken. Although this research can assist in giving a general survey of electronic textbooks, much of it was completed before some of the newer technological capabilities thus not taking into account recent developments in technology and opinions regarding it. The current research that could provide insights regarding electronic textbooks relies heavily on arguing cost advantages and general student opinions without delving deeply into the reasoning behind them. Alternatively, the research and surrounding conversation should be focusing on not only student perception but the student tasks and what is necessary to successfully support academic reading.

2.5.1 User's Perceptions

There are two main users to consider regarding electronic textbooks. One of which is the student user and the other is the professor. Professors often choose the textbooks or in some cases are the authors of said textbooks. The follow section focuses on research that is related to the student perceptions but some research related to the professor perception are also represented.

2.5.1.1 Student Perceptions

One of the main deciding factors for students when obtaining their university resources is cost and how it is perceived by students. On average, textbooks cost several hundreds of dollars a year and regularly put strain on the budgets of students. A 2007 newspaper article in the United States approximated that the average amount students spend a year on textbooks was between $700 and $1000 (Slatalla, 2007). Student views on whether electronic textbooks are an effective financial solution based on their respectively lower cost to physical textbooks is widely varied (Daniel & Woody, 2013; Murray & Pérez, 2011), and companies are starting to see the cost of textbooks as a valid student concern. The cost of electronic texts is one of the key criteria to encouraging adoption by students (Mercieca, 2004). To combat the large costs, Amazon has created a program to rent out select electronic textbook titles to students using Kindle applications with prices based on how many times the textbooks are used within a specified timeframe (Dignan, 2011). Students report other advantages of electronic textbooks such as the online availability, the newfound flexibility in reading locations, and the ease of accessing a textbook online rather than struggling to find it in a library (Rowlands et al., 2007) or navigate the crowds and waits at bookstores (Daniel & Woody, 2013). Students also look favorably on some of the components often added to electronic textbooks such as the dictionary and bookmarks (Simon, 2001a & 2001b).

Although students report many advantages, students continue to prefer print textbooks when they are going to be reading for extended periods of time. Some of the reasons found by Gibbons et al. (2003) are that students do not want to look at the screen or be online reading for long periods of time, paper can be annotated and highlighted easily, personal copies are desired in a physical form, and the portability of paper copies. There are four affordances of print text as defined by Sellen and Harper (2003). These four are tangibility, spatial flexibility, tailorability, and manipulability. Tangibility is related to the experience of holding a physical book. Some elements of this affordance are layout, cover, color, and ability to see your place in the book. Spatial flexibility is defined as the ability to keep multiple physical texts around you at the same time. Tailorability is the affordance to take notes and highlight directly on the printed page. And lastly, manipulability is related to the ease of shifting from reading to writing, especially when taking notes on a separate paper. These four affordances are what students tend to be most nostalgic about and want in their electronic texts.

In general, students tend to meet the trend of moving to electronic textbooks with derision; and several studies have been devoted to the identification of specific student preferences that are affecting their views. The majority of these studies are conducted in a laboratory setting, using electronic textbooks accessed on desktop computers, and collecting data through questionnaires. One such study conducted at the University of Sydney found that interface tools such as search functions, text displays, and page turning caused some of the negative student opinions of electronic textbooks (Kropman et al., 2004). A similar study closely examined the interfaces and students' preferences on content, navigation tools, and general layout of electronic textbooks (Chong et al., 2009). The study showed that students preferred using hyperlinks during navigation, favored the inclusion of more graphics to complement content, and had issues with reading long blocks of texts. Vernon (2006) found that 60.9% of their participants switched back from digital to paper texts by eight weeks and that 70.7% of students in their study preferred physical texts.

Comparable results were found in a separate study when students claimed that large blocks of text on a computer screen caused them duress (Brunet et al., 2011). In this study, students reported a new benefit of electronic textbooks, which is the ability to search through the material quickly. This finding is verified by Dominick's (2005) 1998 study conducted at Wake Forest University that claimed students find querying phrases to be beneficial and an overall assistance in exploring and engaging the material because these students are less willing to spend long periods of time reading as they advance into higher levels of education. Especially in electronic form, students report that they prefer reading short sections (Nicholas et al., 2008). Students tend to treat electronic textbooks as if they were a reference book (Abdullah & Gibb, 2008) that negates the main goals of textbooks, which are learning, becoming proficient in the material, and memorization of passages (Daniel & Woody, 2013). While the use of electronic textbooks as reference material is common, students still report utilizing electronic textbooks the way they were designed to be used when it is considered convenient based on their surroundings (Folb et al., 2011). In fact, 58.5% of students use electronic texts when finding content related to their studies and only 20.8% read extensively from the text (Noorhidawati & Gibb, 2008).

Although students report dissatisfaction with electronic textbooks, statistics show that over the past decade the use of electronic textbooks continues to rise. Educause (2012) has reported that between the years of 2010 and 2012, student use of electronic textbooks has increased from 24% to 70%. This non-profit association also reports a shift in the perception of electronic textbooks by students with 40% of students wanting additional electronic textbooks while less than 20% wanted electronic textbooks to be used less often in their courses (op. cit.). Even amidst lawsuits against distributers regarding electronic textbooks and ownership over those textbooks (Fowler, 2009), statistics of student usage are continuing to rise. Yet, this rise is slow even in the age of digital natives. Research has shown that the adoption of learning technology is complex and rather than simply experience with technology, adoption is related to social agency and individual course requirements (Jones & Healing, 2010).

2.5.1.2 Professor Perceptions

Professors believe that textbooks should be utilized in their classrooms in many different ways, which do not often shift much with the use of electronic textbooks. These ways range from optional resources to mandated readings (Smith, 2000). The perceptions of the usefulness of textbooks stems from various aspects, such as textbooks being in direct contradiction of what the professor is teaching (op. cit.) or the belief that students do not read (Johnson, 2011).

Professors often have mixed beliefs on how to encourage their students to interact with electronic textbooks. Some professors choose to let students decide what form of interaction is best for them, while others will highlight specific components as important (Giacomini et al., 2013). While professors may not always believe that encouraging their students as important, past research has found that students react more positively to components when encouraged to use them by their professors (Bode et al., 2014).

In general, professors perceive electronic textbooks positively in terms of technical capabilities and as products, yet they perceive cost and student access as troubling issues but do not believe digital rights management is troubling (Hilton & Laman, 2012; Bossaller & Kammer, 2014). Professors specifically feel that technical issues students may run into will impede them from accessing the materials or negatively affect the reading task (Carlock & Perry, 2008). Another aspect which make professors feel reticent about adopting electronic textbooks, is the perceived large amount of time it will take to adjust their instructional materials (Giacomini et al., 2013). Additionally, some professors feel that electronic textbooks may diminish their voice and thusly negatively affect their educational mission or that of their university (Bossaller & Kammer, 2014).

2.5.2 Effects on User Performance

As of the time of this dissertation, there is limited research on the tangible effects of electronic textbooks usage; and most of this research relies on academic performance measures such as course results. Much of this research is contradictory and does not draw clear conclusions. For example, Shepperd et al. (2008) reported that there were no major differences in the grades of students using electronic textbooks and those utilizing physical textbooks even though students who used electronic textbooks reported spending less time reading on average. The article hypothesized that this was because electronic textbooks inherently facilitate studying by allowing for notes to be created by copying and pasting rather than manual creation. This shorter reading time could also be related to reported eye fatigue and reading difficulties from the displays of small devices such as mobile phones (Nelson, 2008). Similarly, research at Wake Forest found that students spent less time studying and received equivalent grades although they did not favor electronic textbooks (Dominick, 2005). Whereas Daniel & Woody's (2013) research found that although there was no difference in course results, students took longer to complete their required readings. Simon (2001a; 2001b) found that the time in which students spent reading for their courses did not change at all with electronic textbooks, but that 75% of students studied in more locations.

Along with conflicting effect on reading time and academic performance, some research has attempted to address how electronic textbooks affect the secondary tasks associated with reading. The study by O'Hara and Sellen (1997) found that the tasks of annotation and note taking, which assisted in their comprehension of the material, were performed to a lesser degree in the electronic form of book versus the printed. Participants of the study also reported that the lack of tangibility in the electronic book negatively impacted their experience and slowed their ability to fluidly move through the book. The authors believed that the annotation tools, navigation, and layout flexibility would improve the usability of electronic books.

While this research is limited, it is accepted that various aspects associated with electronic textbooks affect the user physically, which in turn has a negative effect on performance. For instance, musculoskeletal issues associated with reading can negatively impact concentration. Li and Haslegrave (1999) noted that areas such as the neck and lower trunk can become static during reading as their focus increased. These monotonous positions then lead to pain and other problems with the neck (De Roeck, 1998). This is especially evident when the neck is inclined more than 30 degrees, which will cause extreme muscle fatigue (Chaffin, 1973). The posture issues may cause a long-term deformation of the cartilage between the vertebrae and the spine in general (Pheasant & Haslegrave, 2006). The pain and long term effects will make it difficult for students to read without moving for long periods of time and the constant need to fidget will break the student's focus during reading.

Other than the more obvious musculoskeletal issues, eyestrain is another aspect of using electronic textbooks that impacts student performance. Previously, Vernon (2006) had found that 11% of students report eyestrain or headaches from working with the electronic texts. Megaw (1995) found that completing a visual task over a long period of time causes visual fatigue. This may have influenced the previous findings that long blocks of electronic texts are undesirable and the subsequent effects on student academic performance.

2.6 Current Components in Electronic Textbooks

While there are certain similarities in the components included in current electronic textbooks to the supporting activities of physical textbooks, they are markedly different in terms of interaction. Figure 2.6 shows an example of this. In a physical text, student notes are often taken in the margin, thus easily visible. Whereas electronic textbooks that offer annotation components do not typically display the notes on screen, opting instead for a small icon that must be clicked on to revisit the corresponding annotations. This icon may interrupt their reading and cause distraction (Schilit et al., 1998) or cause them to fail to notice their annotations entirely when they are revising. Past research has shown that there is a decrease in the usage of electronic annotation software when compared to traditional notetaking (O'Hara & Sellen, 1997). Another reported issue that negatively affects academic reading is the lack of tangibility (Sellen & Harper, 2003). Past research has specified that electronic textbooks need to improve physical support activities while offering an easy to use interface (McFall, 2005).

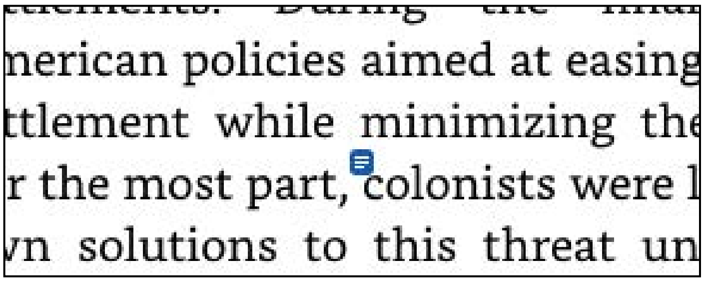


Figure 2.6. Example of note taken in a Kindle etextbook (text: Mauk & Oakland, 2014).

In addition to built-in annotation tools, there are several other components found in current electronic books. Highlighting components make a common appearance in electronic textbooks. These components normally allow for multiple colors, but they do not allow for any freeform highlighting such as stars or other symbols (see Figure 2.7), which often assist in meaning making for the students (O’Hara & Sellen, 1997).

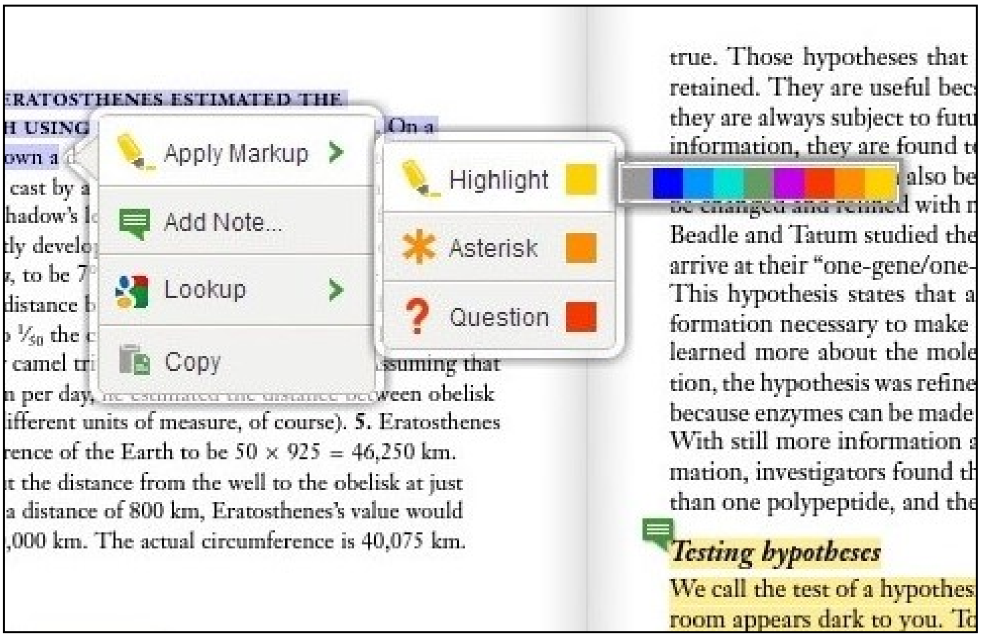


Figure 2.7. Example of electronic textbook components in the Nookstudy app (Sadon & Yamshon, 2011).

Some prototypes of future textbooks have started creating moveable images to add further information and assist in the understanding of the content (see Figure 2.8). While this type of component may be helpful, it has yet to become widely adopted in electronic textbooks and static images remain the norm. In addition, other companies are creating augmented and virtual reality learning systems and software that are changing the way students in classrooms interact with their learning material (zSpace, 2017). While it is not currently employed in electronic textbooks, it is foreseeable that this type of advanced technology could one day be employed in them.

Figure 2.8. Example of a prototype of etextbook components in iBooks (Abramson, 2012).

While some future components for electronic textbooks are being prototyped and slow to adoption, other components not yet seen in electronic textbooks have made their way to electronic fiction books. For example, some electronic books are now taking advantage of the technological advances, which allow video and images to be embedded into their books to supplement the stories (MacWilliam, 2013). Many times these videos are embedded in a way that requires the reader to select the video icon and then the text will shift to allow for the video to be viewed within the book (see Figure 2.9).

Figure 2.9. Example of an embedded video in a fiction e-book (Liu, 2008).

Components often shift from interface to interface. Many of these components act similarly, such as the highlighting and annotation function in Google books, Kindle, and iBooks. There are some other applications, which allow for additional functionality and input that mimics the physical supporting tasks closely. These applications do not normally support electronic textbooks unless they are PDF only, thus making them less applicable to the scope of this work, but the components are worth mentioning as it shows the current technological abilities of interfaces. Figure 2.10 shows the “pro” features of the Evernote application. This application allows for the user to use their finger or a stylus to enter their notes by writing instead of using a typed text input.

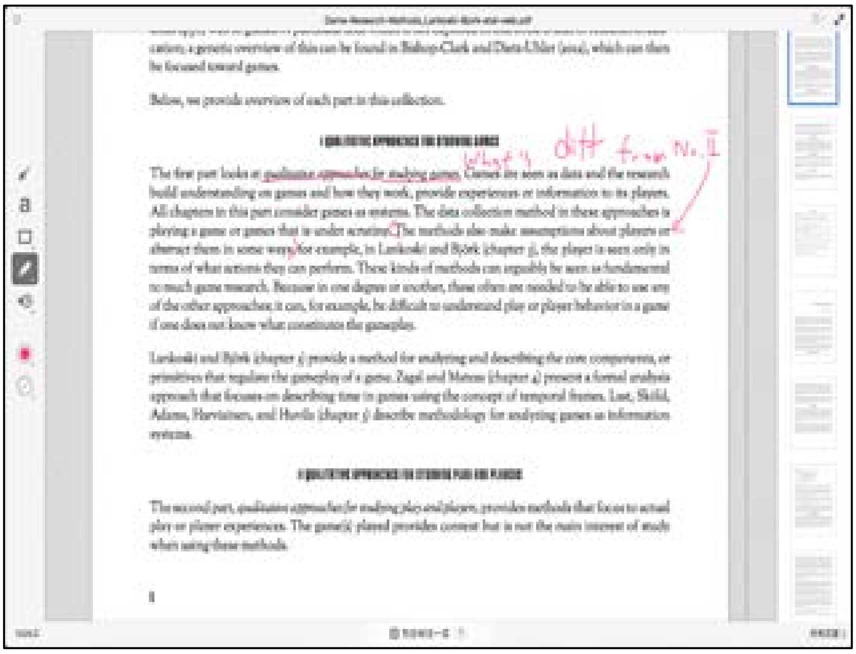


Figure 2.10. Example of notes taken in an electronic text in Evernote.

2.7 The Future of Electronic Textbooks and Universities

The move to electronic textbooks has already been taking place in universities for many years. Since 2005, Louisiana State University Health Sciences Center School of Dentistry has been running its program using only electronic textbooks as reading material (Brunet et al., 2011). It is reported that in the United States, approximately one third of dental schools have transitioned to electronic textbooks (Nelson, 2008). In addition to dental schools, other universities like the University of Phoenix have made this move and have gone so far as to bundle the cost of the electronic textbooks into the tuition fees. Roth (as cited in McFadden, 2012) has reported that publishers are now claiming that approximately 30% of their total sales come from electronic textbooks. The substantial increase in the sale of electronic textbooks is possibly related to the fact that 20% of all bookstores in the US associated with higher education are offering electronic textbooks (Nelson, 2008).

Publishing companies and universities have started to work with each other to create and publish their own textbooks for particular courses. California State University has one of these partnerships so that they may design interactive textbooks, which have no physical counterpart, tailored to students in their science programs (Herther, 2011). Although there is no physical version of the textbook, the textbooks were designed so that students who prefer a physical copy may print the material. Distribution of these university created electronic textbooks is starting to be handled by the universities themselves (Nelson, 2008). This trend is not limited to the United States. A lot of press attention has been paid to Oxford, which has recently developed its own interactive electronic textbook embracing the tablet and moving away from the metaphor of the physical textbook (Couglan, 2012). Contrarily, the core features that will be included in future electronic textbooks are not being decided and created with the students in mind, but by publishers, universities, and academics with a focus on the limitations of the current technologies and the business of education (Tian & Martin, 2013).

While the future of electronic textbooks is still not solidified, McFadden (2012) has predicted the emergence of two unique categories of digital textbooks, native digital and enhanced print. Native digital textbooks operate more as software rather than a static file, turning textbooks into interactive applications suited for a variety of electronic devices. This type of electronic textbook will nullify previous complaints regarding long blocks of text and the page layout. Identifying, selecting or creating, and implementing the new supplemental materials for the electronic textbooks become a new challenge for textbook creators (Defazio, 2012). Whereas enhanced print will be a digital replica of the corresponding physical textbook with the addition of interactive materials, shorter segments of text, and tools that will allow notes to be shared amongst the university population. Note sharing tools are expected to revolutionize the experience of reading a textbook by creating a collaborative environment where faculty and students can share notes inside the textbooks (op. cit.). Similar design changes are already being implemented in eLearning platforms to allow annotations and academic readings to be contained in one integrated learning experience (Tian & Martin, 2013). Although both types of electronic textbooks are going to be more interactive, the current majority of these textbooks are simple digital representations of the existing text because of the length of time it takes to complete a redesign. Leaders in the technology field such as Neilsen believe that designing solely with the book metaphor limits the potential of electronic books and can cause many design issues (1996). When not relying on the metaphor, it would be easier to design additional components to assist in the reading task such as multimedia or annotation components (Shneiderman, 1998).

The advancing technology involving not only electronic textbooks but also the movement towards mobile personal computers may have altered the setting in which students study. It has now become standard for students to complete their readings while standing in lines, taking transportation, or sitting in coffee shops (Fairbairn & Fairbairn, 2001) without necessitating heavy textbooks or printouts. Because most of the previous research on electronic textbooks was conducted using a stationary personal computer at a desk, it has become less applicable to the above situations. Educause (2011) and McFadden (2012) have predicted that the shift to tablets will increase within the next couple of years and eventually will become the primary platform of students replacing PCs and dedicated e-readers (Gross, 2013). Although this current prediction is backed by statistics and tablets are thought to assist in engaging students who would normally not be engrossed by the material (Wright, 2012), tablets in their current state, are not able to support most of the native digital textbooks. The current technology has left tablets without the necessary capabilities of a reliable Internet connection and has not yet optimized the way text is input (McFadden, 2012).

2.8 Research Rationale

While there has been research on the use of newer technology such as tablets while reading for pleasure (Moore, 2009), it has been established that academic reading differs greatly from this type of reading. Thus research needs to be pursued specifically regarding more current academic reading without tying it to the current technological limitations. Although the available research on pleasure reading can offer a baseline for some of the human factors and technological abilities, it is important to note the deficiencies in research. Educational reading as a task is more intricate than pleasure reading because of the supporting tasks that may occur while reading, such as annotation or highlighting. In addition, the intensive quality of academic reading and sustained focus differs from leisure reading (Dominick, 2005).

In addition, past research that studied electronic textbooks has become outdated due to the mobility and technological capabilities new technology offers students. Researchers are also beginning to acknowledge that they cannot offer recommendations regarding student academic success without acknowledging their actions and tasks in their actual environments. This is due to the realization that unique situations and environments influence how students interact with technology (Daniel & Poole, 2009). The current research focuses too heavily on the general preferences of students in regard to electronic textbooks without approaching the reasoning behind their choices or identifying what they need so that they can succeed in their educational goals. Thus extensive research must be conducted in this area to fill the gaps in available research. This study aims to advance the current debate, highlight what students need to complete their reading tasks from a cognitive ergonomics perspective, and provide a design framework based on these results.

Three main research questions were investigated through this study and answer this identified research gap. The methodology utilized to explore these questions is outlined in the following chapter. Shortened labels for future reference of the research questions across this thesis are noted in brackets after each question. The questions have been arranged into three overarching questions with four sub-questions as follows:

1. *What are the relationships between student characteristics and academic reading? (Relationships between characteristics and reading)*

    a. *How do student characteristics play a role in the perception of future electronic textbooks? (Characteristics role in perception)*

    b. *What tasks do students preform whilst completing readings in both their physical and electronic textbooks to support their learning of the material and how does this differ? (Student tasks)*

2. *What components need to be in future electronic textbooks based on the academic reading task? (Components based on task)*

a. *What aspects and components do students and professors feel are necessary to be included in future electronic textbooks? (Aspects and components necessary)*

b. *What are the discrepancies between students and professors' perceptions of components and aspects of future electronic textbooks? (Student-professor discrepancies)*

3. *Would changes based on these needs and desires be considered useful in relation to the academic reading task and would the changes be accepted by the students? (Usefulness and acceptance)*

Chapter 3. Research Methodology

3.1 Overview of Chapter

This chapter details the methodology used to explore this topic and complete the research outlined in this dissertation. First, it introduces the reasoning behind the approach, introduces how the methods will work together, and details the reasoning, procedure, and various aspects of the methods. It concludes by describing how the conclusions drawn through the methods will be used to develop a design framework for electronic textbooks.

3.2 Approach

Research into this subject was required to be extensive, ranging from gaining an understanding of the academic reading task requirements to creating prototypes and investigating subsequent user acceptance. The form of exploratory research utilized dealt predominantly with habits and perspectives of students centered on the requirements of the academic reading task. Thus, this area of research is constructivist in nature due to the many realities related to electronic textbooks constructed by the various disciplines. Constructivism states that reality is not a universal truth but rather socially constructed (Koskinen et al., 2011; Hickman, 2008). In line this theory, the methodology of the work presented here follows the naturalistic paradigm. This paradigm states that reality is constructed socially with a central theme of the individual and their perspectives and is not singular. The paradigm endeavors to understand how individuals construct these diverse realities (Hickman, 2008). The form of inquiry from this paradigm allowed for conclusions to be drawn, which were both meaningful and provided an in-depth understanding of the individual behaviors in a social context (Armstrong, 2010). Naturalistic inquiry is appropriate for exploratory research, particularly when there is limited information on the subjects under investigation (op. cit.), such as university students who belong to different disciplines and have different mindsets.

Undertaking qualitative research allows for an understanding of the construction of student realities (Merriam, 1998), but it does not allow for generalizability of findings that are provided by a quantitative approach. The nature of this research permits the inclusion of various aspects of naturalistic inquiry, which in turn allows for the development of deep and meaningful conclusions and a quantitative approach that allows for a narrative that is more descriptive. This type of mixed approach used in this work is not usually employed in comparable research concerning student perceptions of academic reading, but offers the minimization of many of the limitations in said previous research. For example, Bush and Cameron (2011) utilized similar methods as those employed in the following chapters of this dissertation. Their work investigated the student perceptions of academic reading when transitioning from printed materials to electronic materials on an iPad. They completed surveys, focus groups, and interviews in one overarching case study. Only qualitative data was collected through their research. This type of data often does not provide generalizations to other similar situations and can introduce researcher bias.

By collecting quantitative data as well in a more mixed approach, more distance between the participants and researcher is introduced which then combats possible research bias. In addition, the larger sample size allows for the findings to be more generalized. While quantitative data allows for generalizations, they often only provide a general understanding of the subject and lack the in-depth and meaningful conclusions gathered through a qualitative approach. For example, Abdullah and Gibb (2008) used survey as their primary research method to obtain the levels of electronic book usage and awareness amongst students at a Scottish university. The data gathered gave a general understanding, but gave a limited the understanding of the reasoning behind responses and restricted the depth of the analysis regarding student attitudes. The limitations of these examples emphasize the justification of the mixed approach used in this dissertation (see Figure 3.1).

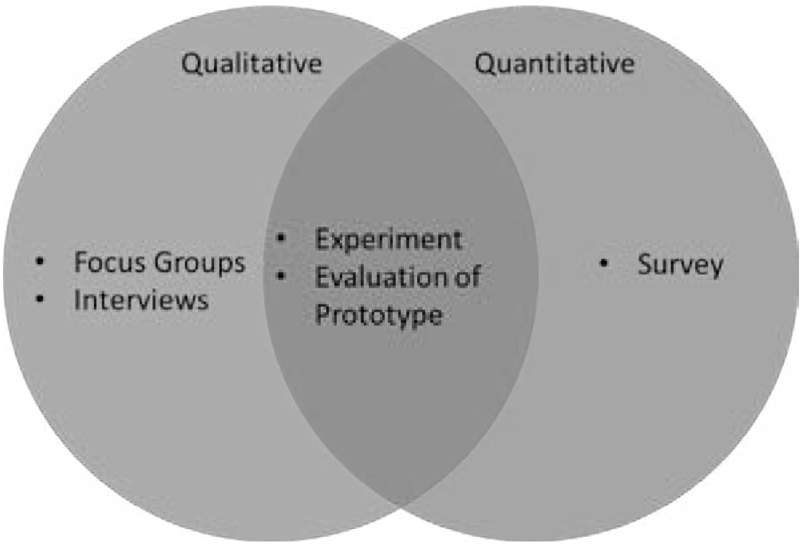


Figure 3.1. Mixed methods.

3.3 Implementation of Methods

The practice of data triangulation with the chosen methods of Internet survey, focus group, interviews, and experiment allowed for the abstraction of data and conclusions that are considered more reliable (Hickman, 2008). It has long been asserted that the use of multiple data gathering techniques is always superior to a singular data gathering method (Webb et al., 1996). The data was also analyzed using the Hexagon-Spindle Model (Benedyk & Woodcock, 2009) to identify ergonomic issues and possible solutions. The conclusions drawn from these methods were then used to inform the subsequent guidelines. Following which, the prototypes were created to evaluate the acceptance of the change in components using a modified TAM questionnaire. The findings from the TAM evaluation were then used to iterate and validate the guidelines.

Each method was used to investigate various cognitive ergonomic aspects and built on each other until the final design framework was developed (see Table 3.1). The Internet survey, focus groups, and interviews complemented each other when gathering quantitative and qualitative data regarding the habits, perceptions, and task requirements of students undertaking their academic readings in relation to electronic textbook components. The preliminary data gathered during the Internet survey was not only applicable to the results, but also beneficial when the in-depth questions utilized during the focus group sessions and professor interviews were developed. The focus group sessions collected qualitative data to assist in gaining an understanding of the complexities of the academic reading task, the reading environment, and perceptions of reading in physical and electronic textbooks. Simultaneously, professor interviews were conducted to identify their views on student reading and task needs, teaching philosophies related to electronic textbooks, and their own needs. As another stakeholder in electronic textbooks, it is important to take their views into account. Following which, an experiment was conducted which assisted in discovering if the size of mobile electronic displays effects reading performance and the subjective impression of completing the task with current electronic textbooks on various mobile devices with the use of supporting tasks. It also investigated the change in reading behavior based on textbook medium. This quantitative and qualitative data assisted in understanding how aspects of electronic textbooks affect the student performance, habits, memory, and their overall impression. Finally, two prototypes were developed from the guidelines created from the findings of the four previous studies, to identify how students would interact with some of the components they requested in their future electronic textbooks and the actual appropriateness in relation to the task through a modified TAM questionnaire. The qualitative and quantitative data gathered regarding student perception, their overall reasoning, effect on their task performance, and if the prototype met the reading task requirements was then used to iterate the previous guidelines and to create a final design framework for electronic textbooks.

Methods	**Cognitive Ergonomics Aspects**
Internet Survey	• Perception • Task Requirements
Focus Groups/ Interviews	• Perception • Reasoning • Task Requirements
Experiment	• Performance • Memory
Prototype Evaluation	• Perception • Reasoning • Task Requirements

Table 3.1. Cognitive ergonomics aspects investigated through each method.

Chapter 4. Study One: Preference on Future Electronic Components Based on Task

4.1 Overview of Chapter

Chapter 4 introduces the first method used, the Internet survey. This chapter informs objective 1 and research questions 1: Relationships between characteristics and reading, 1A: Characteristics role in perception, 2: Components based on task, and 2A: Aspects and components necessary. The survey described in this chapter was used to gain an understanding of the past usage of electronic textbooks within the university and based on the academic reading task, which components students believed were necessary for their academic reading task. The chapter begins with the justification for the use of the method. It then follows with the method and results. Following that, a discussion of the findings in the context of past literature is presented. The chapter ends with a summary of the findings and their context within the larger research.

This chapter is a reproduction of the following publications:

Sheen, K. A., & Luximon, Y. (2015). Relationship between Academic Discipline and User Perception of the Future of Electronic Textbooks. *Procedia Manufacturing, 3*, 5845-5850.

Sheen, K. A., & Luximon, Y. (2015, August). The Future of Electronic Textbooks from a User Perspective. In *International Conference on Learning and Collaboration Technologies* (pp. 704-713). Los Angeles, CA: Springer International Publishing.

Sheen, K. A., & Luximon, Y. (2017). Student perceptions on future components of electronic textbook design. *Journal of Computers in Education*, *4*(4), 371-393.

4.2 Justifications

Based on the methodology outlined in Chapter 3, the first method employed to gain a preliminary understanding necessary to explore the subject was an Internet survey. This method is useful for identifying the experiences and perceptions of various aspects of electronic textbooks when designed around the research questions. Past research has shown that surveys are commonly used to explain and describe situations by directly questioning the target population (Hickman, 2008). In addition, this method aids in understanding actions, perceptions, and opinions (Berger, 1998; Fowler, 1993) which is central to understanding the probability of successful adoption and implementation of electronic textbooks by students based on DIO. Internet surveys are able to quickly gather the quantitative and qualitative data with diverse questions, which are required to understand this subject. Furthermore, surveys have a limited overhead cost and are convenient for participants and researchers (Wright, 2005), which is ideal for reaching the diverse student population and acquiring the necessary general understanding of habits and perceptions. Students are known to have full schedules which may make them difficult to reach in person, however almost a three quarters of students spend over four hours a week online (Jones, 2008). In addition, Internet surveys offer anonymity which makes respondents less likely to report their perceived socially desirable behavior over their actual habits (Lee, 2000). It was for these main reasons, that the Internet survey was chosen to elicit student perceptions of individual components, rank which they would find most beneficial, and whether or not they would use the proposed components through nominal and ordinal scales.

While there are many benefits, such as those listed above, question structure is fundamental in ensuring the correct data is gathered. Questions must be piloted before dissemination of the survey for clarity, since no researcher is present to combat potential ambiguity (Fowler, 1993). Unintentional ambiguous terminology can be problematic when addressing a diverse student population who are a part of different academic programs, use different terminology, and have distinct mindsets. Surveys are also known to encourage under-rater and over-rater bias. This is where respondents look at questions and answer based on the wording and connotations attached to them (Smith, 1983; Isaac & Michael, 1995). In addition, survey respondents are known to attempt to control the impression they give (Lee, 2000); this may lead to claims of opinions not actually held by the respondents (Presser & Traugott, 1992). They may do this by using the response list to uncover the perceived desired responses from researchers (Schwarz & Hippler, 1985). An additional confounding factor is that respondents often blunt their responses by giving a less extreme answer based on the scale rather than representing their true feelings (Lee, 2000). While these challenges are present, they can be circumvented with thoughtful question design. Furthermore, surveys may also suffer from a low response rate, but this challenge may be overcome by short surveys which are highly attuned to the population (Ray & Tabor, 2003). Additionally, it is vital to recognize that perception data collected may not remain constant, preferences often evolve over time. Thus, supplemental methods to assist in identifying underlying thoughts and actions that surround the topic are beneficial (De Munck, 2009). The foil method chosen in this work is described in detail in Chapter 5.

This study utilized an Internet survey as the main method to identify student perceptions on possible components making up electronic textbooks in the future. Components were used as an easy and understandable entry point into the discussion of electronic textbooks. Prior to dissemination, the survey was piloted for question clarity and appropriates based on the target student (Fowler, 1993; Oppenheim, 2006) by professors and a small group of students from various disciplines across the university. Three professors and fifteen students took piloted the questions. This was chiefly used to find any terminology issues that may arise because of the different academic programs. In addition, this piloting was also used to identify questions that needed rewording because of unintentional ambiguity, which may influence understanding (De Munck, 2009). The survey was then distributed via email to all current full-time university students, to offer access to groups generally challenging to reach through other means (Wright, 2005), yet the sample was self-selected as students had the option to disregard the survey or take the time to take part in it.

4.3 Method

4.3.1 Survey Design

Before developing the survey, an extensive review of the literature was taken into consideration. This examination of existing literature assisted in identifying a deficiency in the research and allowed for a better understanding of the predicted future of electronic textbooks. Once the niche was identified and an in-depth understanding of current and future electronic textbooks was gained, open discussions with small groups of students was undertaken to discover what they thought of the future of electronic textbooks and what components were needed to succeed in studying. All of this information was used to identify the components presented to the survey respondents. After components were identified, they were organized and grouped into seventeen components.

The ten-question survey was designed to question student perceptions of the seventeen components (See Appendix A). The components presented in the Internet survey are as follows: Annotation Tool; Bookmarks; Hide unimportant aspects of the book; Highlighting Tool; Integration with eLearning platforms (Blackboard or Moodle); Interactive equations; Link to experts for answers to questions; Manipulatable and 3-D images; Multimedia (videos and podcasts); Project or print annotations; Speech to text; Supplementary materials (PowerPoints, chapter summaries, and quizzes); Synchronization across devices; Text to speech; Text; Time Management System; and Translation, Dictionary, and Encyclopedia. Some of these components already exist in electronic textbooks (see Figure 4.1 and 4.2*)*; others have not yet been developed.

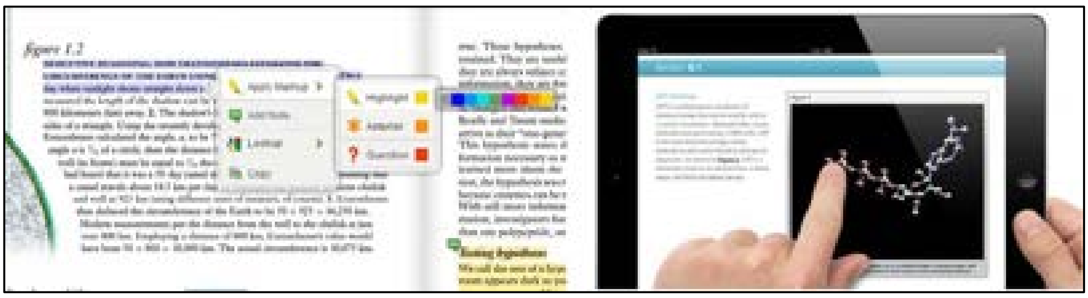


Figure 4.1. Example of components: Highlighting; Annotation Tool; Translate, Dictionary, and Encyclopedia (Sadon & Yamshon, 2011) on the left and Manipulatable and 3-D images (Abramson, 2012) on the right.

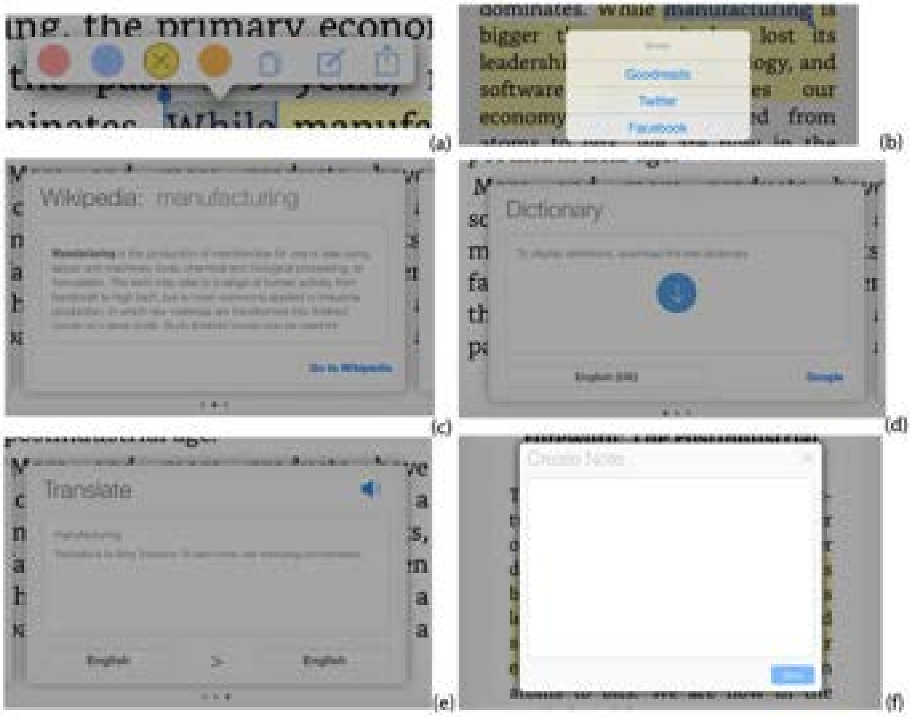


Figure 4.2. Current components: (a) toolbar, (b) share feature, (c) encyclopedia, (d) dictionary, (e) translation tool, (f) annotation tool.

4.3.2 Procedure

Before the survey questions were presented, students were provided with study information, their participant rights, the nature of the data collected, details of data storage, approximate time requirements, and the contact information of the researcher. The survey was designed to include less than twenty questions so that a higher response rate was likely (Deutskens et al., 2004; Ray & Tabor, 2003) and was comprised of an assortment of question types, such as multiple choice and ratio scale questions, to collect the habits, task requirements, and perceptions of students surrounding the subject of future electronic textbook components. In addition, reverse order questions were employed to verify the validity of the data gathered. Limited demographic questions were also included, which are outlined in Section

4.3.2.3. Data was stored for anonymity following the identification of students who wished to and whose inclusion would be beneficial the foil method outlined in Chapter 5.

4.3.2.1 Inclusion & Exclusion of Components

Two questions were used to measure the desires of students related to the inclusion or exclusion of individual components in future electronic textbooks. For both questions, respondents were requested to think outside of the restrictions of current electronic textbook technology. The first question asked students to check the box of all the components that they would want included in future electronic textbooks. The second question asked students if there were any components they would not want to see in electronic textbooks and required them to check the corresponding boxes. These reverse order questions were presented in a similar way to provide validation of the responses. If respondents selected the same component for both questions, it would be deemed that the data from said respondents could not be used. These two questions also measured slightly different aspects. They acknowledged that a respondent may not necessarily check that they wanted a component in their future textbook but that did not mean that they wanted it excluded and vice versa.

4.3.2.2 Ranking of Components

Respondents were also asked to rank the seventeen components from one to seventeen based on their perception of component importance, one being most important and seventeen being least. Each component was given a unique rank. This allowed for a better understanding of the importance of each item in relation to the others. Furthermore, this question allowed for validation of data gathered from the inclusion and exclusion of components questions. It was expected that components students ranked highly would be included during the inclusion question and components ranked lower would be included on the exclusion question. This question was designed to illuminate the most popular and least popular components among students.

4.3.2.3 Classification and Prior Usage

Several questions were used to record gender, age, nationality, current education level and current discipline of study. It was not compulsory for respondents to answer all of the classification questions as the data could still be used for generalized findings. Age ranges were listed as under 18, 18-24, 25-34, 35-50, and 50+. Two questions regarding prior electronic usage were employed to discover if prior usage might have an impact when ranking. The two questions were “Have you ever used an electronic textbook?” and “What percentage of the time do you use electronic textbooks?”

The attributes gender, prior experience, current education level and discipline were used to identify associations with the components that were selected. Age and nationality were not used because of the limited responses in some of the categories.

4.3.3 Dissemination and Data Protection

The Internet survey was generated using Google Forms and was distributed via email to all current students at The Hong Kong Polytechnic University. Prior to dissemination, the School of Design vetted the survey for appropriateness. The survey did not ask for any identifying information, such as names or emails, from the students who chose to participate and no follow-up was performed due to time and resource restrictions.

4.4 Results

4.4.1 Respondent Description

A total of 637 responses were received from students and all five age categories were represented. Of these responses, 51% of respondents were male and 49% were female. Chinese was reported as the most common nationality with 86% of the respondents identifying themselves as such. Prior experience with electronic textbooks was common with 529 (83%) of student respondents noting such, while only 102 (16%) reported having no prior experience. All four options for education level were represented with 384 (60%) of respondents reporting themselves as undergraduates, 137 (22%) masters level, 72 (11%) PhD level, and 43 (7%) pursuing a higher diploma. 30 different disciplines were reported, but only three disciplines provided enough responses for statistical analysis: Engineering (174 respondents, 27% of respondents), Business (101 respondents, 16% of respondents), and Medicine (71 respondents, 11% of respondents). Thus, all disciplines which were reported less than 70 times were deemed to not have enough responses. The following disciplines were reported by students with many of them only having less than ten responses: Agriculture (one respondent), Architecture (seven respondents), Art & Design (61 respondents), Biology (18 respondents), Chemistry (25 respondents), Computer sciences (36 respondents), Cultural and ethnic studies (one respondent), Earth sciences (one respondent), Economics (three respondents), Education (seven respondents), Environmental studies and forestry (nine respondents), Geography (seven respondents), Human physical performance and recreation (three respondents), Journalism, media studies and communication (two respondents, Linguistics (23 respondents), Literature (two respondents), Mathematics (nine respondents), Physics (18 respondents), Political science (three respondents), Psychology (seven respondents), Public administration (six respondents), Social work (14 respondents), Sociology (four respondents), Statistics (five respondents), Systems science (two respondents), Tourism (36 respondents), Transportation (4 respondents), and withheld (18 respondents). While no respondents skipped all of the classification questions, around 9% of respondents did not answer one or more of said questions.

4.4.2 Reliability of Data

A total of 119 respondent surveys of the 637 contained invalid data. Thus, analysis was conducted on a total of 518 surveys. The percentage of genders remained the same. After validating the remaining data, 84% (436) of students were found to have prior experience with electronic textbooks while 15% (79) had no prior experience. A total of 25 surveys from Engineering were discarded leaving 149 (29% or respondents). In addition, 21 surveys from Business were discarded leaving 80 surveys (15% of respondents) and 8 surveys were discarded from Medicine leaving 63 surveys (12% of respondents). Level of education was adjusted to 317 undergraduate respondents (61%), 106 masters level respondents (20%), 60 PhD respondents (12%), and 34 higher diploma respondents (7%).

4.4.3 Reported Desirable Components

The frequency of components reported as desirable by the general respondent population, gender, prior experience, education level, and discipline are displayed in Table 4.1. As shown in the table, the top four components chosen by the general respondent population are Text (84% of the population), Highlighting (82.6% of the population), Bookmarks (79% of the population), and Multimedia (75.5% of the population).

While there were differences in percent of each gender selecting the components, the top four remained the same for both genders. Females reported Text (83.5%), Highlighting (84.3%), Bookmarks (84.3%), and Multimedia (78.8%) as most important to include in electronic textbooks. Men also reported Text (84.4%), Highlighting (80.9%), Bookmarks (73.7%), and Multimedia (72.1%) as most desirable.

The frequency of components desired based on prior experience are similar to the general preference with Text (84.2%), Highlighting (82.3%), Bookmarks (79.8%) and Multimedia (75.0%) selected most often while respondents with no prior experience chose the components 82.3%, 83.5%, 73.4%, and 78.5% of the time respectively.

The top four reported components begin to differ when examining the frequency at education level. Undergraduates and doctoral candidates still chose Text (85.5% and 83.3%), Highlighting (84.2% and 86.7%), Bookmarks (79.2% and 86.7%), and Multimedia (78.5% and 75%) most often. Text (83% and 73.5%), Highlighting (73.6% and 88.2%), and Bookmarks (74.5% and 76.5%) remain the top selected components for Masters and Higher Diploma Students; instead of Multimedia, these students choose to include Translation, Dictionary and Encyclopedias (72.6% and 73.5% respectively).

When examining the differences in frequency based on the disciplines similar trends are found. Engineering students choose Text (83.2%), Highlighting (81.9%), Multimedia (77.2%), and Bookmarks (75.2%) as their top four components. Medical students rate Text (87.3%), Highlighting (82.5%), Bookmarks (81%), and Multimedia (81%) as their four most desirable components. Like changes in frequency in Masters and Higher Diploma Students, Business students have replaced Multimedia with Translation, Dictionary, and Encyclopedias (81.3%) but still frequently chose Text (85%), Bookmarks (80%), and Highlighting (78.8%).

		Text	Highlighting Tool	Bookmarks	Multimedia	Translation, Dictionary, & Encyclopedia	Supplementary Materials	Manipulatable & 3-D Images	Annotation Tool	Link to Experts	Sync w/Devices	Interactive Equations	Integration eLearn	Project or Print Annotations	Text to Speech	Hide Aspects	Speech to Text	Time Management
General	n	435	428	409	391	382	331	283	279	241	236	227	227	203	180	165	155	145
	%	84.0	82.6	79.0	75.5	73.7	63.9	54.6	53.9	46.5	45.6	43.8	43.8	39.2	34.7	31.9	29.9	28.0
Female	n	213	215	215	201	199	171	131	129	115	108	104	123	99	94	92	76	67
	%	83.5	84.3	84.3	78.8	78.0	67.1	51.4	50.6	45.1	42.4	40.8	48.2	38.8	36.9	36.1	29.8	26.3
Male	n	221	212	193	189	182	159	151	149	125	127	122	103	103	86	73	79	77
	%	84.4	80.9	73.7	72.1	69.5	60.7	57.6	56.9	47.7	48.5	46.6	39.3	39.3	32.8	27.9	30.2	29.4
Prior Experience	n	367	359	348	327	326	280	240	234	200	197	183	185	173	147	143	128	119
	%	84.2	82.3	79.8	75.0	74.8	64.2	55.0	53.7	45.9	45.2	42.0	42.4	39.7	33.7	32.8	29.4	27.3
No Prior Experience	n	65	66	58	62	54	49	42	42	38	37	43	39	28	31	21	25	24
	%	82.3	83.5	73.4	78.5	68.4	62.0	53.2	53.2	48.1	46.8	54.4	49.4	35.4	39.2	26.6	31.6	30.4
Undergrad	n	271	267	251	249	236	204	182	171	153	140	143	146	123	111	103	93	87
	%	85.5	84.2	79.2	78.5	74.4	64.4	57.4	53.9	48.3	44.2	45.1	46.1	38.8	35.0	32.5	29.3	27.4
Masters	n	88	78	79	72	77	63	43	51	41	45	41	42	37	35	32	30	29
	%	83.0	73.6	74.5	67.9	72.6	59.4	40.6	48.1	38.7	42.5	38.7	39.6	34.9	33.0	30.2	28.3	27.4
PhD	n	50	52	52	45	43	44	37	40	31	36	28	21	29	18	21	17	19
	%	83.3	86.7	86.7	75.0	71.7	73.3	61.7	66.7	51.7	60.0	46.7	35.0	48.3	30.0	35.0	28.3	31.7
Higher Diploma	n	25	30	26	24	25	19	20	16	16	14	15	17	13	15	9	14	9
	%	73.5	88.2	76.5	70.6	73.5	55.9	58.8	47.1	47.1	41.2	44.1	50.0	38.2	44.1	26.5	41.2	26.5
Engineering	n	124	122	112	115	106	96	87	90	71	72	71	60	64	50	50	45	44
	%	83.2	81.9	75.2	77.2	71.1	64.4	58.4	60.4	47.7	48.3	47.7	40.3	43.0	33.6	33.6	30.2	29.5
Medicine	n	55	52	51	51	46	42	41	29	24	21	16	25	16	21	8	12	12
	%	87.3	82.5	81.0	81.0	73.0	66.7	65.1	46.0	38.1	33.3	25.4	39.7	25.4	33.3	12.7	19.0	19.0
Business	n	68	63	64	57	65	51	31	39	35	31	30	39	26	24	29	20	23
	%	85.0	78.8	80.0	71.3	81.3	63.8	38.8	48.8	43.8	38.8	37.5	48.8	32.5	30.0	36.3	25.0	28.8

Table 4.1. Frequency of desired components by general (n=518), gender (n=518), prior experience (n=515), education level (n=517), and discipline (n=292).

4.4.4 Association Between Desirable Components and Attributes

Pearson's chi-squared test was utilized to identify whether there were any significant associations ($p < 0.050$) between the preference for inclusion of each component and the above-mentioned four democratic categories existed. This statistical test allowed for the identification of relationships between the demographic categories and components in a way that verified the findings were not random. Generally, a limited number of associations were detected between academic discipline, educational level, prior experience, and gender for the 17 components. Nevertheless, some components did exhibit significant associations with the four demographic categories.

Gender was found to be associated with three components: translation tools, dictionaries, and encyclopedias ($X^2(1) = 3.969$, $ø = -0.084$, $p = 0.046$); manipulatable and 3D images ($X^2(1) = 4.320$, $ø = 0.088$, $p = 0.038$); and bookmarks ($X^2(1) = 9.760$, $ø = -.0132$, $p = 0.002$). Prior experience displayed no significant associations with the four demographic categories. Educational level exhibited a significant association with the inclusion of two components: annotation tools ($X^2(3) = 8.001$, $ø = 0.120$, $p = 0.046$) with an adjusted residual of 2.2 for PhD students, and manipulatable and 3D images ($X^2(3) = 11.286$, $ø = 0.142$, $p = 0.010$) with an adjusted residual of -3.3 for master students. Lastly, academic discipline was found to have a significant association with the inclusion of the following components: interactive equations ($X^2(2) = 11.028$, $ø = 0.180$, $p = 0.004$) with an adjusted residual of 3.0 for engineering students and -2.9 for medical students, hiding unimportant aspects of the book ($X^2(2) = 12.705$, $ø = 0.193$, $p = 0.002$) with an adjusted residual of -3.6 for medical students, manipulatable and 3D Images ($X^2(2) = 11.192$, $ø = 0.181$, $p =$

0.004) with an adjusted residual of -3.3 for business students, project or print annotations ($X^2(2) = 6.568$, $ø = 0.139$, $p = 0.037$) with an adjusted residual of 2.5 for engineering students, interdevice synchronization ($X^2(2) = 11.464$, $ø = 0.184$, $p = 0.003$) with an adjusted residual of 3.3 for engineering students and -2.5 for medical students, and annotation tools ($X^2(2) = 6.656$, $ø = 0.140$, $p = 0.036$) with an adjusted residual of 2.6 for engineering students.

4.4.5 Reported Undesirable Components

The frequency of components perceived by respondents as undesirable is displayed in Table 4.2. As illustrated in the table, the top four components reported as undesirable are Hide Unimportant Aspects of the Book (22.8% of the population), Time Management System (22.4% of the population), Speech to Text (18.5% of the population), and Text to Speech (16.2% of the population).

While there were differences in percent of each gender selecting the components, the top four remained the same for both genders. Females reported Hide Unimportant Aspects of the Book (23.5% of the population), Time Management System (21.6% of the population), Speech to Text (15.7% of the population), and Text to Speech (15.3% of the population) as not desirable to include in electronic textbooks. Men also reported Hide Unimportant Aspects of the Book (22.1% of the population), Time Management System (23.3% of the population), Speech to Text (21% of the population), and Text to Speech (16.8% of the population) as undesirable.

The frequency of components deemed undesirable based on prior experience are similar to the general preference with Hide Unimportant Aspects of the Book (23.9% of the population), Time Management System (22.5% of the population), Speech to

Text (19.5% of the population), and Text to Speech (17.4% of the population) selected most often while respondents with no prior experience chose the same first three components 17.7%, 22.8%, and 13.9% of the time, respectively. Instead of choosing Text to Speech, respondents with no prior experience chose Manipulatable and 3-D Images (15.2%) as undesirable.

The top four reported components begin to differ when examining the frequency at education level. Undergraduates and doctoral candidates chose Hide Unimportant Aspects of the Book (24% and 25%), Time Management System (23.3% and 18.3%), Speech to Text (19.2% and 16.7%), and Text to Speech (17.4% and 20%) most often. Hide Unimportant Aspects of the Book (20.8% and 14.7%), Time Management System (21.7% and 23.5%), and Speech to Text (17% and 20.6%) continue to remain the top selected components for Masters and Higher Diploma Students; yet instead of Text to Speech, students choose to include Manipulatable and 3-D Images (14.2% and 17.6% respectively).

When examining the differences in frequency based on the disciplines, similar trends are found. Engineering students choose Hide Unimportant Aspects of the Book (22.8%), Time Management System (23.5%), Speech to Text (13.4%), and Text to Speech (13.4%) as their top four components to not include in their electronic textbooks. Meanwhile medical students rate Time Management System (27%), Hide Unimportant Aspects of the Book (25.4%), Text to Speech (23.8%), and Speech to Text (20.6%) as the four components to exclude. Like changes in frequency in Masters and Higher Diploma Students, Business students have replaced Text to Speech with Manipulatable and 3-D Images (18.8%) but still frequently chose Hide

Unimportant Aspects of the Book (25%), Text to Speech (15%), and Time Management System (15%).

		Hide Aspects	Time Management	Speech to Text	Text to Speech	Manipulatable & 3-D Images	Integration eLearn	Link to Experts	Project Annotations	Equations	Multimedia	Sync w/Devices	Annotation Tool	Translation, Dictionary, & Encyclopedia	Supplementary Materials	Text	Highlighting Tool	Bookmarks
General	n	**118**	**116**	**96**	**84**	59	33	31	29	25	18	18	17	14	13	7	8	5
	%	**22.8**	**22.4**	**18.5**	**16.2**	11.4	6.4	6	5.6	4.8	3.5	3.5	3.3	2.7	2.5	1.4	1.5	1
Female	n	**60**	**55**	**40**	**39**	29	12	15	12	14	5	12	6	5	5	4	0	0
	%	**23.5**	**21.6**	**15.7**	**15.3**	11.4	4.7	5.9	4.7	5.5	2	4.7	2.4	2	2	1.6	0	0
Male	n	**58**	**61**	**55**	**44**	30	21	16	17	11	13	6	11	9	8	3	8	5
	%	**22.1**	**23.3**	**21**	**16.8**	11.5	8	6.1	6.5	4.2	5	2.3	4.2	3.4	3.1	1.1	3.1	1.9
Prior Experience	n	**104**	**98**	**85**	**76**	47	30	27	25	25	17	15	14	14	11	5	7	5
	%	**23.9**	**22.5**	**19.5**	**17.4**	10.8	6.9	6.2	5.7	5.7	3.9	3.4	3.2	3.2	2.5	1.1	1.6	1.1
No Prior Experience	n	**14**	**18**	**11**	8	**12**	3	4	4	0	1	3	3	0	2	2	1	0
	%	**17.7**	**22.8**	**13.9**	10.1	**15.2**	3.8	5.1	5.1	0	1.3	3.8	3.8	0	2.5	2.5	1.3	0
Undergrad	n	**76**	**74**	**61**	**55**	36	18	13	21	12	9	11	8	7	8	6	3	3
	%	**24**	**23.3**	**19.2**	**17.4**	11.4	5.7	4.1	6.6	3.8	2.8	3.5	2.5	2.2	2.5	1.9	0.9	0.9
Masters	n	**22**	**23**	**18**	13	**15**	6	7	3	7	5	4	5	3	1	0	2	0
	%	**20.8**	**21.7**	**17**	12.3	**14.2**	5.7	6.6	2.8	6.6	4.7	3.8	4.7	2.8	0.9	0	1.9	0
PhD	n	**15**	**11**	**10**	**12**	2	6	7	4	4	1	2	4	3	2	1	2	2
	%	**25**	**18.3**	**16.7**	**20**	3.3	10	11.7	6.7	6.7	1.7	3.3	6.7	5	3.3	1.7	3.3	3.3
Higher Diploma	n	**5**	**8**	**7**	4	**6**	3	4	1	2	3	1	0	1	2	0	1	0
	%	**14.7**	**23.5**	**20.6**	11.8	**17.6**	8.8	11.8	2.9	5.9	8.8	2.9	0	2.9	5.9	0	2.9	0
Engineering	n	**34**	**35**	**20**	**20**	12	10	5	11	6	5	3	4	4	5	1	2	1
	%	**22.8**	**23.5**	**13.4**	**13.4**	8.1	6.7	3.4	7.4	4	3.4	2	2.7	2.7	3.4	0.7	1.3	0.7
Medicine	n	**16**	**17**	**13**	**15**	6	3	4	5	3	0	5	4	1	4	0	0	0
	%	**25.4**	**27**	**20.6**	**23.8**	9.5	4.8	6.3	7.9	4.8	0	7.9	6.3	1.6	6.3	0	0	0
Business	n	**20**	**12**	**13**	9	**15**	3	1	1	3	4	2	1	1	1	2	0	1
	%	**25**	**15**	**16.3**	11.3	**18.8**	3.8	1.3	1.3	3.8	5	2.5	1.3	1.3	1.3	2.5	0	1.3

Table 4.2. Frequency of undesirable components by general (n=518), gender (n=518), prior experience (n=515), education level (n=517), and discipline (n=292).

4.4.6 Association Between Undesirable Components and Attributes

As detected when determining the components most desired for inclusion, the level of association between gender, prior experience, educational level, and academic discipline was found to be low. In addition, it was observed that the components reported as undesirable demonstrated no significant associations with educational level.

Gender was found to have a significant association with highlighting tools ($X^2(1) = 8.087$, ø = 0.120, p = 0.004). Prior experience showed significant associations with two components: interactive equations ($X^2(1) = 5.252$, ø = 0.097, p = 0.022), and manipulatable and 3D images ($X^2(1) = 24.323$, ø = - 0.209, p = 0.000). Academic discipline only showed a significant association with manipulatable and 3D images ($X^2(2) = 6.691$, ø = 0.140, p = 0.035) being chosen as undesirable with an adjusted residual of 2.6 for Business students.

4.5 Rank of Components

Respondents were also asked to rank components from 1 (most desirable) to 17 (least desirable). Based on the mean rank of each component, a general rank of the perception on components was developed. The rank can be found in Table 4.3. The top five components of Text; Highlighting; Multimedia; Bookmarks; and Translation, Dictionary, and Encyclopedia support the earlier findings in this chapter on desirable components.

Rank	Components	Mean
1	Text	2.68
2	Highlighting Tool	5.66
3	Multimedia	6.05
4	Bookmarks	6.92
5	Translation, Dictionary, & Encyclopedia	7.67
6	Annotation Tool	7.86
7	Manipulatable and 3-D Images	8.99
8	Interactive Equations	9.16
9	Sync Across Devices	9.16
10	Supplementary Materials	9.26
11	Integration in eLearning Platforms	9.45
12	Link to Experts Rank	9.90
13	Project or Print Annotations	10.35
14	Text to Speech	11.97
15	Speech to Text	12.39
16	Hide Aspects	12.69
17	Time Management System	12.83

Table 4.3. Rank of the components based on general respondent population (n=518).

When examining the rank based on gender, females choose the same top five components as general. While men choose Text, Highlighting Tool, Multimedia, Bookmarks, Annotation Tool as their top five components. The full ranks can be found in Table 4.4.

Rank	Female Components (Mean Ranking)	Male Components (Mean Ranking)
1	Text (2.64)	Text (2.68)
2	Highlighting Tool (5.11)	Highlighting Tool (6.18)
3	Multimedia (5.90)	Multimedia (6.20)
4	Bookmarks (6.86)	Bookmarks (6.97)
5	Translation, Dictionary, & Encyclopedia (7.20)	Annotation Tool (7.72)
6	Annotation Tool (7.99)	Translation, Dictionary, & Encyclopedia (8.09)
7	Supplementary Materials (8.69)	Sync Across Devices (8.55)
8	Manipulatable and 3-D Images (9.33)	Manipulatable and 3-D Images (8.69)
9	Interactive Equations (9.33)	Interactive Equations (8.97)
10	Integration in eLearning Platforms (9.41)	Integration in eLearning Platforms (9.50)
11	Sync Across Devices (9.80)	Supplementary Materials (9.78)
12	Link to Experts Rank (9.89)	Link to Experts Rank (9.93)
13	Project or Print Annotations (10.51)	Project or Print Annotations (10.17)
14	Text to Speech (11.96)	Text to Speech (12.02)
15	Speech to Text (12.37)	Time Management System (12.31)
16	Hide Aspects (12.57)	Speech to Text (12.47)
17	Time Management System (13.40)	Hide Aspects (12.79)

Table 4.4. The ranking of components by gender based on means.

Prior experience had less of an impact on rankings in the top five positions but the variances in rank can be found in Table 4.5. Both groups found the same five components in positions 1-5 but reversed two of the components. Those respondents with prior experience chose Text; Highlighting; Multimedia; Bookmarks; and Translation, Dictionary, and Encyclopedia in the top five positions respectively. Those without prior experience placed Text; Multimedia; Highlighting; Bookmarks; and Translation, Dictionary, and Encyclopedia in the first five positions.

Rank	Prior Experience Components (Mean Ranking)	No Prior Experience Components (Mean Ranking)
1	Text (2.59)	Text (3.20)
2	Highlighting Tool (5.55)	Multimedia (5.09)
3	Multimedia (6.21)	Highlighting Tool (6.29)
4	Bookmarks (6.75)	Bookmarks (7.79)
5	Translation, Dictionary, & Encyclopedia (7.63)	Translation, Dictionary, & Encyclopedia (7.81)
6	Annotation Tool (7.79)	Annotation Tool (8.34)
7	Manipulatable and 3-D Images (9.03)	Interactive Equations (8.52)
8	Sync Across Devices (9.12)	Manipulatable and 3-D Images (8.68)
9	Supplementary Materials (9.18)	Integration in eLearning Platforms (9.23)
10	Interactive Equations (9.28)	Sync Across Devices (9.58)
11	Integration in eLearning Platforms (9.53)	Supplementary Materials (9.58)
12	Link to Experts Rank (9.92)	Link to Experts Rank (9.84)
13	Project or Print Annotations (10.40)	Project or Print Annotations (10.05)
14	Text to Speech (12.14)	Text to Speech (10.96)
15	Speech to Text (12.45)	Speech to Text (12.06)
16	Hide Aspects (12.56)	Time Management System (12.62)
17	Time Management System (12.85)	Hide Aspects (13.35)

Table 4.5. The ranking of components by prior experience based on means.

Table 4.6 shows the changes in rankings based on education levels. The top two rankings of Text and Highlighting respectively remained the same for all four levels of education but the next three rankings changed with each education level. Those studying for Higher Diplomas selected Bookmarks; Translation, Dictionary, and Encyclopedia; and Multimedia in positions 3-5 respectively. Masters students chose Bookmarks; Multimedia; and Translation, Dictionary, and Encyclopedia in positions 3-5 respectively. Meanwhile PhD respondents chose Multimedia, Bookmarks, and Annotation Tools in the last three positions respectively. Finally, Undergraduates chose Multimedia; Bookmarks; and Translation, Dictionary, and Encyclopedia in the final three positions respectively.

Rank	Higher Diploma Components (Mean Ranking)	Undergraduate Components (Mean Ranking)	Masters Components (Mean Ranking)	PhD Components (Mean Ranking)
1	Text (2.97)	Text (2.58)	Text (2.85)	Text (2.63)
2	Highlighting Tool (7.12)	Highlighting Tool (5.35)	Highlighting Tool (6.13)	Highlighting Tool (5.70)
3	Bookmarks (7.21)	Multimedia (5.55)	Bookmarks (6.54)	Multimedia (6.37)
4	Translation, Dictionary, & Encyclopedia (7.21)	Bookmarks (7.02)	Multimedia (6.79)	Bookmarks (6.93)
5	Multimedia (7.59)	Translation, Dictionary, & Encyclopedia (7.63)	Translation, Dictionary, & Encyclopedia (7.57)	Annotation Tool (7.02)
6	Annotation Tool (8.80)	Annotation Tool (7.86)	Annotation Tool (8.09)	Manipulatable and 3-D Images (7.95)
7	Integration in eLearning Platforms (8.85)	Manipulatable and 3-D Images (8.74)	Sync Across Devices (8.52)	Supplementary Materials (8.30)
8	Link to Experts Rank (9.09)	Interactive Equations (8.89)	Supplementary Materials (9.08)	Sync Across Devices (8.37)
9	Supplementary Materials (9.18)	Integration in eLearning Platforms (9.37)	Integration in eLearning Platforms (9.18)	Translation, Dictionary, & Encyclopedia (8.40)
10	Sync Across Devices (9.41)	Sync Across Devices (9.52)	Project or Print Annotations (9.54)	Interactive Equations (9.18)
11	Text to Speech (9.56)	Supplementary Materials (9.52)	Interactive Equations (9.61)	Link to Experts Rank (10.20)
12	Manipulatable and 3-D Images (9.62)	Link to Experts Rank (9.70)	Manipulatable and 3-D Images (10.09)	Project or Print Annotations (10.25)
13	Interactive Equations (9.94)	Project or Print Annotations (10.54)	Link to Experts Rank (10.56)	Integration in eLearning Platforms (10.65)
14	Hide Aspects (11.24)	Text to Speech (12.36)	Text to Speech (11.24)	Speech to Text (12.40)
15	Project or Print Annotations (11.32)	Speech to Text (12.66)	Speech to Text (11.94)	Text to Speech (12.62)
16	Speech to Text (11.41)	Hide Aspects (12.73)	Time Management System (12.63)	Time Management System (12.75)
17	Time Management System (12.50)	Time Management System (12.94)	Hide Aspects (12.65)	Hide Aspects (13.28)

Table 4.6. The ranking of components by education level based on means.

Discipline had the most effect on component rankings (Table 4.7). Business students placed Text; Highlighting Tool; Bookmarks; Multimedia; and Translation, Dictionary, and Encyclopedia in the top five positions. In Engineering, the top five components were ranked as Text, Highlighting Tool, Multimedia, Bookmarks, and

Annotation Tool. Medical students placed the most importance on Text; Multimedia; Highlighting Tool; Manipulatable and 3-D Images; and Translation, Dictionary, and Encyclopedia respectively.

Rank	**Business Students Components (Mean Ranking)**	**Engineering Students Components (Mean Ranking)**	**Medical Students Components (Mean Ranking)**
1	Text (2.25)	Text (2.99)	Text (2.46)
2	Highlighting Tool (5.36)	Highlighting Tool (5.76)	Multimedia (4.54)
3	Bookmarks (6.45)	Multimedia (6.36)	Highlighting Tool (4.94)
4	Multimedia (6.54)	Bookmarks (7.15)	Manipulatable and 3-D Images (6.89)
5	Translation, Dictionary, & Encyclopedia (7.56)	Annotation Tool (7.45)	Translation, Dictionary, & Encyclopedia (6.97)
6	Annotation Tool (8.16)	Translation, Dictionary, & Encyclopedia (7.85)	Bookmarks (7.27)
7	Integration in eLearning Platforms (8.65)	Interactive Equations (8.62)	Annotation Tool (8.38)
8	Supplementary Materials (8.90)	Manipulatable and 3-D Images (8.72)	Supplementary Materials (8.40)
9	Sync Across Devices (9.08)	Supplementary Materials (9.24)	Interactive Equations (9.43)
10	Interactive Equations (9.59)	Sync Across Devices (9.27)	Integration in eLearning Platforms (9.83)
11	Link to Experts Rank (9.76)	Integration in eLearning Platforms (9.47)	Link to Experts Rank (10.03)
12	Manipulatable and 3-D Images (10.29)	Link to Experts Rank (9.72)	Sync Across Devices (10.44)
13	Project or Print Annotations (10.61)	Project or Print Annotations (10.51)	Project or Print Annotations (11.25)
14	Text to Speech (12.03)	Text to Speech (12.00)	Text to Speech (12.08)
15	Hide Aspects (12.48)	Speech to Text (12.50)	Speech to Text (12.52)
16	Speech to Text (12.53)	Hide Aspects (12.54)	Time Management System (13.40)
17	Time Management System (12.78)	Time Management System (12.87)	Hide Aspects (14.18)

Table 4.7. The ranking of components by business, engineering, and medical students based on means.

4.6 Discussion

4.6.1 Sampling and Bias

To properly interpret results from the survey, bias from nonresponse should be evaluated. Internet surveys are known to have a lower response rate with university students than paper surveys (Sax et al., 2003), yet since they are more anonymous respondents are more likely to report their actual opinions (Lee, 2000). There are many factors, which may have influenced the low response rate found in this survey. For example, no incentive was offered to students to fill out the survey. Also, while English is the medium of instruction at The Hong Kong Polytechnic University, the two main Chinese dialects are the most common languages spoken. This survey was only available in English and some students may have had difficulties understanding the questions leading to a lower response rate. The limited timeframe of approximately two weeks to complete the survey and the listserv distribution could have also influenced the response rate. Not all students use their school provided email, some opt out of university wide emails, and some do not check it often and if respondents were traveling or attending the student protests during the two-week time period, they may not have been able to respond to the survey.

There may be one more limitation related to understanding of questions. While both students and professors of various disciplines piloted the questions and responses, there could still be a lack of understanding among the wider student population. This lack of understanding could lead to skewed results. Some of the misunderstandings could be related to language difficulties or respondents with no prior usage being unable to imagine the components. With a large enough sample size and trust in the piloting, the small amount of bias would not be able to influence the larger results.

While the response rate could be perceived as low with just over 630 respondents (approximately 2% of students sent the survey via email responded), there were similarities between the respondent description and the description of the student population at the university. Similar to the respondent description, the three main disciplines at The Hong Kong Polytechnic University are Engineering, Business, and Medicine (PolyU in Figures 2012/13, 2013; PolyU in Figures 2014/2015, 2016). Education level was also similar to response rates with a slightly higher percentage of undergraduates and PhD students responding and a slightly lower percentage of masters level students responding to the survey (op. cit.). Based on Chandrasekhar (2011) assertions, considering the student population of The Hong Kong Polytechnic University (approximately 32,000 students), only 400 valid respondents are needed for the five percent acceptable error rate necessary to draw statistically based conclusions on the data. The survey described in this section received more responses than this, so it can be assumed that an acceptable amount of responses was attained.

4.6.2 General Student Perceptions of Components

Overall, the bulk of the components recorded for inclusion are reminiscent of the activities that students currently use to support their readings in physical textbooks and those identified as undesirable are not possible in the physical medium. Yet, the components reported by students as desirable varied from one respondent to the next. Fairbairn & Fairbairn (2001) also assert that there is no set way for students to engage with material and that there are many supporting activities that may be used to assist reading. The majority of students did claim that text; highlighting tools; bookmarks; multimedia; and translation capabilities, dictionaries, and encyclopedias ought to be included in future electronic textbooks. Schcolnik (2001) also found that when reading in a digital form for information, components like the bookmark were used while annotation tools were not. These activities may evolve as the technology changes, but it would be useful to include them when attempting to acclimate students to the new medium of textbooks so as to not completely contradict their mental models and help them accept the new technology. Carroll et al. (2016) observed that both non-STEM and science, technology, engineering, and mathematics (STEM) students alike regularly reported the desire to highlight in their electronic books. Future advances in technology may affect habits, yet it would still be beneficial to include highlighting tools to support students while they became accustomed to the new medium of textbooks and avoid contradicting students' existing mental models. Landoni et al. (2000) claimed that such an inclusion supports students in accepting and understanding new technology. While the metaphor can be important in the adoption of electronic textbooks, it is vital to understand how the two main approaches of studying, the deep and surface approaches (Hartley, 1990), may affect the components and criticisms that students have. The surface approach only provides a student with a superficial understanding of the subject while the deep reading approach allows students to relate the material to their current knowledge (Bowden & Marton, 2003). The inclusion of components such as dictionaries and encyclopedias would contribute to student connection making within their existing knowledge. Moreover, the selection of multimedia, such as annotated embedded video, for general inclusion has been revealed to assist in student learning in the past (Dennis et al., 2015).

4.6.3 Associations Between Classifications and Perceptions

The four demographic categories used to analyze the Internet survey showed a small association with the perceived desirability of some of the components; nevertheless, none of the demographic categories showed associations with all the components. Furthermore, when examining the differences in frequency, examinations of residuals, and rankings within the demographic categories some components were found to be desired more than others.

Of the various demographic categories investigated by the Internet survey, two were found to exert less influence on the perception of components. While some small associations between experience level and gender were identified, overall the number of associations observed were limited when compared to other categories. Past research by Woody et al. (2010) indicated that gender had no significant impact on student preferences for physical textbooks over electronic textbooks. Results from this study partially support this past research. Gender was observed to have only a small association regarding three components: the desirability of bookmarks; translation tools, dictionaries, and encyclopedias; and manipulatable and 3D images and no association in the other components. Bookmarks and translation tools, dictionaries, and encyclopedias were reported favorably significantly more frequently by females than males. However, the component of manipulatable and 3-D images was reported significantly more frequently by males. When investigated undesirable components, highlighting tools was observed to be associated with gender. No female respondents reported highlighting tools as undesirable, while fewer than 10 males reported not requiring highlighting tools in their future electronic textbooks. Additionally, prior usage was also found to not heavily influence opinions surrounding electronic textbooks, something echoed by Gu et al. (2015). Only two of the components were revealed to have associations with prior experience. Manipulatable and 3-D images and interactive equations were associated with prior experience as undesirable components. Additionally, those without prior experience reported not desiring manipulatable and 3-D images more frequently, and those with prior experience stated that they did not want interactive equations to be included more frequently. Some current constraints or practices in technology may have influenced some results; for instance, the load time of images can still be long even with faster Internet speeds and the employment of images tends to be conventional. This negative association may have influenced responses for those with prior experience.

Some association with both the inclusion of the less traditional component of manipulatable and 3-D images and more traditional learning component of note taking was found with educational level. Based on inspection of residuals, annotation tools was chosen more frequently by PhD students than expected, while master's students selected manipulatable and 3-D images less frequently. Such differences may be related to differences in reading task requirements amid the educational levels. For example, PhD students have different academic goals than students studying at the lower levels. They will present the conclusion of their academic research work in a dissertation, which necessitates a literature review, whereas lower level students have exams or small and focused papers.

The most associations with the selection of components were observed with the different academic disciplines, which supports the trend of creating course-specific electronic textbooks that can currently be observed at universities such as Oxford and the California State University system (Coughlan 2012; Nelson 2008). These findings also resonate with the views in Jones and Healing’s (2010) article, which found a strong association between courses and usage of technology in general. An extension of this associated can be inferred in cases of interactive equations; hiding unimportant aspects; annotation tools; and manipulatable and 3-D images. Interactive equations was found to be more desirable among engineering students based on analysis of the residuals. Engineering students logically requested the component more than business and medical students as their textbooks often rely on equations, such as the textbook Modern Control Engineering (Ogata & Yang, 1970). A preference for task–technology fit was found with engineering students regarding electronic textbooks. Jou et al. (2016) specified the importance of translating concepts into actual examples, which illuminates the association between academic discipline and that specific component. Engineering and business students also selected hiding unimportant aspects more often for inclusion than medical students. The examination of residuals found the component was chosen less often by medical students than expected. This may be related to the broader spectrum of information presented in engineering and business textbooks, which specialized students may not require, whereas medical students specialize in a particular area much later. Annotation tools was also found to be associated with academic discipline. More than half of the engineering respondents requested this component and examination of residuals showed that it was selected more often than expected. Finally, manipulatable and 3-D images was requested for inclusion most frequently by medical students, followed by engineering students, and least frequently by business students. Examination of residuals showed that business students requested the component less than expected. Images are vital to the understanding of medical information and thusly are prevalent in medical textbooks, such as in Clinical Anatomy: Applied Anatomy for Students and Junior Doctors by Ellis and Mahadevan (2013). Images can be important for engineering students as well, especially when visualizing how systems work, while it is not as vital for images to be included in business students’ textbooks to assist their understanding of concepts. The reasoning behind the association is slightly more obscure with interdevice synchronization and projecting or printing annotations; it may be a result of the technical nature of the components and requires further investigation. Engineering students, followed by business students, and lastly medical students requested projecting or printing annotations most frequently. Interdevice synchronization was requested most frequently by engineering students, followed by business students, and least frequently by medical students.

The practice of tailoring electronic textbooks to the specific courses may seem to be an appropriate response that would better support student learning, but it is happening on too small of a scale and would be a waste of time and resources to do this for every class across the world. Instead, development of a new design framework for the various disciplines would be more appropriate. At the point of study one, it is too soon to completely change the way electronic textbooks are designed because students are still approaching their electronic textbooks the same way they approach the physical counterpart. Yet some components can be initially analyzed to find some common components. This can especially be seen in the desire for inclusion and ranking of text and highlighting tools. This approach may differ in a few years as students become acclimated to using electronic textbooks and the technology changes, but it would be useful to embrace these components and approaches so that students feel more comfortable using the new technology.

4.7 Summary

The survey described in this chapter found that text, highlighting tools, bookmarks, multimedia, translation capabilities, dictionaries, and encyclopedias should be included in future electronic textbooks over other components. Evidence suggests that there are many attributes, which have a significant association with students' perception of components that they feel should be included in their textbooks, so it may be recommendable to design future electronic textbooks with these attributes in mind. The variance in rankings supply evidence that components in electronic textbooks should continue to be tailored based on the discipline for which they are developed.

More research was necessary in identifying why students are selecting certain components when studying and why they may feel one component is more necessary for their electronic textbooks than a different one. This was investigated through the focus groups described in Chapter 5. Following that, research was undertaken to identify how students interact with some of the real world components currently employed in electronic textbooks, which is outlined in Chapter 7. Also, research was conducted on some of the future components students requested in their future electronic textbooks and the genuine appropriateness in relation to the academic reading task detailed in Chapter 8. This will ascertain if there is what Simon (2001a) dubbed the “fickleness gap”, a reported importance of components with limited actual usage.

The high variance in disciplines required the research in this dissertation to be subsequently scoped down. Based on survey results, two disciplines were selected to study in-depth: Design and Engineering. These disciplines were chosen based on their similarity of goals, yet fundamental differences in practices and ways of approaching their goals. Based on this narrowing in the research area, components from the survey were analyzed for engineering students and design students, and those components were then presented to the focus groups as outlined in Chapter 5 Section 5.4.3 and the interviewees as detailed in Chapter 6 Section 6.4.3.

Chapter 5. Study Two: Current Academic Reading Task and Future Requirements

5.1 Overview of Chapter

Chapter 5 introduces the second method used in this research, the Focus Group, which meets objectives 1 and 2 and assists in informing research questions 1: Relationships between characteristics and reading, 1B: Student tasks, 2: Components based on task, and 2A: Aspects and components necessary. The focus groups were used to gain an in-depth understanding of the students' academic reading task in both physical and electronic textbooks, identify changes in reading tasks, and elicit what students felt they needed from electronic textbooks to succeed in their academic reading tasks. The chapter begins with the justification for the use of the method. It then follows with the method and results. Following that, a discussion of the findings in the context of some past literature is presented. The chapter ends with a summary of the findings and their context within the larger research.

This chapter is a reproduction of the following publications:

Sheen, K.A., & Luximon, Y. (2016, April). Focus Group Study on Student Perception of Electronic Textbooks. In *ACHI 2016, The Ninth International Conference on Advances in Computer-Human Interactions* (pp. 110-115). Venice, Italy: IARIA.

Sheen, K.A., & Luximon, Y. (2016). Student Views on Academic Reading and its Future in the Design and Engineering Disciplines. *International Journal On Advances in Life Sciences, 8*(3&4), 257-266.

5.2 Justifications

The second method appropriate for this type of research, when applied in tandem with the survey, is focus group sessions. Focus group sessions are beneficial when gathering an in-depth understanding of student responses to the survey and subsequent reasoning behind student real world behaviors. Major advantages of focus groups are their ability to provide an interpretation of data not achievable through qualitative approaches, verification of data interpretations where validity could be questioned, and assist in examining complex problems (Vaughn et al., 1996). Student behaviors and perceptions when interacting with electronic textbooks are one such complex problem in which focus groups can be employed. Furthermore, this method is inexpensive, large amounts of data can be gathered quickly, and sessions can be easily revisited by researchers with recordings which were taken unobtrusively to assist in analyzing language (Berger, 1998). Focus groups sessions can be either directed or undirected and include small or large groups in their collective conversations based on what the research necessitates (Lee, 2000).

The research outlined in this chapter entails gaining more data and closely examining underlying issues related to the data obtained through the Internet survey, thus focused semi-structured focus groups were deemed most suitable. This form of focus group interviews employs a well-defined question set based on the responses from the survey and necessary additional information, but were still conducted as a conversation between student participants (Yin, 2009). This type of interview was used and outlined later in the chapter and the questions are located in Appendix B. Using a less structured moderator position in the focus group allowed for open and relaxed discussions between the student participants. Semi-structured interview questions and preplanned activities were core to the process so as to ensure relevance of the information gathered.

The inherent flexibility of focus groups over standard interviews, allows for the participants to expand on ideas or dispute other participants' ideas in a group discussion; thus, supplying more profound responses and circumventing the reluctance to respond which is sometimes found in participants (Yin, 2009). This advantage is beneficial to this research as it was conducted with Chinese students who often are reluctant to verbalize their opinions in standard interview settings. The group interview style of focus groups is suitable for investigating student attitudes as it allows them actively to discuss the issues they find most important and pursue their own specific interests on the subject (Kitzinger, 1994). Multiple students will be able to offer input on this single subject and come to a more complete consensus on the created reality (Hickman, 2008). The socially constructed nature of the reality of electronic textbooks is discipline specific, thus, focus group data will assist in the acquisition of the in-depth research necessary for this work.

Focus group sessions are robust but still must be properly focused since they are only able to answer why questions (Berger, 1998), the data gathered is often complex, ideas are frequently interrelated, some the data collected will be irrelevant, and the data is often complex (Kitzinger, 1994). While a different method, focus groups often share the same challenges as interviews. For example, they are time intensive when properly conducted. Several of the steps prior to conducting the focus group sessions require thoughtful design, such as question creation and recruiting an effective moderator who is able to avoid inserting bias in the conversations (Isaac & Michael, 1995). Additionally, conducting the focus group sessions and transcribing the data is time consuming. Another challenge is identifying possible participants for the focus groups and needs to be completed with consideration so as to not cause problems. If focus groups are not balanced with the proper participants, generalizations cannot be made from the findings (Berger, 1998). The participant selection is particularly significant in the area of student perceptions. Different disciplines have an effect on the terminology used by students, their approach to the academic reading task, and the primary knowledge they already have. Thus, the focus group sessions were separated by the two disciplines identified as the scope of the research outlined in this dissertation.

Furthermore, perceived socially desirable behavior and opinions may be over reported by participants (Bishop et al., 1980) so as to control how the moderator views them (Lee, 2000). While true, this is less likely to occur in focus groups than interviews as focus groups allow more anonymity in the recorded data (Bradburn et al., 1979). Still it is vital to understand that the context of the questions may influence the participant reactions (Lee, 2000). Personality types of participants and potential reactions to the recording of the sessions also needs to be considered in the moderation of focus groups, as they may cause issues and restrained responses (Berger, 1998). In addition, the personality of the moderator must be accounted for as it can influence responses (Schuman & Converse, 1971). This person must be able to focus the discussion but not stifle or influence it by overpowering the participants (Berger, 1998). The challenges listed above can be avoided by careful question design with a focus on the research questions, informing participants of their rights and the goals of the focus group, and choosing a proper moderator who is neutral and sensitive to group dynamics (Bush & Cameron, 2011).

5.3 Method

5.3.1 Participants

The student participants were recruited from The Hong Kong Polytechnic University. There were only two qualifications for participation in the focus groups. Participants were required to be currently enrolled in either a higher diploma or undergraduate level engineering or design program at the university and they were required to have prior experience with electronic textbooks. After a student volunteered for participation and it was deemed they met the two requirements, they were assigned to focus groups of three people from their specific discipline. Separation of focus groups considered only the discipline of students, not the separate programs within said disciplines. For instance, the Engineering Discipline at the university is comprised of many programs such as product engineering, computer science, and electronic engineering. Students from these different programs could be assigned to the same engineering focus group session. Similarly, students from programs such as communication design, multimedia design and product design could all be assigned to the same design focus group session.

5.3.2 Session Design

Each focus group focused on a singular discipline so that approaches and the language employed remained consistent. There is no general consensus on how many participants should participate in a focus group or how many sessions are necessary to reach homogeneity. Prior research has found that larger groups are able to produce more concepts (Fern, 1982), but smaller groups encourage more participation (Carey, 1994) and are easier for a moderator to facilitate (Morgan, 1996). Past research has also generally deemed between ten and three focus groups as appropriate to reach homogeneity (Millward, 1995; Krueger, 1994; Stewart & Shamdasani, 1990).

Questions for the semi-structured interview regarding reasoning behind component choices and reading habits, which were the basis of the focus group sessions, were created based on the findings from the Internet survey and piloted the same way the survey questions in the previous chapter were, with three professors looking over the questions and six students in two sessions piloting the focus group experience. A script with semi-structured questions, found in Appendix B, was utilized to allow for flexibility based on student answers (Singleton & Straits, 2005). In line with the constructivist theory that this research follows, an activity reminiscent of Khattri and Miles' (1993) cognitive mapping activity, was utilized in the focus groups to assist in the identification of the student perception of what an "electronic textbook" is and what they should look like in the future. This type of activity aids in the researcher's understanding of how participants understand systems and how concepts fit together (Langford & McDonagh, 2003). The artifacts created during the focus groups later helped inform and design the prototype used to validate the final design framework. The sessions were short to avoid participant fatigue and all student information collected was anonymized before storage. The semi-structured questions focused on determining why students responded to the survey as they did and any issues surrounding academic reading.

Before the sessions began, students were given an information sheet regarding the focus group sessions and signed a consent form. The information sheet detailed the researcher's contact information, informed them of data storage and their participant rights, and included details about the research. Any questions participants had regarding the study was also answered by the researcher at this time. Prior to the start of the sessions, participants were asked for their permission for the sessions to be audio recorded. There was only one moderator in the room who took notes during the sessions, asked the questions developed from the survey, and oversaw the cognitive mapping activity.

Each session took place in a laboratory room and lasted roughly one hour. Sixteen semi-structured interview questions were core to the sessions, but follow up questions based on responses were unscripted. Many of these follow up questions were similar due to the parallels within responses. Two activities were also conducted during these sessions. The first of which asked students to define electronic textbooks. The second asked students to describe, outside of the constraints of current technology, what they felt electronic textbooks based on their discipline should be like in the future. Students were requested to focus on the components that should be included and after which were asked how they would interact with the envisioned future electronic textbooks. Markers and paper were supplied to students during these activities. The moderator only spoke during these activities to ask for clarification or to answer student questions. Following the sessions, the audio tapes were transcribed and the artifacts from the activities were analyzed. Some examples of these activity artifacts are presented later in this chapter.

5.3.3 Analysis Techniques

After transcription of the sessions, the data was coded. Analysis of this type of data takes between double and five times the amount of time it took to collect the data (Miles & Huberman, 1994). Additionally, words collected through this type of qualitative method may have multiple meanings which can be challenging, yet overall the words collected are more meaningful than numbers (op. cit.) making it ideal to illuminate the previous quantitative findings. Analysis was conducted with the aims, objectives, and research questions at the core but careful consideration was employed so that unexpected findings would not accidently be disregarded as insignificant. Data was condensed and analyzed as it came in and coding was conducted through iterative reflection. This ensured that a theory was able to emerge from the data based on the code's sensitivity to the larger context. These codes, or labels used to assign common meaning to portions of text, were pattern, interpretive, or descriptive depending on the nature of the data. Based on Strauss' (1987) philosophy the codes were founded on conditions, consequences, interactions, and strategies and grounded in the data (Glaser & Strauss, 2009). For easier analysis, the data was organized in recurrent topics and subtopics, descriptions, and theory development. Some examples of the codes emerging from the analysis of the focus groups are as follows: ergonomics issues, habits, preference, task requirements, technical issues, and technical requirements. The general findings and codes developed from the analysis of the focus groups were audited by the final prototype evaluation for confirmability (Trochim, 2006). This is later described in Chapter 8.

5.4 Results

The semi-structured interview questions described above explored the preferences, task requirements, and behaviors of students regarding academic reading. The questions sets were separated in three segments: current physical textbook readings, current electronic textbook reading, and the future of electronic textbooks. While both design and engineering focus groups were asked the same questions, follow up questions varied based on student responses. Students were also asked to give feedback on the ranking data gathered from the survey outlined in Chapter 4 in the future of electronic textbooks segment. One of the two activities was conducted during the current electronic reading segment while the other was at the end of the future of electronic textbooks section and wrapped up the focus group sessions.

5.4.1 Participants

A total of ten, three person, focus group sessions were conducted. Five of those consisted of students in the Design Discipline and five from the Engineering Discipline. Thus, 30 students partook in the ten focus group sessions. Homogeneity was reached after three sessions in each discipline and could have ended (Millward, 1995; Krueger, 1994; Stewart & Shamdasani, 1990) but continued for two more sessions per discipline for more significant findings. Of the total participants, 16 were male and 14 were female. Their ages ranged between 18 and 23. A total of four females and 11 males partook in the engineering focus group sessions. Whereas ten females and five males took part in the design focus groups sessions. The distribution of genders in the various departments is reflected in the increased number of female participants in the design sessions and the increased number of males in the engineering sessions.

5.4.2 Physical Textbooks

5.4.2.1 Student Behaviors

The questions asked in the current physical textbooks segments primarily dealt with student habits and behaviors during academic reading. While responses regarding the individual preferences and habits varied, trends emerged when analyzing the data together. Design students reported that their frequency of use of physical textbooks ranged from 20% to 90% of total time spent reading. Yet, the initial percentages are misleading. Later in the sessions, students with lower numbers acknowledged underestimating their use of physical textbooks. This was due to categorizing the reading as electronic when they actually printed out the text. In reality, the usage of physical texts was closer to the higher end of the range for all participants. The majority of this physical text reading was conducted in the morning at a desk at home, either before lectures or very late in the evening. Other locations for completing physical readings were reported by design students such as on the couch at home, in the classroom, or while traveling. Generally, students did not prefer reading while traveling, as they felt dizzy or found heavy books or stacks of paper cumbersome to use on transportation. Design students felt that the purpose of textbooks was to learn concepts and often used them as a starting place to find outside resources on the same concepts.

While design students spent most of their time with physical textbooks, engineering students reported their physical textbook usage as less than 50% of their time reading. Two participants out of 15 reported an even lower percentage of physical textbook use as they would alter their behavior so they could use electronic textbooks as often as possible. Time spent with physical textbooks in an average reading session varied drastically based on study habits. Some students reported to reading almost every day while others only read during exam times. Those students who read only during exam periods reported spending upwards of five hours reading per instance in a day. Overall, these students felt that reading should only be completed if it was required and it was not necessary to explore concepts outside of what was taught in the classroom. Engineering students highlighted that they required quiet when carrying out their readings. Students who had a quiet home would work at their desks at home, while those who did not felt the school library was preferable. Engineering students did not report completing academic readings whilst traveling. Overall, the engineering students felt that academic reading should only be undertaken if required for homework or for a review of what was learned in the classroom.

5.4.2.2 Task Requirements

The focus group sessions also investigated the academic reading task requirements for physical textbooks. The students were asked about the supporting activities they used to assist in engagement and comprehension while reading in physical textbooks. Design students described various supporting activities such as highlighting, keyword searching for additional information, and summarizing the important points into lists. Students reported taking notes in the margins of the text if it was their own book and would chose to use a separate piece of paper if it was a library book. They would eventually attach these notes to the corresponding text through post-its or another nonpermanent way. The majority of design students reported that their annotation style was visual in nature and often consisted of timelines or sketches. When keyword searching for concepts, students reported that they used Google rather than other sources. Likewise, engineering students described supporting tasks such as highlighting, looking over materials from class, looking up definitions, taking notes in the margins of the text, and underlining. Additionally, engineering students often completed their discipline specific practice exercises.

5.4.2.3 Ergonomics Issues and Other Considerations

In addition, some ergonomics issues and other considerations were reported by students as influencing their usage of physical textbooks. Both disciplines reported that physical textbooks are very difficult to physically hold and carry with them. Another recurring topic was the high cost of physical textbooks in comparison to electronic textbooks. However, students perceived physical textbooks as more convenient in which to take notes. They also stressed that it supported the visual style of notetaking that they required (see Figure 5.1). They reported that this style of notetaking aided in recall and comprehension of the material. Additionally, students reported the perception of more focused reading with a physical textbook due to easily avoiding the distractions that electronic devices inherently afford, such as the Internet. Students also reported feeling accomplished when they finished reading from a physical page.

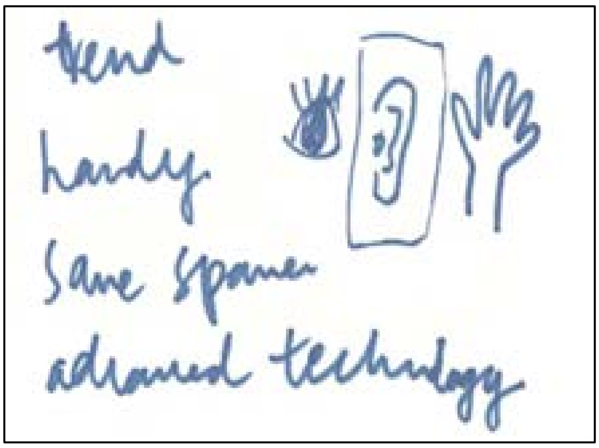


Figure 5.1. Example of visual notes that a design student made.

5.4.3 Electronic Textbooks

5.4.3.1 Definition

Before being presented with questions that mirrored those asked regarding physical textbook reading, each focus group completed a preplanned activity in where they were asked to define the term “electronic textbook.” The following are how each design student focus group defined electronic textbooks.

An “electronic textbook” is:

1. “A digital content that allows easy access by different media and can be easily modified and shared.”
2. “A gadget that allows us to learn wherever we are.”
3. “A portable smart device, which is eco-friendly and able to store varied books with Internet support.”
4. “A tool for learning without physical barriers. It contains lots of text, with additional elements including pictures, audio, and video.”
5. “Allows a user to read through electronic devices (examples: computer, tablet, & phone), which provides more interactions and information by images, notes, which is more interesting, attractive, and convenient than traditional printed textbooks.”

There is a variance in the definitions presented above, yet they provide insights into the perceived important aspects. Emphasis was placed on mobility and the diversity of devices in which the text could be read. At the definition stage, descriptions of various components of the electronic textbooks were limited, with definitions simply describing them as text or books.

Still, a few components of current electronic textbooks were highlighted by design students as important. Some of these were animations, dictionaries, images, infographics, text, and videos. The most vital of which was considered to be text. Students believed that the absence of text would signify the loss of the purpose of a textbook. Additionally, design students emphasized various ways that electronic textbooks have already enhanced their learning experience. They reported that electronic textbooks increased the interaction between the reader and text, increased mobility, and facilitating communication.

The following are how each engineering student focus group defined electronic textbooks.

An "electronic textbook" is:

1. "A non-physical reading material, displayed by electronic devices. The reading experience depends on the user interface of the software."
2. "A portable device, which includes all notes or text, video, and pictures into one appliance. It is cheap, environmentally friendly, and convenient when comparing to the physical textbook."
3. "A softcopy that provides us useful content academically."
4. "A textbook in a soft copy version. It's the same as a physical textbook."
5. "A textbook, which does not print out on paper physically, but can be viewed and edited via electronic device like computer, phone, tablet. It has basic

features as physical textbook and advanced features such as video, audio, tests, and animation."

Similar to design student focus groups, the definitions supplied by engineering students differed between groups. Yet once again, parallels between definitions emerged. The groups perceived electronic textbooks as being quite similar to physical textbooks. Nevertheless, many groups included advanced features not found in the physical counterparts in their definitions.

Value was placed on several affordances specific to the technology electronic textbooks employ, such as additional components like animations, images, and video that assist in the facilitation of learning the material and the ability to search for keywords. The students also reported that the primary purpose of electronic textbooks was specifically to facilitate the revision of concepts taught in the classroom.

5.4.3.2 Student Behaviors

The questions asked in the current electronic textbooks segments primarily dealt with student habits and behaviors during electronic academic reading. Design students reported that their frequency of use of electronic textbooks was significantly less than physical textbook reading. The few reports of higher usage of an electronic textbook by students were later clarified to state that they were printouts of the electronic text when the readings were longer than a few pages. While students reported more flexibility, electronic textbook readings were most often completed at a classroom desk whilst the lecture was conducted. Students reported that this supported their understanding of the concepts being taught. Time spent with electronic textbooks rose during projects as students reported requiring access to them the entire day. Students most often reported that electronic textbooks were accessed on laptops unless they owned a tablet. Phones were considered a last resort for if the reading was short and it was necessary to complete the reading that way. It was only then that they felt the convenience offset the dizziness and other discomfort they felt. The preference for a larger screen was also due to the reported benefits of saving full chapters or pages, the increased storage space available, and the avoidance of eye fatigue. Engineering students reported spending around half of their time with traditional electronic texts. They reported using the electronic medium in the afternoons and evenings while at home or when traveling due to the convenience of this type of textbook. Similar to design students, engineering students most often reported that electronic textbooks were accessed on laptops unless they owned a tablet. Once again, phones were a last resort only for immediate revision or while traveling.

5.4.3.3 Task Requirements

The focus group sessions also investigated the academic reading task requirements for electronic textbooks. The students were asked about the supporting activities they used with current electronic textbooks to assist in the engagement and comprehension. Design students described various supporting activities such as highlighting functions, annotation functions or Microsoft Word to take notes, and listening to music to aid in concentration. Students reported that they found themselves taking fewer notes when working with electronic textbooks. This was due to the issues students found while trying to work with the annotation components and the inability for these components to fully support their visual note style. The supporting tasks that engineering students described differed from design students.

Students often used dictionary, highlighting, encyclopedia, search, and screen capture components. Similarly, engineering students reported a change in their notetaking behavior. Some students reported not taking any notes when using electronic textbooks. If they did take notes, they would do so on paper or in a Word document. After doing so, they would not refer back to the text when revising.

5.4.3.4 Ergonomics Issues and Other Considerations

Students reported some ergonomics issues and other considerations as influencing their usage of current electronic textbooks, even though they were not explicitly asked. Both disciplines reported eye fatigue. They attempted to combat this issue by only using electronic devices for shorter readings. The following statement given by a participant sums up the general consensus of both groups of students:

> *"If I need to read a long article, for example 20 pages, I would print it out instead of looking at the monitor. But if I only read for just one or two pages, I then will just read it on the monitor."*

Students stated that the eye fatigue from long readings would cause dizziness or problems reading the text. If students could not avoid a longer reading on an electronic device they reported skimming the material or focusing on only the main concept they needed to learn and disregarding the rest of the text. Design students also reported that they felt the addition of many components to electronic textbooks could possibly limit their creative potential and would prefer to continue printing long texts. Similarly, engineering students printed long text, but they highlighted that electronic textbooks allowed for mobility and were lighter to carry.

Other aspects influenced the use of electronic textbooks, especially technical issues. The current battery life of mobile devices were considered inappropriate for academic reading by design students. Additionally, scrolling through long blocks of text and small font sizes were reported as making reading difficult. While true, both groups felt that the facilitation of communication and ease of accessing electronic textbooks was beneficial. Students reported accessing electronic textbooks was easier and took less time than going to the library. Finally, students felt that moving between texts was facilitated by electronic textbooks and was beneficial to their ultimate academic reading goals.

Students also felt that finding new resources was much easier due to the ease of keyword searching. When students identified a concept that was necessary for them to learn, they would be able to quickly go to Google or the library catalogue and find more resources. Although, overall students disliked reading electronic textbooks on small mobile devices, they did feel that it helped them to manage their time better. They reported being able to continue required readings if they could not sleep, were stuck in traffic, or if friends were late with ease due to their phones. And while students often took less notes with electronic textbooks, they felt confident that they would not lose the notes they took which was considered a possibility in the physical form. Many students stated they stored some of their physical notes electronically because of the risk of losing them. This was often done by taking pictures of the handwritten notes or loose pages of textbooks so that they could be accessed quickly later. Students also considered the low cost of electronic textbooks, environmental friendly nature, and afforded mobility as desirable.

While there were several benefits to using electronic textbooks, students also described many technological issues. Students felt they were less engaged with the material when they were typing notes over hand writing them. This led them to believe they would have trouble recalling and comprehending the concepts. While engineering students reported applications that supported the ability to naturally input notes or draw, they deemed these currently unusable due to their speed and technical bugs. Both groups of students also felt that keyword searching was troublesome. While it saved time, students reported being afraid they were missing information that was necessary to truly understand the concepts. They worried that this put them at a disadvantage over their peers using the physical versions of the text. The final issue that students reported with electronic textbook reading was related to the devices they were accessing the text on. This issue was distractions. Some of the distractions students reported were notifications from messaging applications and social media, online games, and YouTube.

5.4.4 Future Electronic Textbooks

5.4.4.1 Necessities of Future Electronic Textbooks

The final segment of the focus groups investigated future electronic textbooks. Design students felt that if future electronic textbooks were less static and more interactive, it would increase the likelihood that they would use them. These students reported several components as desirable for future electronic textbooks such as images that could be manipulated, better selection and highlighting of text, accurate text to speech functionality, and bookmarks that could be placed on a word or sentence rather than a page. They also desired text displays that used e-ink technology or had the ability to adjust text contrast based on the individual's preference so as to reduce eye fatigue. Similarly, engineering students felt that interactive electronic textbooks were desirable and that they would assist in learning the material, make them more efficient students, and speed up the learning process. These students felt that less text and more complimentary content such as 3-D or manipulatable pictures would facilitate the learning of the material. Both engineering students and design students felt that shorter blocks of text would improve electronic textbooks. Many felt that summaries of the main concepts with complimentary materials would be enough to meet their academic goals. Both groups of students wished for projections or holographic images that they could interact with. They felt that the material could be more detailed and interesting if presented that way. In addition, they highlighted that annotation components needed to be improved and that natural input would be preferable. They felt that hand writing in the electronic text with a finger or stylus would be ideal. While they wished for these things, they feel that current commercial technology could not support the necessary components.

5.4.4.2 Validation of Survey Results

Additionally, students were asked to validate the top five desirable components from the survey described in Chapter 4. Overall, design students felt that the components presented were suitable for their future electronic textbooks (see Table 5.1). Although they agreed with the components, they felt that text was ranked too low as they deemed it vital to their learning process. Through discussion, they generally felt that the ranking may have been influenced because of the diversity of their readings, many of which design students find unimportant. They also felt that the rank of multimedia was logical due to the design discipline but felt that text was still vital and should not be subverted by multimedia.

Design students also validated the bottom five undesirable components described in Chapter 4 (see Table 5.2). Design students struggled with the idea of speech to text being undesirable before ultimately deciding that the potential benefits were not actually appropriate for notetaking. Instead, they felt that notetaking required more engagement than the component afforded. Out of the five design focus groups, one questioned link to experts as being undesirable. This group believed that the component could be useful since they had limited contact with their course tutors. Whereas the other groups felt this component was unnecessary.

Rank	Design Students	Engineering Students
1	Multimedia	Text
2	Bookmarks	Highlighting Tool
3	Highlighting	Multimedia
4	Text	Bookmarks
5	Translation, Dictionary, & Encyclopedia	Annotation

Table 5.1. Components desired by students.

On the other hand, engineering students felt that importance of text had been overestimated by survey respondents and that other complimentary components had been underestimated. Overall, they felt that the responses given in the survey should be the core of electronic textbooks and were similar to the conventions already in use. The students felt that the responses were given because they were familiar to students and easy to envision. Overall, they believed that both the desired components and undesired components described in Chapter 4 were valid. They expressed agreement with the undesirable component of time management systems, as they believed it would make the reading experience more stressful than it already was.

Rank	**Design Students**	**Engineering Students**
1	Hide Unimportant Aspects	Hide Unimportant Aspects
2	Speech to Text	Time Management System
3	Time Management System	Speech to Text
4	Link to Experts	Text to Speech
5	Text to Speech	Project or Print Annotations

Table 5.2. Components undesired by students

5.4.4.3 Future Discipline Specific Textbooks

Finally, students were asked to complete the final activity. During this activity, they were asked to outline their perception of their discipline's perfect electronic textbook. Students were asked to think outside of the current constraints of technology, so some of the components students requested are not feasible at this time. Design focus groups created artifacts that had a more visual nature by providing sketches (see Figure 5.2), while engineering students expressed their textbooks in list form (see Figure 5.3). Design students kept notes regarding the detailed features and functionality around the sketches or provided sketches to support the notes. The interface of future electronic textbooks had the ability to add their own content, such as notes or photos, in line and took inspiration from applications like Illustrator. Additionally, students requested short blocks of text that emphasized the important concepts. They also wished for things such as manipulatable images, adjustable text size and line spacing, audio, bookmarks, dictionaries, encyclopedias, synchronization across devices, table of contents, translation components, and video. While they felt that highlighting and annotations were not as important to this type of textbook, they were still vital and should be included. Students felt that these two components could not be as rigid as they had been in the past. Highlighting components needed to allow free form entry and annotation tools needed a more naturalistic input method. Once again, students emphasized that typing notes was not appropriate for learning and engaging with the material and felt that hand writing was more suitable. This type of input would allow for timelines, graphs, pictures, and lists to be created by the students. They felt that this would improve their ability to comprehend and recall the material. Students also included the hide unimportant aspects automatically to offset any the shortened blocks of text. They felt that supplemental text may be beneficial to read if the concept was deemed important and could easily be implemented with this component. Overall, both groups had many similar components in their future electronic textbooks with only a few differences in the engineering future electronic textbooks. Engineering students felt that their textbooks required less text, but necessitated discipline specific components such as interactive equations.

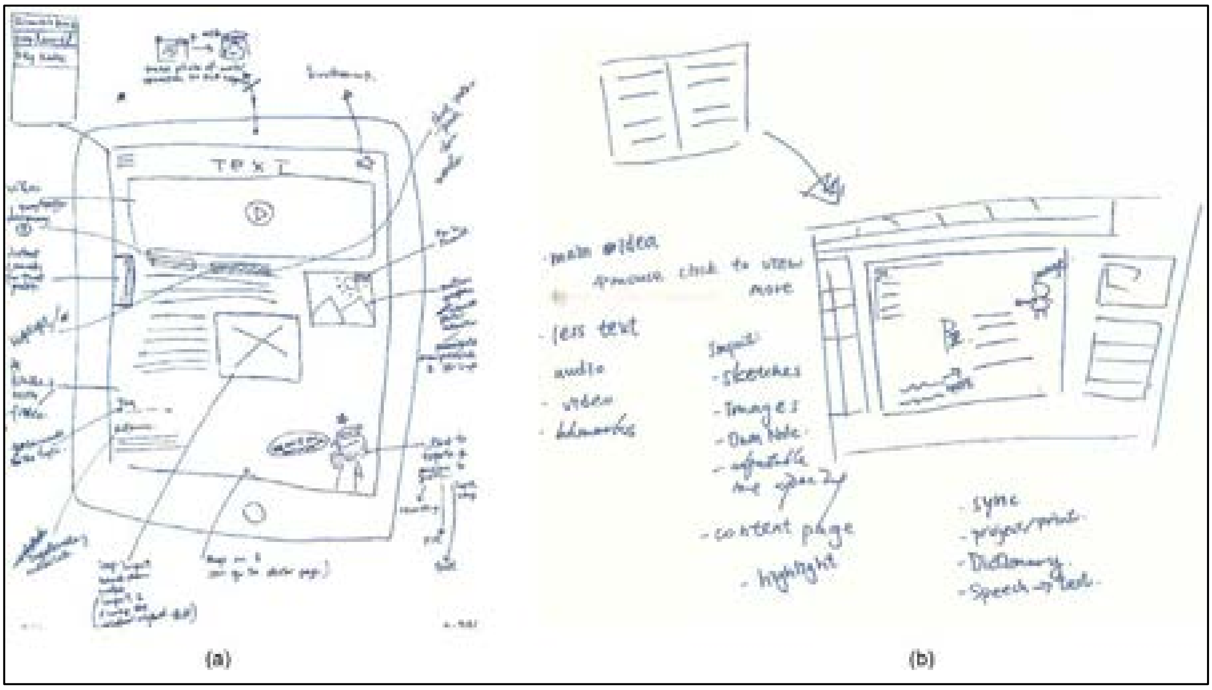


Figure 5.2. Two examples of the future electronic textbook by design students.

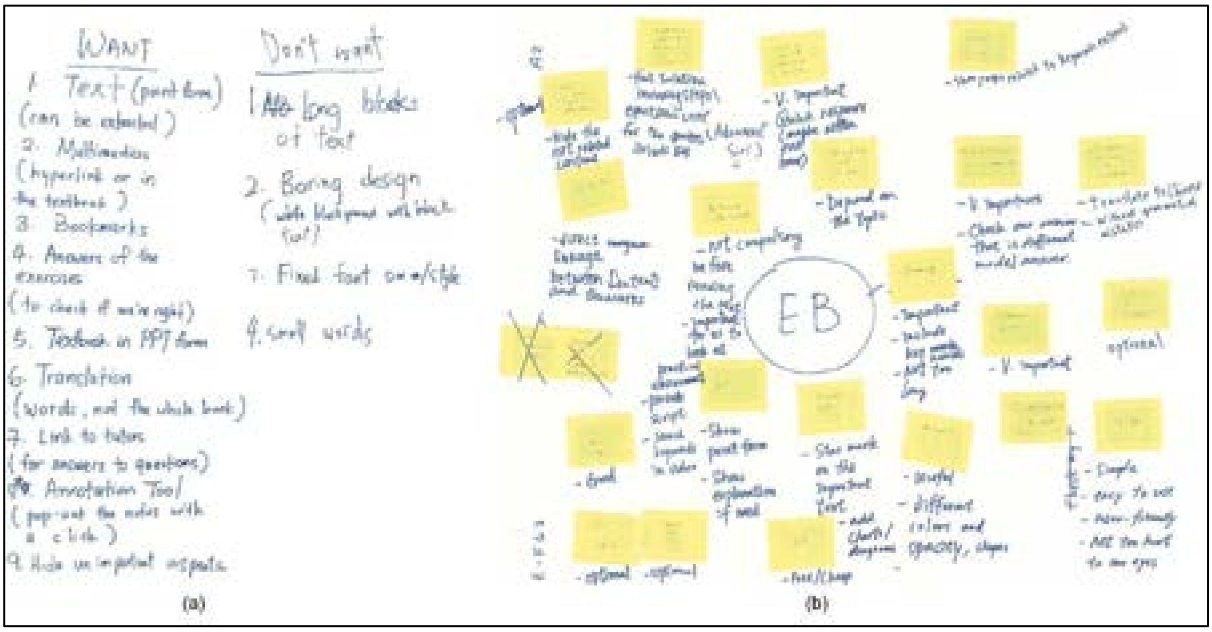


Figure 5.3. Two examples of the future electronic textbook by engineering students.

5.5 Discussion

5.5.1 Student Usage

All aspects of the use of both mediums of textbooks differed by discipline. Nonetheless, both groups believed that the electronic textbooks currently available to them were unable to meet their academic reading task requirements as well as physical textbooks could. They reported using electronic textbooks only because of faculty requirements, peer pressure, or extenuating circumstances. This finding is similar to past research that found faculty encouragement of electronic textbook use increases student usage (Miller et al., 2013). While these focus groups did find that mobility changes when and where students study, this perceived convenience did not outweigh the limitations of the medium that students reported. This finding is supported by past research that also found that mobility and ease of access did not diminish the student preference of physical textbooks (Denoyelles et al., 2015).

Similar to past research which found that stationary computer users were more likely to have prior experience reading electronic textbooks (Miller et al., 2013), the focus groups found that students were frequently accessing electronic textbooks on larger technology rather than more mobile devices. Other findings from the focus group sessions were echoed in past literature, such as the preference for short blocks of text while reading electronic texts (Kropman et al., 2004) and the reported nostalgic feelings when working with physical textbooks (Massis, 2010), which students in the focus group reported making them feel reluctant to adopt electronic textbooks. Almost all of the participants in the focus groups would print out long readings over reading them from a screen. Even when printing functionality was not built into the electronic textbook or not allowed, students reported finding a work around so they could still print. Some work arounds that students reported were taking screeenshots of the text and later printing those images and searching for copies of the textbooks that did not have Digital Rights Management (DRM) restrictions. The printed pages allowed for the continued experience of the four affordances of printed materials: spatial flexibility, manipulability, tangibility, and tailorability (Sellen & Harper, 2003). It was these affordances that students perceived as triggering their feelings of nostalgia.

The supporting activities students reported for physical readings changed when moving to electronic. Similar to past findings, students reported frustration with annotation tools, bookmarking, and highlighting components (O'Hara & Sellen, 1997). Both groups reported taking fewer notes or even going so far as to no longer using any supporting tasks. Students felt that hand writing notes was easier and facilitated their learning of the material by helping them engage with the concepts and view their notes in context of the text while revising. Students who took notes in an electronic form, preferred Microsoft Word so that they could incorporate outside material with their notes on the important concepts. Some of this outside material reported was links to other material, paragraphs from other sources, and pictures. If students utilized these electronic notes, they reported only revising their notes without going back to the original text.

While the change in supporting activities is severe, the addition of distractions inherent to digital devices was reported by students as serious. Students emphasized that certain aspects in digital devices such as search functions, which are often used to support electronic textbooks, adds a dangerous temptation to leave the academic material or at best simply increases the time it takes to complete the reading. Past research has acknowledged that these interruptions of deep reading will negatively impact the comprehension of the material (Aamodt, 2016).

5.5.2 Future Textbooks

Overall, the components students desired for their discipline specific electronic textbooks were similar, despite some key differences. Both groups of students felt that the amount of text in these future textbooks should be in bullet point form for short paragraphs. They still wished for additional information to be available to them but hidden by default. Both groups also believed that interactive textbooks would assist in engagement and learning of the material. These student design recommendations are attempting to rectify a shift in reading style that past scholars and the students in these focus groups both identified. Scholars have asserted that electronic textbooks have encouraged students to be less engaged with the material and read in a style termed surface reading rather than deep reading (Phillips & Phillips, 2007; Bowden & Marton, 2003), which is necessary for academic success. Surface reading is that which only provides the student with a superficial understanding of the subject based on anticipated questions while the deep approach allows students to relate that material to their current knowledge (Bowden & Marton, 2003). While recommended changes may assist in creating electronic textbooks that facilitate deep reading, potential future interaction and the recommended changes may be influenced by current ideas of electronic textbooks. Additionally, the enthusiasm students currently feel for future components may decrease over time when actually used; however past research has shown that this decrease in enthusiasm should not influence the component's effectiveness (Bode et al., 2014).

Reading quality has been shown to be positively associated with the student preference for shorter blocks of text (Chong et al., 2009), thus, it can be recommended that content designers use shorter blocks of text to convey information with extended supporting text hidden. The potential impact of shortening the initial view of the text can be diminished by including complimentary components such as multimedia or 3-D and manipulatable images. Although shortening the blocks of text may allow for easier digestion of materials, the common supporting tasks of highlighting and notetaking need to be improved. Students commonly requested that annotation tools allow for a natural input. This input method has been executed in a few applications, such as Evernote (see Figure 5.4), but it is still reported as difficult to use and is not available in many of the common applications which provide academic texts. Findings from the focus groups show that user friendly, well designed and advanced versions of annotation components would be welcomed by students and assist in easing the reluctance students feel regarding using electronic textbooks. Some students believed they would feel most comfortable using a stylus to take notes, a method reminiscent of pencil and paper. Yet, additional complications may arise from this tool compared to only allowing input with a finger. For example, a misplaced stylus could cause anxiety when notes need to be taken and replacement styluses would be an additional cost or students may feel the same reluctance to take notes while traveling which is present with physical textbooks.

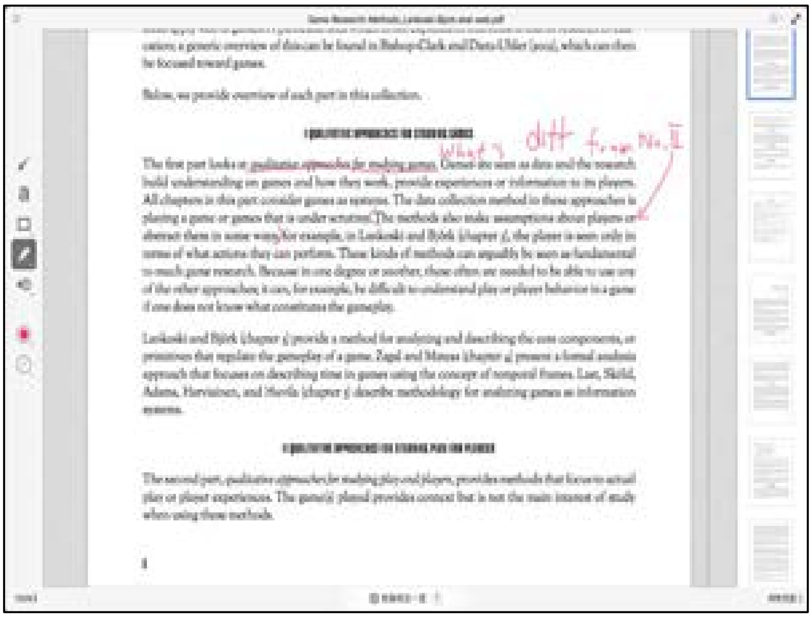


Figure 5.4. Example of notes taken in an electronic text in Evernote.

5.5.3 Comparison of Disciplines

Overall, both disciplines of students had similar perceptions of which components were important for future electronic textbooks and how interfaces of these textbooks should be designed, yet fundamental differences were still apparent. One of the major differences became apparent through the second activity. This activity showed that while the disciplines had similar requirements, student mindsets and their interaction with others and academic materials differ. Design students were more comfortable using visual representations for their future electronic textbooks and worked as a group to create the final artifact. Each student added to the design of the textbook throughout the process. This may be attributed to the fact that design projects are often conducted in a group, especially in the School of Design. Conversely, engineering students felt more comfortable presenting their electronic textbook requirements in a list form. Instead of working together throughout the process, as design students had, they created individual lists and then attempted to unify their views through discussions. Additionally, only one student created the final list unless the other students felt they did not fully agree with a component another student felt strongly about, in which case they would change designated writers. This may be due to the nature of engineering projects, which are often solitary during the early stages.

Specific discipline requirements become clear when analyzing the differences in the details of the components students desired. Both groups reported that they desired the ability to insert photos as a form of notes either within the text or hidden with clear icons to mark the location of the photo and desired shorter bocks of text in bullet form. While both groups ultimately requested a natural input annotation tool, engineering students felt that notes were not necessarily needed in their new textbook. When questioned about their initial reluctance, engineering students reported that bullet points almost completely eliminated the need to take notes but ultimately they felt that the component still had value if used in other ways. Yet, design students did not feel the same hesitancy and felt the ability to continue taking notes was vital. This is indicative of the underlying requirement founded in the creative and interdisciplinary nature of the design process. Unlike design students, engineering students felt that interactive equations were vital to their future electronic textbooks. This is consistent with the discipline requirements, as practice equations are regularly a part of assignments.

Components in future electronic textbooks need to change based on the discipline specific requirements of the content. These components need to need to adapt and support the material students are required to learn. In the past, it has been requested that future textbooks become more coherent and content is tailored based on the reader group utilizing them (Hartley, 1990). This idea needs to be extended to electronic textbook components. Hartley recommended that “changing the way we write textbooks is one way in which we can make a major improvement in the quality of instruction” and suggested that electronic textbooks could support this by offering different examples to different reader groups (op. cit.). The idea has long been accepted in content design, but should also be extended to the technical design of electronic textbooks. Educators have started calling for these changes by requesting interactive digital textbooks, which merge various types of content such as text and multimedia (Miners & Freedman, 2009). This call is clearly echoed in the findings of the focus group sessions.

5.6 Summary

Students who participated in the focus group sessions believed their learning and engagement with material would be facilitated by future electronic textbooks that are more interactive. Design and engineering students believed that improved annotation components, content specific multimedia, and 3-D and manipulatable images would be beneficial to their learning experience. Both groups believed the annotation components needed improvement, as they did not currently support their needs. Students also wished for components that are currently outside of current technological capabilities, such as holographic and manipulatable images. Although there were many similarities in components, comparison showed differences in the fundamental characteristics of the disciplines. These differences need to be supported in future electronic textbook design.

Some general design criteria for future electronic textbooks can be identified from these focus groups. Future textbooks need to include less text, become more discipline specific, and become more interactive. Additionally, discipline specific components are vital to the adoption of electronic textbooks and student success. For example, engineering textbooks need to include interactive equation components so as to better support student's learning and engagement. Investigation on how both mediums of current electronic textbooks are used and how that differs allows for a deeper understanding on design recommendation and potential issues that may arise from design changes. For example, understanding the effects of long passages of text on students assists in acknowledging the need for shortening blocks of text. In addition, understanding the influence of nostalgia allows for opportunities to integrate aspects reminiscent of the four affordances, such as the ability to see notes on the page instead of hidden within an icon, which can potentially positively influence future electronic textbooks adoption. Furthermore, the comparative nature of the investigation outlined in this chapter allowed students to think about present technical and ergonomic issues that may not have been identified without comparing perceptions of the two mediums. This information can then be used in future designs to avoid some of these issues.

Applications for these design recommendation are vast, ranging from academia to industry, but more research was required after this study. First, verification of the reported interactions with current electronic textbooks needed to be undertaken and then acceptance of changes students recommend needed to be verified. The verification of electronic textbook interaction was done through an experiment outlined in Chapter 7. Moreover, the verification of acceptance was done with the

TAM evaluation of the two prototypes described in Chapter 8. In addition, the perceptions of educators also required investigation to fully comprehend the use of electronic textbooks as an aid teaching material. The perspective of educators is more diverse because of the individual teaching philosophies of teachers, thus necessitating a more individual investigation. This was completed through the interviews with professors described in the next chapter, Chapter 6.

Chapter 6. Study Three: Professor Perceptions of Electronic Textbooks and the Future

6.1 Overview of Chapter

Chapter 6 introduces the foil method to the focus groups, which was the interview that met objective 3 and research questions 2: Components based on task, 2A: Aspects and components necessary, and 2B: Student-professor discrepancies. Interviews were conducted with the other main stakeholder and user of electronic textbooks, professors. The professors who were interviewed were asked about their views on academic reading, electronic textbooks, and what they felt needed to be in electronic textbooks for students to succeed. The chapter begins with the justification for the use of the method. It then follows with the method and results. Following that, a discussion of the findings in the context of some past literature is presented. The chapter ends with a summary of the findings and their context within the larger research.

This chapter is a reproduction of the following publication:

Sheen, K.A., & Luximon, Y. (2016, July). Academic Professor Perception of the Future of Electronic Textbooks. In *Advances in Physical Ergonomics and Human Factors* (pp. 165-173). Orlando, FL: Springer International Publishing.

6.2 Justifications

In order to fully address the future of electronic textbooks, another stakeholder needed to be investigated. This stakeholder is the professors who choose and use electronic textbooks in their classrooms. While professor perception of electronic textbooks has been reported by previous literature, similarly to student perception, it was primarily obtained during or after experimental classroom usage studies. The data gathered did not tend to be focused on the professor's perceptions of how current electronic textbooks fit into their teaching methods, how they believe students should interact with electronic textbooks, and what they perceive as necessary in the future for their students so that the academic reading requirements may be fully met.

This chapter fills this gap by investigating the professional perceptions of professors on the subject of electronic textbooks and their opinions on necessary components for future electronic textbooks. Interviews hold many of the same advantages and disadvantages outlined in Chapter 5 Section 5.2. These interviews were semi-structured (see Appendix C). The semi-structured form was chosen so that interesting answers could be followed up as necessary (Yin, 2009). The questions were piloted for clarity by three professors at the university.

Professors were chosen from fulltime staff at The Hong Kong Polytechnic University, from both the School of Design and Faculty of Engineering. Understanding the diversity in approaches to and understanding of electronic textbooks held by the different disciplines and professors beliefs of what is necessary for inclusion in future electronic textbooks to fully meet discipline specific needs is beneficial to creating electronic textbooks which are suitable for the corresponding discipline. Thus, assisting in fighting the one size fits all mentality of publishers. Additionally, findings may aid in emphasizing potential mismatches between the professor and student perceptions on electronic textbooks and the future.

6.3 Method

6.3.1 Participants

To obtain an understanding of professor views on current and future electronic textbooks, short semi-structured interviews were conducted. Professors from the design and engineering faculties were chosen for numerous reasons, such as their similarities yet differences in mentalities, which have been outlined in the previous chapters. For example, creativity is valued over working within predesigned protocols within the field of design, whereas working within constraints and being practical are desired within the engineering field. This is especially noticeable in both disciplines' views on product creation. In the design discipline, products tend to be created with a user-centered approach and a focus on aesthetics, while product creation tends to focus on technicalities and practicalities in the engineering discipline. These mentalities are especially present in education.

6.3.2 Procedure

The interview sessions contained six semi-structured questions but allowed for unscripted probing questions based on responses (Singleton & Straits, 2005). Educators were asked about their teaching experience, perceptions of electronic textbooks based on their personal teaching philosophies, perception of their student's engagement and use of electronic textbooks, perceptions of how physical and electronic textbooks differed, views on the student responses surrounding electronic textbook components from Chapter 4, and what components they as educators believed should be included in electronic textbooks. These short interviews lasted less than 15 minutes. Interview questions can be found in Appendix C.

6.3.3 Analysis Techniques

The qualitative data gathered from the interviews were coded to find trends in the same way that was outlined previously in Chapter 5 Section 5.3.3. Where analysis was conducted with the aims, objectives, and research questions at the core but careful consideration was employed so that unexpected findings were not disregarded as insignificant. Each interview was analyzed immediately after it was transcribed and coding was conducted through iterative reflection. This was to ensure that a theory was able to emerge from the data based on the code's sensitivity to the larger context. These codes used were pattern, interpretive, or descriptive depending on the nature of the data. Based on Strauss' (1987) philosophy the codes were founded on conditions, consequences, interactions, and strategies and grounded in the data (Glaser & Strauss, 2009). For easier analysis, the data was organized into recurrent topics and subtopics, descriptions, and theory development. Some examples of the codes emerging from the interviews were as follows: preference, habits, task requirements, educational requirements, and technical requirements.

6.4 Results

6.4.1 Participants

Participants were recruited from the academic faculty at The Hong Kong Polytechnic University. The requirement for participation was that the professors were from either the design or engineering discipline and taught undergraduate courses. Ultimately a total of eight professors were interviewed, four from engineering and four from design. University level teaching experience ranged from four years to 22 years with a median of 15.5 years for design professors and between two and 20 years with a median of 12 years' experience for engineering professors. Professors from both disciplines were predominantly Asian.

6.4.2 Professional Views on Electronic Textbooks

Professors were initially requested to state if and in what capacity electronic textbooks were used in their classrooms. Generally, design professors reported assigning electronic textbooks as student readings and directed students to locate the books themselves via the library website. Professors had many reasons why they chose electronic readings over physical readings, such as the ease of linking from Blackboard, the assurance that enough copies would be available for students, and the ease of assigning last minute readings. While they reported many benefits, they felt that electronic textbooks did not always meet the needs of the students or their own needs. Professors felt the courses that taught typography or required many pictures necessitated a physical textbook so that quality was ensured. Professors also reported that they believed their students often chose tutorials on YouTube over written tutorials in textbooks. This differed with engineering professors. While design professors mostly assigned electronic readings, engineering professors often assigned both and did not encourage the use of one over the other in students. Yet, these professors believed that the majority of their students used mostly electronic textbooks because of cost, ease of access, and the familiarity their students had with reading on screens. Professors who assigned electronic readings tended to do so as they felt that physical textbooks are archaic and it was easier to integrate the content into their lectures. A total of two of the eight professors interviewed, one from design and one from engineering, reported rarely assigning electronic readings but actively encouraging their use as a reference material, even supplying specific page numbers and passages they felt students should read.

After this, professors were asked how they assumed their students interacted with electronic textbooks. Generally, design professors assumed their students read the assigned material, but were unaware of specific habits or interactions and did not encourage any specific reading techniques. Professors were split on whether they believed there was a difference in student engagement with the material. Some believed there was no difference between physical and electronic reading while other felt that electronic textbooks caused their students to read less deeply and worried this would impact student success. In addition, professors suspected unethical behavior in students because of electronic textbook usage. They believed that students were illegally downloading books and plagiarizing these texts in their assignments. While design professors thought their students read, engineering professors believed their students read the material only when absolutely necessary Overall, engineering professors felt that student interaction did not truly differ between textbook mediums, but also worried that the change in medium may mean their students were not reading as deeply.

Following this, professors' views were then elicited on differences between electronic and physical textbooks. Professors from the design discipline felt that electronic textbooks carried additional benefits. These benefits were the ease of access and mobility afforded by electronic textbooks, ability to zoom in on material, ability to search the material, the efficiency when reading at night, the minimal aesthetic, and the low cost. While they believed there were benefits, they felt that it was easier for students to accidentally plagiarize another person's work. Additionally, design professors felt that physical textbooks still provided benefits not available with electronic texts, although they felt these advantages were slowly fading. When students used the physical library, professors felt they could find other resources easily due to the categorical organization of the bookshelves. Professors also reported that there is a sense of urgency attached to library books because of due dates. Engineering professors had a similar view of the situation. Yet, the believed that new types of electronic textbooks also had benefits such as videos. They also felt that generally electronic textbooks had better formatting, allowed for more books to be carried at once, allowed for faster searching of the material and were more reader friendly.

6.4.3 View on Future Electronic Textbooks

The final questions professors were asked were regarding their views on future electronic textbooks. Professors were asked to provide their views on the components students felt should (see Table 6.1) and should not (see Table 6.2) be included in future electronic textbooks from the survey discussed in Chapter 4. Overall, both groups of professors found the students' choices understandable. And while they recognized that some of these components existed, they believed that the components were not yet optimized but were similar to current student interactions. Professors were excited for videos that supported the concept comprehension, although one professor from design was hesitant about the inclusion as he believed it may be used by students to hide poor literacy skills or learning disabilities and a professor from engineering felt that videos worked best in lectures.

Rank	Design Students Components	Engineering Students Components
1	Multimedia	Text
2	Bookmarks	Highlighting Tool
3	Highlighting Tools	Multimedia
4	Text	Bookmarks
5	Translation, Dictionary, & Encyclopedia	Translation, Dictionary, & Encyclopedia

Table 6.1. The top five desired components by design and engineering students.

When presented with the top undesirable components, both groups of professors once again generally agreed that the views were understandable and valid. One design professor believed that while the components were not necessarily vital there could still be some value. A different design professor felt that these components reported as undesirable may be cultural or related to a poor grasp of the English language. While engineering professors generally agreed with the undesirable components, they felt that 3-D and manipulatable images was inappropriately listed and should be included in future engineering electronic textbooks. Professors believed that these could facilitate concept comprehension especially when studying proteins or circuit boards.

Rank	Design Students Components	Engineering Students Components
1	Hide Unimportant Aspects of Books	Hide Unimportant Aspects of Books
2	Speech to Text	Time Management System
3	Time Management System	Speech to Text
4	Link to Experts to Answer Questions	Text to Speech
5	Text to Speech	3D and Manipulatable Images

Table 6.2. The top five undesired components by design and engineering students.

Finally, professors were given the opportunity to describe components they envisioned in future electronic textbooks. Design professors described an advanced cross-referenced and sharable tagging system. They believed this would help organize materials and allow for more critical and diverse opinions on concepts to be found by students. They also wanted direct links from bibliographies to the referenced material, integrated touch menus, links to supplementary online media, and the inclusion of better encyclopedias. Professors from engineering emphasized the student choices but wished for some additional components. The professors wanted links to contact the authors of books, so they could easily supply feedback for future editions of the text and so that students could ask questions. Professors also felt the need for PowerPoints they could use in their lectures in teacher editions, 3-D and manipulatable images, and the inclusion of virtual reality. They felt that virtual reality could aid in a student's engagement with the material and understanding of abstract concepts. Engineering professors also felt that annotation should have a natural input similar to that, which is afforded by physical textbooks.

6.5 Discussion

The use of electronic textbooks in a classroom changes drastically based on the instructor (Giacomini et al., 2013), this was also found through the professor interviews. Comparable to past research, these interviews found that professors feel that students do not read or do not read deeply. Professors are incorporating textbooks less during lessons and course creation, which actually causes students to believe that textbooks are not relevant (McFall, 2005). Recently, some professors have chosen to decline assigning textbooks as they feel students do not read (Johnson, 2011). Yet, other studies and findings from the focus group in Chapter 5 found that students do read the assigned books but not at the expected time (Clump et al., 2004). Still, even when a textbook is assigned, students tend to read less than the instructor believes is ideal (Giacomini et al., 2013). The interview sessions outlined in this chapter echoed many of the same concerns about student reading that was found by past research, but the professors did not actively try to encourage reading strategies or reading in general in their students. While professors do not do this, past research has found that when professors encouraged electronic textbook component usage and active reading strategies, students used those components more (op. cit.). Thus, professors ought to encourage students to take advantage of the full potential of electronic textbooks, which should positively affect student academic success.

The cost of textbooks, ease of student access, and the ability to assign last minute readings were some of the influencing factors on professor use of electronic textbooks, some of which has been found by previous research (Hilton & Laman, 2012). While the professors interviewed hoped students were using the library website, they were aware that some students were illegally downloading the books.

When this was reported in the past, similarly professors were not particularly focused on the illegal aspect (Bossaller & Kammer, 2014). And although there are benefits, the professors interviewed found that electronic textbooks are not appropriate for all courses and reported assigning a physical textbook if it was necessary for comprehension, a common action among professors (Killingsworth & Marlow, 2010).

Overall, both students and professors have similar beliefs regarding future electronic textbooks tailored for their disciplines. Like students, professors believed that the components students wanted in future electronic textbooks would aid in comprehension and engagement. While generally they felt the same as students, professors felt some of the components might mask poor literacy skills or learning disabilities that need to be addressed. In addition, engineering professors felt that 3-D and manipulatable images had a place in future electronic textbooks, something mirrored in the engineering focus groups. Similar professor perception of interactive figures was seen in past research, which was shown to be beneficial to students even after initial student enthusiasm diminished (Bode et al., 2014). Electronic textbooks also afford a simpler reporting of errors to publishers (Bossaller & Kammer, 2014), something which the interview findings mirrored. The ability to identify and quickly correct incorrect information and feedback on particular concepts which students find challenging is not only valuable to the industry, but also to educators and students.

Other components, such as tagging features, are perceived as beneficial components in future electronic textbooks not only due to the benefits to professors' individual research projects but also to the students. These students will be exposed to different views, more information on assigned concepts, and encouraged to read more deeply through engagement with the key concepts. While this component was discussed in the focus groups, it was not emphasized as it was by professors. This is possibly due to the lower level critical approach to research undergraduate students have. If professors had not be interviewed and provided insight on the benefits of this component, it may have been deemed less important than it actually is.

6.6 Summary

Findings from the interviews showed that professors do not necessarily believe that students are reading, but believe that electronic textbooks will be beneficial in the future. In general, both design and engineering professors' perceptions mirrored those of their students regarding future components necessary for the academic reading task. Professor views on the subject take into account the realities of the rigors of research more than the student views, thus they placed more emphasis on components that would help them explore concepts deeply such as tagging. The insights provided by professors can assist in creating guidelines which combat surface reading, which is one of the largest issues surrounding electronic textbooks, based on their experience and understanding of how students learn to comprehend complex concepts.

The findings outlined in this chapter assist in identifying areas of mismatch in student and professor mindsets, so that in the future electronic textbooks meet the needs of both user groups. The findings also assist in highlighting the requirement changes based on disciplines, which in turn assists in combatting the publisher's one size fits all mentality on textbook design. In addition, this data is valuable when used with the data collected in the Internet survey and focus groups described in Chapters 4 and 5. Still, student interaction with current electronic textbooks needs to be investigated. As the core of the research presented in this dissertation is focused on the academic reading task, an experiment with current electronic textbooks, including interaction with current supporting activity components, is necessary. This was conducted in Study 4 and is outlined in Chapter 7.

Chapter 7. Study Four: Current Reading Behavior Changes with Electronic Textbook Usage

7.1 Overview of Chapter

Chapter 7 introduces the final data gathering method, the experiment, which was an experiment conducted on current electronic textbooks to investigate changes in reading behavior, perceptions of aspects, and identify any changes in comprehension and recall when moving from the paper to the electronic medium. It also identified if there were any changes in comprehension or behavior when moving from the paper medium to an electronic medium of the same size, so as to ascertain whether the move to electronic textbooks would severely negatively affect students. This study met objective 4 and helped to inform research questions 1B: Student tasks and 2: Components based on task. This experiment used a current electronic textbook to identify how reading changes from the paper to electronic medium. The experiment used three different screen sizes, which were identified as commonly used within the university based on the focus groups. The experiment required the use of the two most common supporting tasks used at the university, highlighting and annotation. Interactions with these components were observed to identify changes and issues. The chapter begins with the justification for the use of the method. It then follows with the method and results. Following that, a discussion of the findings in the context of some past literature is presented. The chapter ends with a summary of the findings and their context within the larger research.

This chapter is a reproduction of the following publication and is waiting result for the journal *International Journal of Human-Computer Studies*:

Sheen, K. A., Luximon, Y., & Zhang, J. (2017, July). Reading Task Investigation of the Kindle app in Three Mediums. In *International Conference on Applied Human Factors and Ergonomics* (pp. 357-364). Los Angeles, CA: Springer International Publishing.

7.2 Justifications

Before designing the prototype and the TAM evaluation of it, it is vital to decide which size tablet is necessary to use during testing based on the cognitive ergonomics aspect of student performance and observe the changes in use of current electronic textbook components, such as highlighting and notetaking, from the paper equivalents. It is also important to gain more information on student preferences and issues they encounter after using an electronic textbook. These changes need to be done from an extremely structured and experimental standpoint.

This study evaluates a single electronic textbook on the Kindle app using three mobile devices, which are of the same operating system and commonly used by students and a paper control. The paper control was the same size and format as the largest mobile device so as to eliminate as many confounding factors as possible when looking at the difference between the move from physical to electronic mediums. Finally, two of the commonly used supporting activity components, highlighting and notetaking, were also investigated to identify any changes in the behavior of students when moving from paper to electronic and across sizes.

This study consists of two driving research questions. *Do the common screen sizes of mobile technology have an effect on student academic reading performance and behavior? and Do the in-application supporting components for highlighting and notetaking change the supporting activity of students?* Past research has given insights on the first question, but there is little information on important aspects of electronic textbooks such how supporting activities change. While the past research has attempted to answer these question, but it tended to be reliant on the technology at hand, was based on obscure measures of student performance, or allowed for too much personal control during the experiments, which may have skewed the data gathered.

7.3 Background

The findings of past research on display size and its effect on comprehension and recall are often contradictory. Some studies have asserted that the electronic presentation does not have a negative impact on comprehension and in some instances improves comprehension results (Connell et al., 2012; Bridgeman et al., 2003); however, various aspects of presentation, such as sentence splitting across pages, are likely to negatively influence comprehension because they overload working memory (Dillon, 1992). Working memory is limited; consequently, the complexity involved in a learning task increases the cognitive load on working memory, thereby impeding the acquisition of learning material (Sweller, 1994). Although past research has revealed minimal differences in student comprehension of material when changing mediums, changes in student behavior have been observed. Certain aspects of physical textbooks have been shown to be used more often, such as summaries and questions (Woody et al., 2010). Several studies have established that students spend more time with electronic textbooks (Connell et al., 2012; Daniel & Woody, 2013; Morineau et al., 2005); however, this was discounted in a separate study (Shepperd et al., 2008).

Academic achievement and working memory have a long established correlation (Yuan et al., 2006). Certain aspects of electronic texts, such as hypertext and typing notes, have been shown to increase cognitive load (DeStafano & LeFevre, 2007; Schilit et al., 1998). While some individual aspects of recall were hindered by electronic text (Morineau et al., 2005), past research has found that various types of e-readers do not affect learning (Weisberg, 2011). In fact, the different functions available through electronic textbooks, such as notetaking and built-in dictionaries, have been reported to be beneficial to students (Demski, 2011). Although, these in-app components do not provide the same allowance for a variation in meaning of highlights, underlines, and notetaking that paper does and reading may be disrupted in electronic texts (O'Hara & Sellen, 1997). Supporting activities are important to student success and an in-depth understanding of the material (Schilit et al., 1998; Kulhavy et al., 1975; Slotte & Lonka, 1999). The design of the in-app components for highlighting and notetaking is important since reading from screens often cause a change in behavior marked by less engagement with the material (Liu, 2005). Past research has found that highlighting and taking notes electronic has several issues such as the blending of electronic notes in with the text, something that is not inherent to physical texts (Schilit et al., 1998) and that electronic notetaking is completed after the reading was completed or with long periods of editing (O'Hara & Sellen, 1997).

On the basis of previous research, the following three hypotheses were developed for this study.

H1) *There will be no significant changes in time spent reading, comprehension and perception when moving from paper to electronic medium of the same size and format.*

H2) *Screen size will change the time spent reading, perception of the reading task, and reading task behavior due to increased sentence splitting.*

H3) *The usage and perception of the supporting tasks of highlighting and notetaking will change on electronic devices when compared to paper.*

7.4 Method

7.4.1 Participants

There were a total of three qualifying factors for participation in the experiment. First, the participant had to be a current student at the university. Students were chosen as experiment participants because of their familiarity with academic texts. Second, students were required to have normal or corrected vision. Finally, students were required to have a native language other than English and pass a reading pretest. Education level was not considered a qualifying factor for this experiment, as a student's reading level did not necessarily coincide with their education level. If a student performed too poorly on the pretest, they were disqualified from participating in the experiment. Passing results were categorized in three different classifications: Low, Medium, and High.

7.4.2 Experimental Design

The findings presented were discovered during a mixed factorial design experiment, which used four settings. The four settings were using different devices including mobile phone, mini-tablet, normal sized tablet, and a control group who used paper. The paper control was the same size as the normal iPad so as to identify if changes in task behavior were based on the change in medium without confounding factors such as layout and size.

Participants were separated into three different groups, which were balanced by the three pretest classifications. The pretest was based on SAT recall and comprehension readings questions. The SAT is an examination given to students preparing for study at universities in the United States. Therefore, it was deemed an appropriate reading level bench marker for current university students. Group A contained 31 students and completed the readings with the three different screen sizes and paper in the four conditions. Group B contained 31 students who completed the same process but were requested to use the built in highlighting function or to highlight directly on the paper. And the 30 students in Group C also completed the same process but were requested to use the annotation tool while using the devices and to take notes directly on paper when in the print condition.

Each session ranged from one hour to one and a half hours based on the individual’s time spent reading. Participants were paid for their time after their completion of the experiment. If a student did not successfully pass the pretest, they were thanked for their time, paid a nominal amount, and dismissed.

7.4.3 Variables

Each of the three mobile device conditions had several control variables: a set number of sentence splits, a set lines of sentences on a page, and a set number of words of one line based on the screen size. These variables were preset by experimenters and remained consistent throughout the entire experiment. In addition, eye height, viewing distance, and posture while reading were all preset with a fixed stand to control. The chapter students were asked to read was randomized. Participants read a different chapter on all three of the mobile device sizes and the paper.

There were two main independent variables in this study: screen size and medium and supporting activity. Three different devices with three different screen sizes were used: iPhone 6s, iPad Mini, and full sized iPad and a paper control which was the same size and layout as the iPad. In addition, students were placed in individual groups who took notes, highlighted, or did nothing while reading.

The dependent variables in which data was collected are identified as reading performance and subjective impression. Reading performance is defined in this experiment as the ability of the students to recall and comprehend information they have read, the number of times of paging backwards, and the time spent reading. Time spent reading was calculated by the number of words in the individual reading divided by the time the student spent on the reading. Students were told when they were allowed to read and the timer was stopped when students indicated that they were comfortable with the text. Paging and reading time were recorded with a video camera. Subjective impressions were defined in terms of this experiment as the impression of amount of text, screen size, ease of page turning, format of text, readability, and highlighting or notetaking if applicable. A post-test, similar to that used in Connell et al. (2012) was used to identify the participant's ability to recall and comprehend the text and a questionnaire used to elicit their subjective impressions on completing the task in the various conditions (see Appendix D).

7.4.4 Equipment

An iPhone 6s, iPad mini, and iPad were used during this experiment (see Table 7.1). The three forms of mobile devices used were chosen based on the prevalence of usage within the university. All devices used the same operating system so as to have the least amount of differences within the app and subsequent interactions. All three devices had the text size, brightness, and layout preset so the conditions were the same across devices. Devices were also presented to students on a stand (see Figure 7.1) and they were not allowed to hold the devices or alter the state of the devices except to change the page, take notes, or highlight depending on group assigned.

Figure 7.1. Angle of a Microsoft Surface on the stand.

The Kindle app was chosen as the application on which the textbook would be presented. This was because of ease of access across the devices and previous research into students at the university showed a general familiarity with the app. The textbook chosen for the students, American Civilization: An Introduction (Mauk & Oakland, 2013) was written in English by professors at a Scandinavian University to be used in their classrooms when teaching American History. This subject and book were chosen for several reasons. As this experiment was conducted with students who did not speak English as their first language, a book written with this in mind was important. In addition, the subject of American History was chosen because students would be highly unlikely to have experience in this area, which may influence comprehension or recall scores. Finally, history was chosen as the general reading area because all students would have experience reading history texts at one point of time and there are no common learning strategies associated with the field that would place a student at the university at an advantage. Four individual chapters were chosen from the textbook and educational reading experts deemed appropriate for the experiment, as they were similar in length and reading level.

A Sony HDR-PJ440 Handycam was also used to video record the students interacting with the mobile devices during the reading sessions. The video camera was placed on a tripod located behind the left shoulder of the participants.

Display Features	**iPhone 6s**	**iPad Mini**	**iPad**
Screen Resolution	1334x750	1024x768	1024x768
Screen Size	4.7 inches	7.9 inches	9.7 inches

Table 7.1. Screen sizes and resolutions of mobile devices.

7.4.5 Procedure

Participants were briefed on the experimental procedure and signed a consent form. After taking a reading comprehension and recall pretest, students were allocated to one of the three groups. Before the students began reading, they were briefly shown how to use the app and any functions they were required to use. They also had the opportunity to try navigating in the book and opening the annotation tool or using the highlighting function.

The student then began the reading assigned to the condition. After each condition, a rest period of three minutes was completed and students filled out a questionnaire regarding their experience during the reading task (see Appendix D). Then they were given a post-reading test. Following that, the next condition began. After all conditions were completed, students were asked to compare their experiences in all the conditions and report their general impressions and any issues they found.

7.4.6 Analysis Techniques

The quantitative data collected during the experiment was related to the time a student spent reading, comprehension of the material, and the perception of the various aspects related to reading the material in the conditions. This data was then analyzed using descriptive statistics. Some of these descriptive statistics were mean, median, and standard deviation. Interactions between group and condition (paper control and the three screens) were first investigated using two-way MANOVA. When no interactions were found, a nonparametric test was chosen to investigate results, Kruskal-Wallis H test, to better take into account the differences between students' habits and to properly approach the ordinal data resulting from the scale questions properly. Qualitative data, which was gathered during open-ended subjective questions on the questionnaire and observations of the readings, were coded based on the themes identified. Some qualitative data is presented quantitatively as frequency.

7.5 Results

7.5.1 Participants

A total of 92 students participated in this research. Of those 92, 51 of those students were female while 41 were male. The age of participants ranged from 18 years to 50 years with an average age of 25 years with a standard deviation of 6 years. Participants came from all disciplines across the university. The majority of the participants came from the engineering and design disciplines. Specifically, 27 students reported they were from design, 26 from engineering, 18 from medicine, and the others were from various disciplines across the university. The number of participants from the different education levels are as follows: one participant was a higher diploma student, 57 participants were undergraduate students, 11 were studying for a master's degree, and 23 for a PhD degree.

7.5.2 Time Spent Reading

This experiment found that the time spent reading changed not only between the paper control and the various mobile device sizes, but also between groups. Yet not all of these were found to be significant when analyzing the time spent reading with the Kruskal-Wallis H test. Table 7.2 presents the average time spent reading for each condition in words per minute (wpm) by groups and Table 7.3 shows the time spent reading in wpm for each screen with combined groups. Time spent reading was identified in wpm by dividing the words in the individual reading by the time in which students read during each condition.

Group	Condition	n	Median	Mean	SD
A	Paper	31	118.52	121.29	36.19
	iPhone	31	110.22	116.07	38.45
	Mini	31	122.07	129.63	38.17
	iPad	31	108.77	127.01	41.84
B	Paper	31	89.36	96.01	28.50
	iPhone	31	96.13	98.80	30.03
	Mini	31	101.50	106.45	34.70
	iPad	31	108.25	104.48	30.61
C	Paper	30	92.58	92.45	34.22
	iPhone	30	96.66	95.84	32.92
	Mini	30	93.14	103.68	35.60
	iPad	30	97.01	99.91	35.61

Table 7.2. Time Spent Reading in Word Per Minute for each group and condition.

Condition	n	Median	Mean	SD
Paper	92	101.72	103.37	35.21
iPhone	92	103.71	103.65	34.79
Mini	92	111.79	113.36	37.66
iPad	92	105.97	110.58	37.85

Table 7.3. Time Spent Reading in Word Per Minute for each condition.

The Kruskal-Wallis H test was conducted on the time spent reading for each condition separated by group. Significance across groups was found for the paper condition ($X^2(2) = 11.816$, $p = 0.003$), the iPad Mini Condition ($X^2(2) = 8.343$, p =

0.015), and the iPad condition ($X^2(2) = 7.014$, $p = 0.030$). The distribution of the time spent reading in the iPhone 6s was the same across all of the groups ($X^2(2) = 4.418$, $p = 0.110$). The Kruskal-Wallis H test was also conducted on the time spent reading for each condition with combined groups. No significance was found ($X^2(3) = 4.004$, $p = 0.261$).

7.5.3 Comprehension Scores

Comprehension and recall were measured with a short test based on the reading. These questions were multiple choice. The test was given after a three-minute break after each reading. The median and means are shown in the two tables below. One table is broken down by group and condition (Table 7.4) and one is grouped only by condition (Table 7.5).

Group	Condition	n	Median	Mean	SD
A	Paper	31	6.00	6.03	2.11
	iPhone	31	5.00	5.00	2.10
	Mini	31	6.00	5.48	1.93
	iPad	31	5.00	5.55	2.17
B	Paper	31	5.00	5.42	1.96
	iPhone	31	4.00	4.58	2.05
	Mini	31	5.00	5.52	2.59
	iPad	31	5.00	5.39	2.73
C	Paper	30	5.00	4.90	2.19
	iPhone	30	5.00	5.63	2.39
	Mini	30	5.00	5.37	2.14
	iPad	30	5.00	5.00	1.89

Table 7.4. Comprehension for each device by group and condition.

Condition	n	Median	Mean	SD
Paper	92	5.00	5.46	2.11
iPhone	92	5.00	5.07	2.20
Mini	92	5.00	5.46	2.22
iPad	92	5.00	5.32	2.28

Table 7.5. Comprehension for each condition.

The Kruskal-Wallis H test was conducted on the comprehension scores for each condition separated by group. No significant differences in comprehension scores were found for the paper condition ($X^2(2) = 4.881$, $p = 0.087$), iPhone 6s condition ($X^2(2) = 3.495$, $p = 0.174$), iPad Mini condition ($X^2(2) = 0.204$, $p = 0.903$), or the iPad condition ($X^2(2) = 0.657$, $p = 0.720$) across all groups. The Kruskal-Wallis H test was also conducted on the comprehension score for each condition with combined groups. No significance was found ($X^2(3) = 2.602$, $p = 0.457$).

7.5.4 Preferences of Mediums

After the experiment was completed, students were asked to compare the mediums used for the experiment and report, which they felt was worst for academic reading. The iPhone was reported as the worst device to complete academic readings by 84 (91%) participants. These reports were relatively evenly spread across the three groups (28 in A, 27 in B, and 29 in C). Two participants reported the mini iPad (2%) as worst. Both of these participants were from Group C. No participants from Group A reported the mini as the worst. Similarly, two participants reported the iPad as the worst (2%). One participant was in Group B and the other in Group C. Finally, four participants (4%) reported paper as the worst medium to read on. Three of the participants who reported paper as the worst were in Group A and one was in Group B. No participants in the notetaking group, Group C, reported the iPad as the worst.

Following that, students were asked to report which medium they felt was best. Students often reported paper and one of the devices as tied for best unlike worst, where students were more certain of their answer. Two answers were reported by 57 students when asked which was best, and one of those students reported a third. Of these 57, 15 of the participants reporting two best mediums were in Group A, 23 were in Group B, and 19 were in Group C. The participant who reported three best answers was in Group B. All of the participants who gave paper believed that it was first in their best category.

The iPad was reported as the best by 54 participants (59%). Of these 54, 33 (61%) also reported paper as best. In addition, 37 (40%) participants reported that the mini iPad was the best. Similarly, 22 (59%) of those participants also reported paper as the best. Paper was asserted as remaining the best medium for academic reading by 57 participants (62%). Finally, three (3%) participants believed that the iPhone was the best device to read from. These three participants had also reported paper as best. Students frequently reported that their choices of paper were due to nostalgia, although there were some reports that the devices simply did not support the students' reading habits. This was especially prevalent in Group C. Students also cited eye fatigue as another reason for hesitancy to state that a specific device was the best over paper.

7.5.5 Perceptions on Aspects

Perceptions based on various aspects of the conditions were elicited from participants immediately after reading in that condition was completed. When students were asked to think about these aspects, they were requested not to take into account any other condition that they may have already completed. The perception of the amount of text presented and the screen size were elicited using a 5-level scale where 3 was ideal. Tables 7.6 and 7.7 present the median, mean, and standard deviation of these two perceptions. The perception of turning pages, format of the text, general readability of the text, highlighting and notetaking were elicited using a 5-level scale which ranged from 1 (very bad/difficult) to 5 (very easy/good). Tables 7.8 and 7.9 present the median, mean, and standard deviation for the perception of turning pages, format of text, and general readability of the text. Table 7.10 presents the perception of highlighting and notetaking in the four conditions.

		Text Amount				Screen Size		
Group	**Condition**	**n**	**Median**	**Mean**	**SD**	**Median**	**Mean**	**SD**
A	Paper	31	3.00	2.74	0.68	--	--	--
	iPhone	31	4.00	4.06	0.77	2.00	1.81	0.54
	Mini	31	3.00	2.94	0.51	3.00	2.77	0.62
	iPad	31	3.00	2.65	0.55	3.00	3.35	0.84
B	Paper	31	3.00	2.90	0.47	--	--	--
	iPhone	31	4.00	3.68	0.95	2.00	1.87	0.62
	Mini	31	3.00	2.90	0.30	3.00	2.77	0.50
	iPad	31	3.00	2.68	0.65	3.00	3.48	0.77
C	Paper	30	3.00	3.07	0.69	--	--	--
	iPhone	30	4.00	4.00	0.91	2.00	1.73	0.58
	Mini	30	3.00	2.87	0.57	3.00	2.73	0.58
	iPad	30	3.00	2.87	0.43	3.00	3.33	0.71

Table 7.6. Perception of the Amount of Text Presented and Screen Size for each device by group and condition.

		Text Amount			Screen Size		
Condition	**n**	**Median**	**Mean**	**SD**	**Median**	**Mean**	**SD**
Paper	92	3.00	2.90	0.63	--	--	--
iPhone	92	4.00	3.91	0.89	2.00	1.80	0.58
Mini	92	3.00	2.90	0.47	3.00	2.76	0.56
iPad	92	3.00	2.73	0.56	3.00	3.39	0.77

Table 7.7. Perception of the Amount of Text Presented for each condition.

			Turn Pages			Text Format			Readability		
Group	**Condition**	**n**	**Median**	**Mean**	**SD**	**Median**	**Mean**	**SD**	**Median**	**Mean**	**SD**
A	Paper	31	4.00	3.65	0.84	4.00	3.45	0.81	4.00	3.84	0.58
	iPhone	31	4.00	3.61	0.72	2.00	2.26	1.06	2.00	2.55	0.93
	Mini	31	4.00	4.00	0.58	4.00	3.61	0.62	4.00	3.58	0.81
	iPad	31	4.00	4.03	0.71	4.00	3.52	0.85	4.00	3.52	0.93
B	Paper	31	4.00	4.03	0.75	4.00	3.58	0.85	4.00	3.90	0.79
	iPhone	31	4.00	3.65	0.76	2.00	2.32	0.91	2.00	2.42	0.92
	Mini	31	4.00	3.48	0.85	4.00	3.77	0.62	4.00	3.81	0.54
	iPad	31	4.00	3.61	0.76	4.00	3.39	0.88	4.00	3.61	0.76
C	Paper	30	4.00	3.93	0.94	4.00	3.60	0.86	4.00	3.57	0.94
	iPhone	30	3.00	3.33	0.96	2.00	2.30	1.09	2.00	2.30	0.84
	Mini	30	4.00	3.63	0.89	4.00	3.67	0.80	4.00	3.60	0.89
	iPad	30	4.00	3.77	0.73	4.00	3.77	0.63	4.00	3.80	0.85

Table 7.8. Perception of the ease of Turning Pages, Text Format, and Readability for each device by group and condition.

		Turn Pages			Text Format			Readability		
Condition	**n**	**Median**	**Mean**	**SD**	**Median**	**Mean**	**SD**	**Median**	**Mean**	**SD**
Paper	92	4.00	3.87	0.85	4.00	3.54	0.83	4.00	3.77	0.79
iPhone	92	4.00	3.53	0.82	2.00	2.29	1.01	2.00	2.42	0.89
Mini	92	4.00	3.71	0.81	4.00	3.68	0.68	4.00	3.66	0.76
iPad	92	4.00	3.80	0.75	4.00	3.55	0.80	4.00	3.64	0.85

Table 7.9. Perception of the Ease of Turning Pages, Text Format, and Readability for each condition.

	Ease of Highlighting				Ease of Notetaking			
Condition	**n**	**Median**	**Mean**	**SD**	**n**	**Median**	**Mean**	**SD**
Paper	31	5.00	4.35	0.88	30	4.00	4.00	1.02
iPhone	31	3.00	3.03	0.88	30	2.50	2.67	1.12
Mini	31	4.00	3.35	0.92	30	3.00	3.13	1.11
iPad	31	4.00	3.29	1.01	30	4.00	3.47	0.90

Table 7.10. Perception of the Ease of Highlighting and Notetaking for each condition.

The Kruskal-Wallis H test was conducted on perceptions on the various aspects of the conditions for each condition separated by group. No significant difference across groups was found for the perception of the amount of text shown in any of the four conditions: paper ($X^2(2) = 3.134$, $p = 0.209$), iPhone 6s ($X^2(2) = 3.087$, $p = 0.214$), iPad Mini ($X^2(2) = 0.367$, $p = 0.832$), and iPad ($X^2(2) = 3.076$, $p = 0.215$). Significance across groups was found for the perception of the ease of turning pages in the iPad Mini condition ($X^2(2) = 6.322$, $p = 0.042$). No significant difference was found in the other three conditions: paper ($X^2(2) = 2.883$, $p = 0.237$), iPhone 6s ($X^2(2) = 3.015$, $p = 0.221$), and iPad ($X^2(2) = 4.839$, $p = 0.089$). Also, no significant difference across groups was found for the perception of the readability of the text in any of the four conditions: paper ($X^2(2) = 2.126$, $p = 0.345$), iPhone 6s ($X^2(2) = 0.714$, $p = 0.700$), iPad Mini ($X^2(2) = 1.616$, $p = 0.446$), and iPad ($X^2(2) = 1.622$, $p = 0.444$). In addition, no significant difference across groups was found for the perception of the format of the text shown in any of the four conditions: paper ($X^2(2) = 0.382$, $p = 0.826$), iPhone 6s ($X^2(2) = 0.181$, $p = 0.913$), iPad Mini ($X^2(2) = 1.460$, $p = 0.482$), and iPad ($X^2(2) = 3.066$, $p = 0.216$). Finally, no significant difference across groups was found for the perception of the screen size in any of the three digital conditions: iPhone 6s ($X^2(2) = 0.810$, $p = 0.667$), iPad Mini ($X^2(2) = 0.021$, $p = 0.989$), and iPad ($X^2(2) = 0.777$, $p = 0.678$).

Finally, the Kruskal-Wallis H test was also conducted with combined groups across all conditions. Significance was found in all perceptions across conditions. Overall, the distribution of the perception of the amount of text ($X^2(3) = 120.060$, $p = 0.000$), ease of turning pages ($X^2(3) = 8.079$, $p = 0.044$), format of the text ($X^2(3) = 100.310$, $p = 0.000$), readability ($X^2(3) = 107.608$, $p = 0.000$), screen size ($X^2(2) = 149.672$, $p = 0.000$), ease of highlighting ($X^2(3) = 32.460$, $p = 0.000$), and ease of notetaking ($X^2(3) = 21.696$, $p = 0.000$) was different across all four conditions.

7.5.6 Changes in Reading Behavior

There were changes in the behavior of students when using components, which support their reading. Overall, when moving to the Kindle App, students took fewer notes and used the highlighting tool less frequently (see Table 7.11).

	Back Pages (Groups A, B & C)				Unique Highlights (Group B)				Number of Words (Group C)			
Condition	**n**	**Median**	**Mean**	**SD**	**n**	**Median**	**Mean**	**SD**	**n**	**Median**	**Mean**	**SD**
Paper	92	0	1.11	1.63	31	27	32.39	25.82	30	57	72.27	73.3
iPhone	92	2	4.53	5.99	31	10	10.26	8.18	30	4	8.37	12.93
Mini	92	1	2.1	2.88	31	9	11.16	11.43	30	5	13.1	22.81
iPad	92	1	2.15	3.07	31	10	12.52	13.44	30	6.5	14.37	23.25

Table 7.11. Mean, median, and standard deviation of Back Pages, Unique Times Highlighted, and Number of Words in Notes.

Kruskal-Wallis H Test was conducted within Groups B and C to better understand the significance and changes across the paper control and three devices.

Each highlight was counted not by number of words highlighted, but each unique highlighting done by students. In the paper format, circles, crosses, and stars were counted as a unique highlight. Notes were counted by words. In the paper format, non-word notes were counted as a unique word. The distribution of unique highlights ($X^2(3) = 26.409$, $p = 0.000$) and words ($X^2(3) = 51.838$, $p = 0.000$) were not the same across the four conditions for both groups. In addition, both group and condition were also analyzed by the number of times students paged backwards in the condition using the Kruskal-Wallis H Test. The distribution of back pages across groups was found to be the same for each of the four condition of paper ($X^2(2) = 5.485$, $p = 0.064$), iPhone 6s ($X^2(2) = 0.928$, $p = 0.629$), iPad Mini ($X^2(2) = 0.393$, $p = 0.821$), and iPad ($X^2(2) = 3.882$, $p = 0.144$); whereas the distribution across conditions was not the same ($X^2(3) = 24.498$, $p = 0.000$).

Students frequently reported, during the experiment, that the platform did not sup-port their habits. Analysis of paper controls found that 73.3% students in the notetaking group used a more visual notetaking style that is not supported by the app’s simple textbook input (see Figure 7.2). In addition, 16.1% students in the highlighting group used other marks such as circling or starring to help identify the importance of the material in addition to simple highlighting (see Figure 7.3).

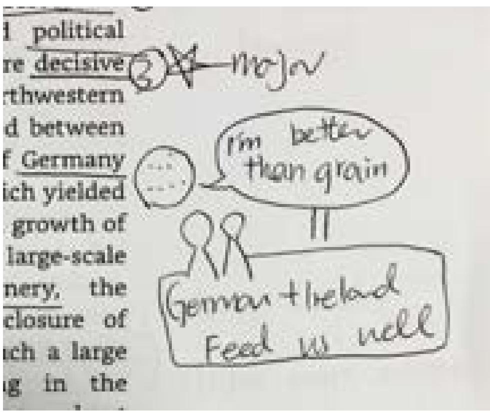


Figure 7.2. Example of notetaking behavior not supported by Kindle app.

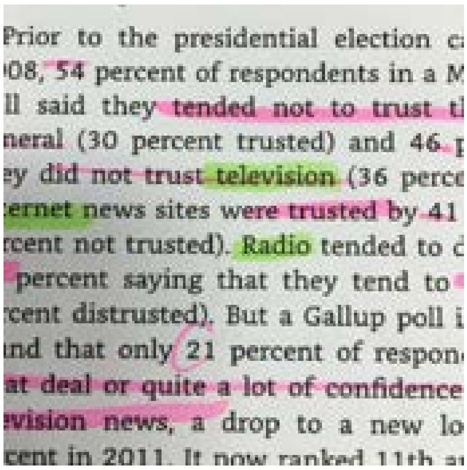

Prior to the presidential election c
08, 54 percent of respondents in a M
ll said they tended not to trust t
neral (30 percent trusted) and 46 p
ey did not trust television (36 perce
ernet news sites were trusted by 41
rcent not trusted). Radio tended to c
percent saying that they tend to
rcent distrusted). But a Gallup poll i
und that only 21 percent of respon
at deal or quite a lot of confidence
evision news, a drop to a new lo
cent in 2011. It now ranked 11th a

Figure 7.3. Example of highlighting behavior that is not supported by Kindle App.

The most common reported approach to reading was identifying key words, terms, or concepts and reading while focusing on those with 45 of the participants reporting doing this. The second most common reported approach to reading was to simply read though the material with 20 participants doing this. Other approaches were not very common and varied greatly.

Students reported that their approach to reading changed 54 times (59% of participants) and most commonly on the iPhone (35 times; 38%). Of these 54, 17 students reported that there was a change between paper and all three devices. Moreover, it was twice that they reported that the change was only in the Mini and iPhone. The commonly reported reasons for the change were eye fatigue, loss of focus in electronic devices, increased sentence splitting in the iPhone, the screen dimming based on screen time, and the fact that students found supporting activities were more difficult.

7.5.7 Observations and Subjective Perceptions

Several issues were identified during the experiment through facilitator observation and student report after each task. Some of these were related solely to the specific mobile device and others were found across all of the mobile devices.

Device specific issues were found on the iPhone 6s. This was due to the small screen size. Students frequently reported issues reading the material due to the limited information on the screen. Students also reported difficulties of taking notes and highlighting. The issues of taking notes were related to the small size of the keyboard input. The issues related to highlighting were frequently related to the increased sentence splitting caused by the small screen size. Students would have to highlight text on two different pages and reported this as being difficult and often time consuming.

Issues with the in-app components used in both Groups B and C were reported across devices. Highlighting was reported as difficult for students to complete without using more than one highlighting movement to cover the complete sentence. Similar to what the students reported, the facilitator also observed student issues when they attempted to make an existing highlighted section longer or shorter and at times ended up completely removing the highlighted section and started again. Students also reported that they often went back or forward a page while attempting to highlight a passage.

Students also struggled frequently with the annotation tool. Students reported that the keyboard input was not ideal for inputting their notes. Many students reported frustration with the fact that they could not move the textbox popup so that they could see the text they were referencing. Instead, they had to spend more time opening and closing the textbox repeatedly until they could edit their notes to their satisfaction. In addition, the facilitator observed many students getting confused when attempting to access the annotation component. When they would select a word or phrase, students would initially look at the larger dictionary, thesaurus, Wikipedia boxes that pop up below the toolbar. Some students even attempted to select those options out of reflex. Students also showed frustration with the way the notetaking icon was represented. Several students deleted the note to try and select a phrase once again to only have the same icon appear. A few of these students then used the highlighting component to identify the corresponding phrase.

7.6 Discussion

In general, the time spent reading across all groups and conditions was not significantly different. These findings are important when examining if there is a change between paper text and electronic text in the same size and format; this was especially apparent in Group A. While the results were not significant, examining the median time spent reading had some differences; paper resulted in a faster reading time than most of the electronic mediums in Group A, which is in line with previous research (Daniel & Woody, 2013). However, according to the means, reading was completed faster on the iPad mini and iPad, which is in line with a study that found that the time spent reading decreased when using the electronic version of texts (Shepperd et al., 2008). This shorter time spent reading in the paper medium was not sustained in Groups B and C when the components were introduced. This discrepancy can be attributed to the increase in highlights and notes made by students in those groups when using the paper medium, which differed from the other conditions. Past research has considered this an overall advantage as the inclusion of notetaking increases the time spent with the text (Kulhavy et al., 1975) which then in turn allows students to feel they are deepening their understanding of the text (O'Hara & Sellen, 1997). Not only do students feel their comprehension of the material is improved but also encourages active reading and in-depth reading which is required for academic reading (Schilit et al., 1998; Liu, 2005; Wolf & Barzillai, 2009; Hartley, 1990).

While students often feel that supporting activities such as notetaking improve their comprehension, no significant differences were found across devices or with the use of components. This finding is not surprising as the way in which supporting activities were used and how comprehension was consequently tested in this experiment is not a reflection of the real world situation. This is something that has been found in similar studies in the past (Riley & Dyer, 1979). In this study, supporting activities were not allowed to be reviewed before the comprehension test in this experiment. They were only implemented to understand the behavior change across conditions and to identify if there were major changes in comprehension while using the components when moving from the paper to the full sized iPad. Similar to the findings of this study, past research in physical texts have found that the addition of highlighting and underlining do not have an immediate effect on the retention of material, yet the same study found that active highlighting and underling are valuable to what students do, at least weakly, increase the overall retention of the material (Fowler & Barker, 1974). Other studies have shown that supporting activities are more often used by students during revision or paper writing to avoid needing to reread material, thereby providing them with subsequent insights at a different time which allows for the deeper understanding of the material (Slotte & Lonka, 1999; Kuhavy et al., 1979; Dyer et al., 1979). While there was an absence of significant changes in immediate comprehension, it is still noteworthy that the mean comprehension score for iPhones for Group C was the highest, which is similar to past findings (Connell et al., 2012). This result was not duplicated in the groups highlighting or reading alone. This was most likely due to students retaining the information they were going to take notes on in their short-term memory. Students reported that they had to try to quickly memorize the text due to the increased sentence splitting and the fact that the notetaking input functionality took up the entire screen, unlike for the iPad mini or iPad.

There was a significant difference in the number of unique highlights and notes taken across conditions. The paper condition afforded the most unique highlights and notes. Past research has found that paper allows for many benefits that electronic textbooks do not such as integrated reading and notetaking, allowing for rich and varied marks to assist in meaning making, and ease of finding the notes or highlights on a page (O'Hara & Sellen, 1997; Schilit et al., 1998). These benefits and the variance on paper text were also found in this study, which showed that many students' notetaking and highlighting habits differed depending on the input supported by the electronic devices. The more visual style of notetaking or highlighting even changed across students or within one student's paper condition. Words were sometimes highlighted fully, underlined, numbered, crossed out, or circled (See Figure 7.4). In the notetaking groups, students created arrows, timelines, pictures with words, standalone pictures, and other features to help them create associations across the text and within their knowledge base (Figure 7.5). The decrease of notes and highlights in the electronic textbooks is due to the struggle that students reported because the in-app components do not support their habits. Although past surveys have shown that hundreds of thousands of students wish to take notes or highlight in their electronic textbooks (Warren, 2010), these components are not yet optimized for students using the Kindle app. In fact, these essential features are not yet perfected in any e-reader (Ferguson et al., 2010). Although all the students in Group B were able to use the highlighting function in this study, albeit with difficulty, past research found that less than 80% of the examined users of the Kindle app on an iPad, three were able to fully utilize the highlighting function within one minute (Jardina & Chaparro, 2013). Although members of Group C were able to use the notetaking functionality, some students refused to take notes in certain electronic devices because of the difficulties associated with the component.

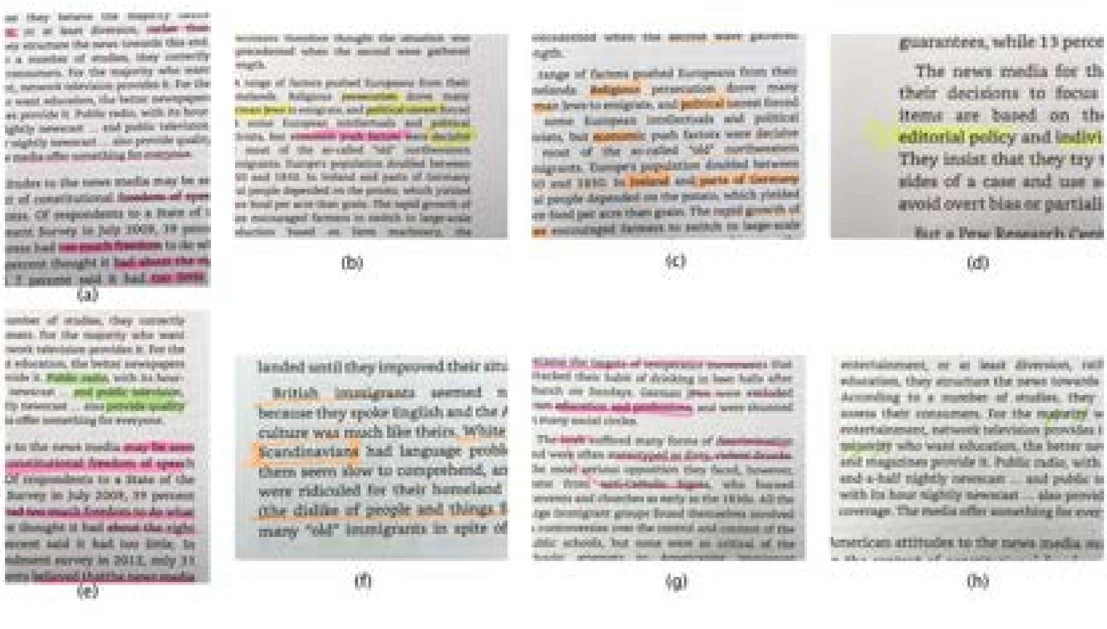


Figure 7.4. Examples of types of highlighting behavior (a) underlying and highlighting (b) circling (c) numbers (d) symbols (e) multiple colors and underling (f) boxing words (g) using connection lines and (h) crossing words.

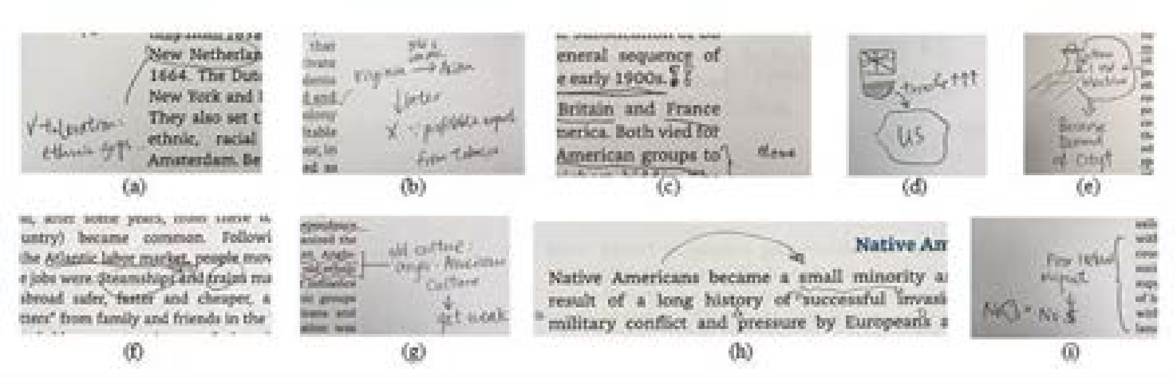


Figure 7.5. Examples of notetaking behavior (a) words with connections (b) symbols to help understanding (c) symbols to show importance (d) images that symbolize thoughts without words (e) connections with words (f) arrows for meaning (g) subcategories (h) various symbols for meaning (i) symbols with individual meaning as a phrase and (j) pictures to give full meaning.

The preferences that students reported mirrored many of the aspects observed during the experiment. The iPhone 6s consistently scored poorly and was thought to be the worst of the reading mediums. It also caused the most changes in reading behavior. Changes in reading behavior were often quite noticeable across the conditions and groups. For example, back paging was found to be significantly different in all the devices and paper textbook, and the iPhone 6s yielded almost double the average number of back pages. Students reported this phenomenon after reading on the iPhone 6s and believing that it was due to the sentence splitting and lack of text available to them on the screen. The perceptions of the various aspects and the overall reported best device showed differences. At the end of the sessions, students most often reported that the iPad was the best device for completing academic readings and that paper was the best medium overall. However, the perceptions of the individual aspects revealed a different response. The iPad mini and paper were most frequently rated the best. However, many students stated that there was not a substantial difference between their perception of the iPad and the iPad mini when questioned. Overall, this study had similar findings to past research that has repeatedly found that students will still prefer to use paper for in-depth reading due to various reasons (Schilit et al., 1998; Liu, 2005).

7.7 Summary

The findings from this study mostly support all three of the original hypotheses. In support of H1, the findings support that there was no significant change in comprehension and perception of aspects of the reading when moving from paper to the iPad. In addition, in support of this same hypothesis, the time-spent reading was very similar for students reading in a print medium in the same size and format as the electronic textbook. H2 was mostly supported by the findings of this experiment. Perception of the reading task and the behavior of taking notes, highlighting, and back paging differed across the four conditions. While the time spent reading did differ across the conditions, this change was not significant thus it does not support H2. The marked decrease in time spent reading was when students used the iPhone 6s in all groups and students reported the least satisfaction with reading on that device in general due to their greater difficulties in reading the material and using the functions due to the sentence splitting increase. In line with H3, students created significantly more unique highlights and notes in terms of number of words and different styles in paper format than any of the electronic devices. In addition, students struggled to use the functions in general and found them frustrating.

While the move to electronic textbooks may not have a significant effect on student reading goals, the behavior does change quite significantly. The Kindle App does not lend itself well to academic reading, as it does not support the way students highlight and take notes, which are considered important to students who later need to revise for examinations or write final papers. To fully understand how this may affect comprehension or recall in a more holistic way, a similar experiment should be repeated where students come back at a later time and review their notes before taking the comprehension and recall post-test.

Overall, these findings assisted in understanding how student behavior changes and what design changes should be made to current electronic textbook components to allow full academic support of the academic reading task. The integration of the findings from this experiment with the other studies is described in Chapter 8.

Chapter 8. Design Framework

8.1 Overview of Chapter

First, this chapter presents an overview of the process of integrating the findings of the various methods to develop the design guidelines and framework, which meets objectives 4 and 5, and research question 3: Usefulness and acceptance. It then presents the initial guidelines for future electronic textbooks based on the previous methods. The chapter also overviews ergonomics issues identified through the focus groups and observations and investigates them using the Hexagon-Spindle Model. The chapter then presents the validation process and final iteration of the guidelines and a comparison of what is available in existing applications.

8.2 Integration of Methods

All methods described in this dissertation were analyzed together so that a design framework for future electronic textbooks could be created. This framework focuses on the two student attributes that were discovered to be most important by the research outlined in Chapter 4 and then explored in Chapters 5, 6 and 7. These two attributes are discipline and education level. The similar components of the textbook between the two chosen disciplines, engineering and design, and the chosen education level, undergraduate, was identified and compose the core design aspects. Following that, the components identified as important for the different disciplines were grouped together to identify which components were discipline specific. This allows for easy identification of the important aspects of electronic textbooks for the content and visual designers.

Designing the textbooks based on the attributes of education level and discipline will better support the students' ability to learn the material. Different disciplines have different requirements for the students to learn. For example, engineers will need to learn equations while design students will instead need a better understanding of materials. A singular design of textbooks will not work for all students. In addition, students of higher levels of education approach their studies in a different way than students studying at a lower level of education, so a textbook designed for graduate students will not be the same textbook appropriate for undergraduate students. This concept is the norm in physical textbooks, but there tends to be no distinction in the design of electronic textbooks, which could use technology to support the learning needs of the different levels. In addition, the supporting materials that one education level or discipline needs may not be the same as those needed by other disciplines. Undergraduate level work has a different goal when it comes to assessments than postgraduate studies.

Finally, by presenting the components outside of the restrictions of a specific piece of technology, yet taking into account the effect of layout and content on cognitive load, will allow for more flexibility in future technological applications. Only a decade ago, electronic textbooks were tethered to stationary computers, while now tablets have freed students to study in a wider variety of places, not to mention the technological advances in virtual reality, 3D technology, and storage capacities. The future technological advances will only create more environments for students to study in. The focus now needs to be on successfully supporting students in their endeavors to successfully succeed in their educational goals. This support has to be done on a discipline specific level.

When the preliminary research methods of survey, focus groups, and interviews are analyzed together, they can lay the foundation to truly understanding the aspects related to the academic reading task that may result from student use of electronic textbooks, which in turn affects the adoption process based on the Technology Acceptance Model. The survey, based on the research sub-question of *How do student characteristics play a role in the perception of future electronic textbooks?*, helps to identify the general mindset of the various groups of students in respect to the components of electronic textbook and assists in identify the various approaches to reading as related to aspects such as discipline. From this point, two disciplines were chosen to investigate closely. These were the disciplines of engineering and design. These two disciplines were chosen because of their similarities in goal, to create something, and differences in mindset and process. By investigating similar yet different disciplines, it allows for a better understanding of how the core differences in disciplines change electronic textbooks.

Following this, the focus groups, founded on the results of the survey, assisted in answering the “why” questions that were previously unanswered. This method allowed for a deeper understanding of student perceptions, task, habits and how that may evolve with the change in medium from paper to electronic. In addition, the focus groups helped to validate the inferences made from the Internet survey and illuminate the reasons behind the data. By understanding the task and the student view of electronic textbooks, identification of the components for electronic textbooks becomes understandable.

While a picture starts to emerge, students are not the only main user of electronic textbooks. Professors are another important consideration for future electronic textbooks. Not only are they users of the textbooks, but they are also the ones choosing which textbooks are used during their courses and often creators of textbooks themselves. Findings showed that how professors view electronic textbooks is actually mirrored in their students. This can explicitly be seen in the findings of the focus groups and interviews in which professors and students from the design discipline both believed that textbooks are only a starting point for understanding the main material and moving past them is important. Those professors and students in the engineering discipline had a different view of electronic textbooks and, like in the design discipline; this fact was reflected in the components selected, academic supporting tasks, and usage habits. Their view was that a textbook's sole use should be for learning the assigned material. From these findings, it can be ascertained that professor opinions and desires regarding electronic textbooks is vital to the future of this academic tool.

While the survey, focus group, and interviews gave a strong foundation for the various components that would be included in the framework, an understanding of the actual usage of electronic textbooks in relation to physical textbooks and the implications of the change in medium were missing. The experiment outlined in Chapter 7 provided the final necessary input and allowed for limitations of current electronic textbooks to be identified. The post-test questionnaire also allowed for more direct insights on the experience of academic reading and the observation of those reading sessions allowed for identification of habits, which went unreported by the respondents.

8.3 Identification of Ergonomics Issues with Electronic Textbooks

Not only was the experiment beneficial to the creation of the design framework, when used in conjunction with the focus group sessions, both physical and cognitive ergonomic issues surrounding electronic textbooks were able to be identified. The findings described in Chapters 5 and 7 were analyzed with the Hexagon-Spindle Model (Benedyk & Woodcock, 2009). This model is a high-level holistic method, which focuses on educational situations, the task, and surrounding factors of influence. Analysis with this model allows for the identification of ergonomic risks associated with the actual task and suggests courses of action for ergonomics solutions. In the past, it has been used in similar ways as described in this dissertation, such as the use of laptops in classroom settings (op. cit.) but it has an inherent flexibility that allows it to be transferred to other educational situations, such as individual learning. Table 8.1 shows the Action Table from the Hexagon-Spindle Model examination. Various issues, factors, and prospective ergonomic solutions are offered in said table. One solution in particular is explored more fully in the final sections of this chapter and is the main contribution from this body of work. The presented solution states: "In app components, such as annotation components, need to be designed to better support the academic reading task." In the following sections, cognitive design guidelines presented in a larger framework are offered as the required solution to this problem.

Levels	External factors	Work setting	Workplace	Workstation	User
All influencing factors	• Devices in which electronic textbooks are used, cannot be regulated for home and mobile use on a government level. • Common reason for use are the ease of access and requirements by professors. Devices which students access the electronic textbooks are based on what they have. Few bought devices specifically for educational purposes.	• Hardware and software on tablets are not specifically optimized for usage with electronic textbooks. • University web systems where books are located do not always support all the various mobile devices well. • Because of mobility, facilities do not always include necessary aspects like Wi-Fi. • Policies and training sessions on the proper usage of electronic devices for reading are nonexistent at most universities.	• Environments of use are not limited to any one place (rooms in houses, libraries, classrooms, travel, et al.).	• Furniture, if used, is not optimised for electronic device usage with electronic textbooks. • Support activities, such as note taking, are frequently completed on paper or do not support the required input method of students. • Reports of various postures during use.	• Undergraduate design and engineering students at The Hong Kong Polytechnic University.
Ergonomic issues	• There are no regulations to guide users or universities on using electronic textbooks.	• Issues accessing electronic readings for university/potential copyright issues. • Lack of understanding within users regarding potential health and security issues.	• Impossible to predict where a student will use an electronic textbook and what support activities they will use. • Sunlight/lamp light causing glares. • Designs of interfaces for electronic textbooks are different leading to confusion and psychological discomfort. (PDF, Kindle, iBooks, et al.). • Digital Rights Management (DRM) is stricter in some electronic textbooks, which may cause psychological discomfort and confusion.	• Postural issues, especially during sustained reading. • Lighting issues (glare, eyestrain, insufficient lighting).	• Various musculoskeletal issues (neck, back, wrist). • Eyestrain. • Digital Rights Management (DRM) concerns and issues. • Difficulty understanding electronic textbook components.
Ergonomic approaches to situations	• Create and disseminate more information regarding health information for use of electronic textbooks related to eye strain and posture.	• Ensure there is technical support for students having issues with their electronic textbooks. • Offer support for users regarding health concerns associated with electronic device usage.	• Create guidelines and educate users on appropriate practices for using an electronic textbook to complete required readings. • Create spaces in university associated property such as on campus or in halls residences that support usage of electronic textbooks on electronic devices.	• In app components, such as the annotation component, need to be designed to better support academic reading task. • Provide anti-glare screens for mobile technology and use softer lighting/backgrounds for text displays.	

Table 8.1. Hexagon-Spindle Action Table for electronic textbooks.

8.3.1 Discussion of Ergonomic Issues

Observations during the experiment outlined in Chapter 7 found that chosen postures during academic reading could be described as monotonous and sedentary. Similar to what Li and Haslegrave (1999) explained, the neck of students and the lower trunk area became static during their readings. As students focus more on their readings, they often become tenser and lean closer to the textbook. This leaning is often supported by one arm. This was observed during both electronic textbook and physical textbook usage. While this action decreased when reading in a physical form while highlighting or taking notes, the action continued to be observed during electronic textbook reading with those supporting tasks.

This type of static sitting can result in problems with the neck (De Roeck, 1998). When the neck has an inclination greater than 30 degrees, regularly observed during the experiment by visual assessment, severe muscle fatigue can result (Chaffin, 1973). During the experimental setting, it was observed that some participants tried to ease their fatigue by repositioning their necks. Other participants even drastically changed their posture during breaks in the experiment, such as moving from a sitting position to a standing position. Examples of this were students who stood or leaned as far back in the chair as they could. Several students attempted to alleviate their discomfort by picking up the mobile devices, but were reminded that the devices needed to remain on the stand. The final attempt to alleviate their discomfort agrees with Young et al. (2012) who recommended changing the height of mobile devices or angle of the screen to assist in rectifying poor neck posture. Overall, the postures observed cause deformation of the cartilage and vertebrae of the spine and cause issues with blood flow over long periods of time (Pheasant, 2006).

Eyestrain was one of the most reported issues for textbook reading in the physical and electronic mediums during the focus groups and the experiment. Visual fatigue, such as those reported, is common when a user is subjected to the same conditions over long periods of time during a visual task (Megaw, 1995). Students may change conditions, such as brightness, or take small breaks during their academic reading to alleviate this issue. Many students, especially engineering students, report reading for excessively long periods of time during revision. These students may be averse to taking breaks when they feel pressured placing them at risk for severe visual fatigue.

Glare was also discussed in regards to electronic and physical textbook readings, but was considered easily rectifiable with a change in posture. Glares are frequently caused by light sources; this would negatively affect the visibility, subsequently reduce the visual performance, and often cause discomfort (Howarth, 1995; Sanders & McCormick, 1993). Physical texts, which have gloss on paper, or electronic textbooks, read on a screen, are susceptible to glare. This problem can be rectified in electronic devices with screen protectors, which reduce glare, yet this type of product is not available for all devices.

8.4 Cognitive Design Framework for Future Electronic Textbooks

The following guidelines are based on the findings from the previous detailed above research are intended to be used to support electronic textbook interface designers and content creators when designing current and future electronic textbooks, especially in the disciplines of engineering and design. Overall, it is a set of guidelines for electronic textbook creation based on the academic reading task, thus it not only presents information for content creators but also interface designers. The framework presents guidelines that allow for flexibility for creators based on the content that is represented and based on future technological advances that may occur. These guidelines are less concerned with the final visual design of the user interface, but they provide insight on how the designs need to be presented and the allowances of interaction to a certain extent based on the academic need. The following guidelines were then broken up into a larger hierarchical framework. Both content creators and visual designers should view the guidelines together so that a holistic understanding of what is necessary to complete the academic reading task successfully can be fully realized in future electronic textbooks.

8.4.1 Identification of Components

The triangulated data from the survey, focus groups, and interviews regarding the future electronic textbooks were considered with the experiment data based on the current components' effect on reading and the academic reading task to create the final list of components. Once all of this information was identified, it was then visualized using a modified pie format (Figure 8.1). Following the visualization of the components based on discipline, the detailed data was compiled and arranged into the guidelines.

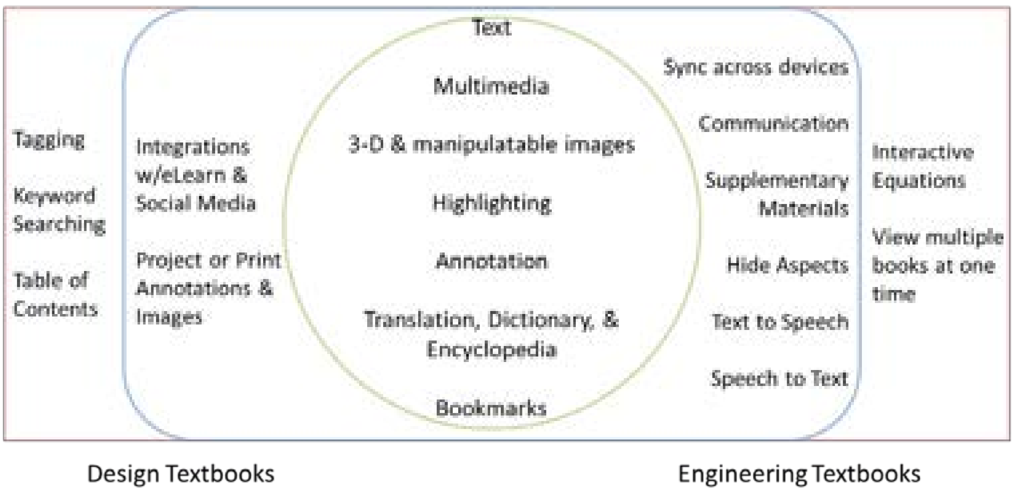


Figure 8.1. Visualizations of components in guidelines and their degree of inclusion by the two disciplines.

8.4.2 Core Component Guidelines

The following guidelines are the core for all disciplines based on the academic reading task across disciplines.

Text

Text remains core to the future electronic textbook. The text content will be highly relevant to the purpose of the electronic textbook and will be kept short and to the point. Only the most vital content will be represented in short blocks of text with additional text of explanations and examples minimized with an expanded option so that the additional text can be viewed if chosen.

Visually, text shall be manipulatable. Users can change the font, spacing between the words, spacing between the lines, and spacing between the paragraphs. Additionally, text color and background can be changed to suit the visual preference of the user.

Multimedia

Multimedia will act as a supplement for the shortened text. Only multimedia that is highly relevant to the content will be included. Various types of multimedia can be included based on the relevancy. Some examples of multimedia that could be included are videos, audio, podcasts, and animations

A subset of multimedia, images should be presented in a way, which is most appropriate to support the content. All images should be expandable to full screen.

Images will be able to be manipulated and are represented in 3-D to facilitate learning. The images can have layers removed, spliced, and rotated so that the full information can be understood, especially when representing complex systems.

Highlighting

Highlighting tools assist in students locating information they previously deemed important. Highlighting tools need to allow a free form input rather than one that only selects text. This tool will allow for users to select from a range of colors that fit their needs.

Highlighting tools will allow for students to edit the highlights easily without creating gaps or requiring the entire highlight to be changed.

Annotation

Annotation tools are tools, which allow students to add their own notes to their textbooks so that they may find them quickly at a later date and deeper connections may be made by the student.

Annotation will allow free form input with a finger or stylus to mimic physical notetaking. Naturalistic input will allow for visual notetaking styles to be supported. In addition, annotation components will allow for the insertion of pictures, graphs, and other charts. Annotation tools will allow for spelling and grammar to be checked if desired by the user. In addition, the annotation component will display the notes where they are taken and a variety of colors will be available for users to choose from.

All annotations, whether text or visual, shall be accessible easily. Students should be able to print, project, or find annotations that they made without searching page by page.

Translation, Dictionary, and Encyclopedia

Translation, Dictionary, and Encyclopedia options will be available for all text in the electronic textbook. Translations shall be available for any amount of text from a single word to the entire book. These components will assist students in understanding the concepts described in the text.

Bookmarks

Bookmarks allow students to return to areas of their work that they feel are important or where they left off.

Bookmarks should be presented in a way which is easy for students to see and can be placed not only on pages, but also on exact words students left off at.

8.4.3 Multiple Discipline Component Guidelines

The following guidelines are specific for the disciplines of design and engineering.

Integration with other Programs

Electronic textbooks should have integration with other programs. These programs may be learning based such as Moodle or Blackboard where students can access their notes or easily switch between the two if necessary.

In addition, integration with communication programs is important as well. This integration will allow for group discussions to be facilitated with video call or text messaging programs. Integration with social media may be necessary, for example an image in Pinterest may be imported as an annotation.

Additionally, links to experts for questions via email or other means is also vital. This will allow for immediate clarification of concepts and will also be useful for content creators for revisions.

Adaption with Various Devices

Electronic textbooks should work with all devices a student may use and synchronize across them without student intervention. This will allow for a streamlined use of the material and reduce cognitive load and stress.

Supplementary Materials

Supplementary Materials in the form of exercises, PowerPoints, and quizzes will be available with the electronic textbooks as appropriate to the content. These materials will include any answers fully worked out if necessary. This will facilitate student learning and classroom instruction for professors. The supplementary materials will be highly relevant to the content of the electronic textbook.

Hide Unimportant Aspects

Similar to the expanded section of text outlined in the text guideline, students shall be allowed to hide sections of text they deem as not relevant to their studies. The hiding action will not be permanent and hidden material can be reselected at any time. This component will allow for faster and more focused revision.

Accessibility Technology

Speech to Text and Text to Speech will also be included for students with various impairments. Speech to Text will allow users who are not able to use a naturalistic input or text input to use the annotation tools. Text to speech will read the selected text to the user, which is beneficial for those users with visual impairments.

8.4.4 Discipline Specific Guidelines

The following guidelines are specific to the disciplines of design or engineering only.

8.4.4.1 Engineering Specific

Equations

The use of equations is a common requirement in the study of some content. Equations presented in electronic textbooks will allow for more interaction with the user. These equations will allow for users to work out the equations themselves in the textbook direction and then highlight any wrong steps. Detailed solutions will be provided to users and multiple strategies to achieve the solutions will be displayed if applicable.

View of Multiple Materials

The ability to view multiple electronic textbooks at once is beneficial to users when working on projects or during revision. Interfaces will allow for multiple textbooks to be viewed and interacted with at once in a clear way, which makes a distinction between the various materials.

8.4.4.2 Design Specific

Concept Orientation

Concept orientation to allow for flexibility and freedom in understanding the concepts presented are important when making connections that supports deeper reading.

Strategies such as tagging and search functions shall be used to do this through a nonlinear model whereas table and contents and indexes shall do it in a more traditional and linear model. Clicking on a tagged concept will show not only where the concept is within the book, but also will give links to other resources such as textbooks and journal articles on the same content. The links provided should reflect nonbiased representations of the concepts through varied and critical opinions. Search functions should allow for easy searching of any concepts within the text, not only those that are tagged as more important.

8.5 Prototype

Following the creation of the initial guidelines, two prototype electronic textbooks were created to validate the guidelines and understand the reaction students would have to change based on those guidelines. Only the components that were deemed more vital by students were prototyped. This helped to create an understanding of how students would interact with some of the components they requested in their future electronic textbooks and the actual appropriateness in relation to task. This ascertained if there is what Simon (2001a) dubbed the “fickleness gap”, a reported importance of components with reduced actual usage.

8.5.1 Component Mockups

Using the framework identified in Sections 8.3.2, two electronic textbooks, one for design and one for engineering, were mocked up using the online mockup software of Balsamiq (Balsamiq, 2017). Aesthetics were not considered important at this stage of testing and focus remained with the components and overall functionality in relation to the academic tasks of the prototype. The mockups did account for the principle of proximity from the Gestalt Laws of Grouping (Banerjee, 1994). This principle states that items, which are related, be grouped visually together so that a more organized layout emerges. Items that are unrelated should be placed far apart so that a lack of relationship can be emphasized for the user.

The initial mockups did not include text. The mockup for the design textbook included a full mockup of the following components: annotation; highlighting; translation, dictionary, and encyclopedia; multimedia (video); image (manipulatable); and tagging (see Figure 8.2).

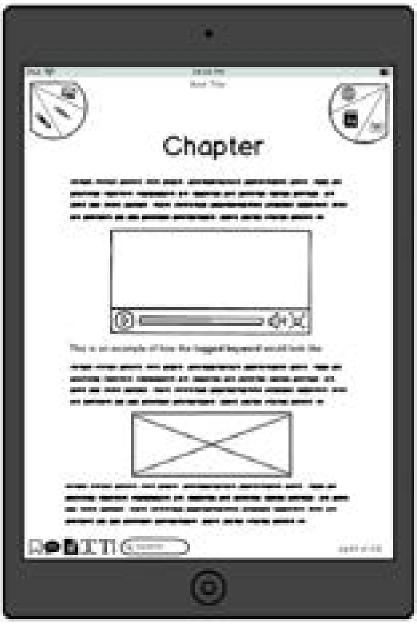


Figure 8.2. Mockup of design textbook interface.

The mockup for the engineering textbook included two pages. The first page included a full mockup of the following components: annotation; highlighting; translation, dictionary, and encyclopedia; multimedia (video); and image (manipulatable). The second page was dedicated to the interactive equation component (see Figure 8.3).

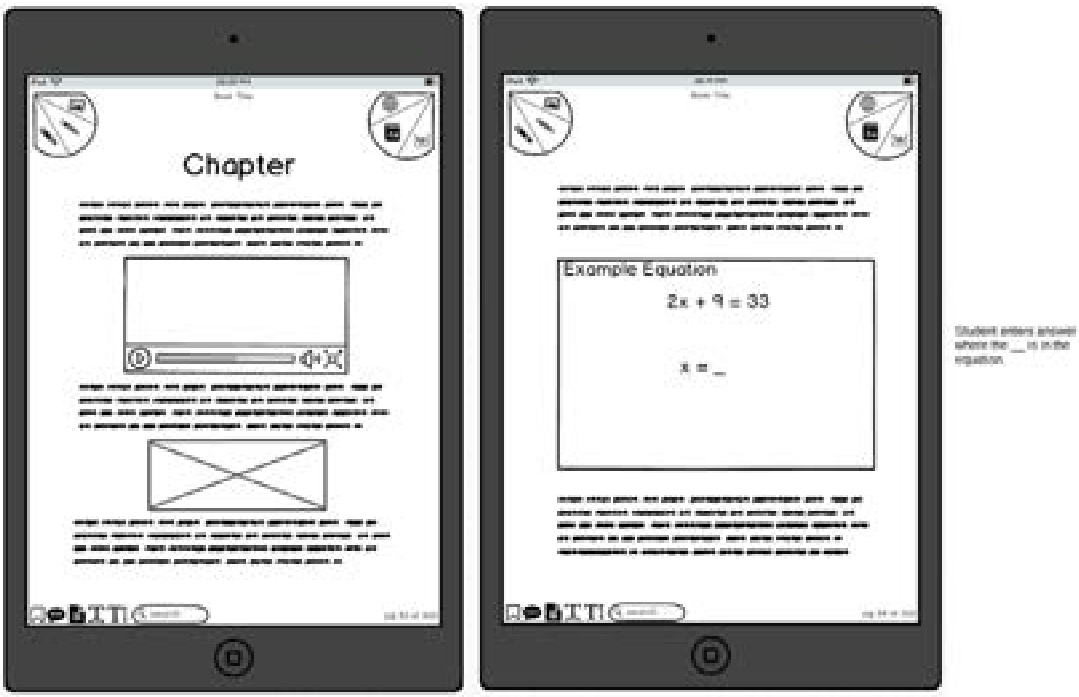
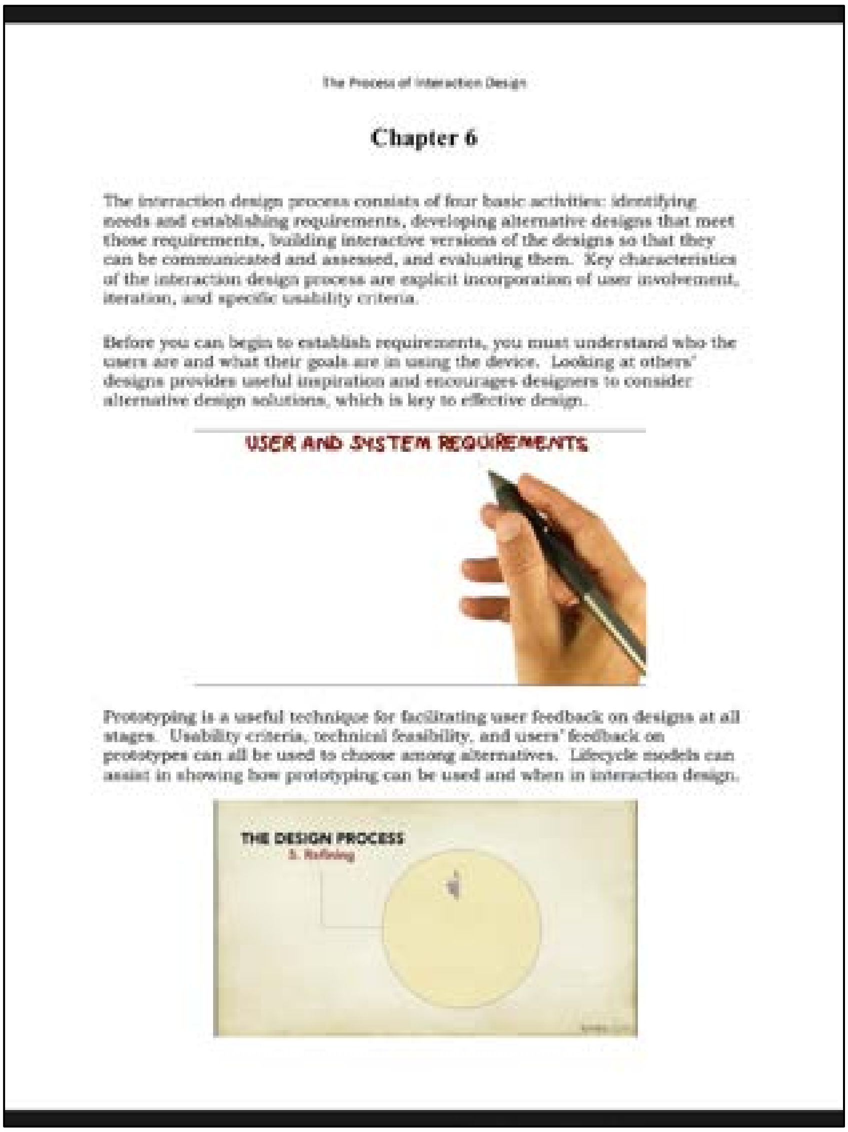


Figure 8.3. Mockup of engineering textbook interface.

8.5.2 Content Mockups

Following this, two more mockups were created which contained the content and some interactive functionality, such as embedded videos. These mockups were made using Adobe Acrobat. The videos included in them not only represented the multimedia video, but also mimicked the interaction for the manipulatable images and interactive equation.

The design mockup was created with source material from *Interaction design: Beyond Human-Computer Interaction* (Sharp et al., 2007). The video used in the prototype was *User and System Requirements - Georgia Tech - Software Development Process* (Udacity, 2015). The mockup only included the content and not the interface components, such as annotation and highlighting (see Figure 8.4)


The Process of Interaction Design

Chapter 6

The interaction design process consists of four basic activities: identifying needs and establishing requirements, developing alternative designs that meet those requirements, building interactive versions of the designs so that they can be communicated and assessed, and evaluating them. Key characteristics of the interaction design process are explicit incorporation of user involvement, iteration, and specific usability criteria.

Before you can begin to establish requirements, you must understand who the users are and what their goals are in using the device. Looking at others' designs provides useful inspiration and encourages designers to consider alternative design solutions, which is key to effective design.

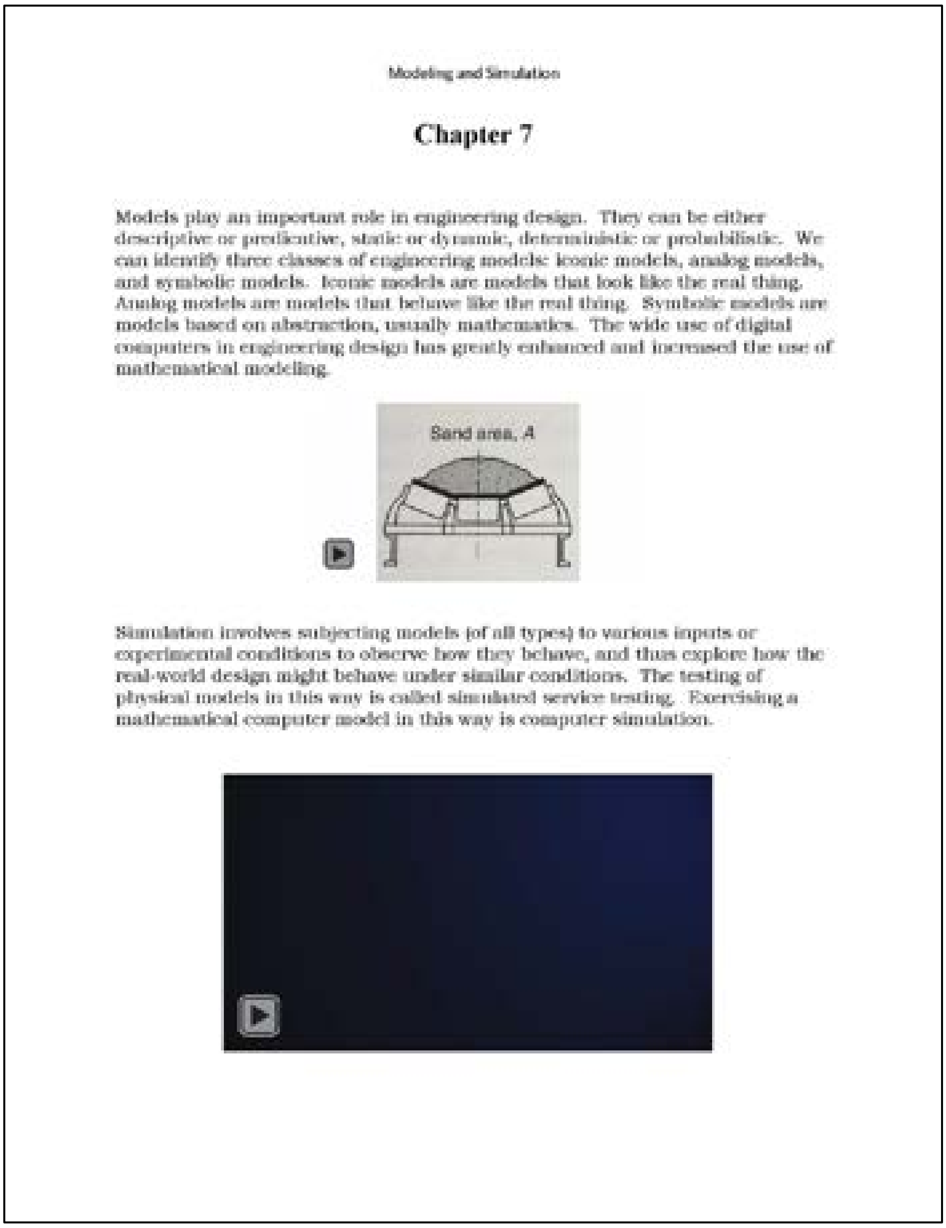
USER AND SYSTEM REQUIREMENTS

Prototyping is a useful technique for facilitating user feedback on designs at all stages. Usability criteria, technical feasibility, and users' feedback on prototypes can all be used to choose among alternatives. Lifecycle models can assist in showing how prototyping can be used and when in interaction design.

THE DESIGN PROCESS

Figure 8.4. Mockup of design textbook content.

The engineering mockup was created with source material from the textbooks *Engineering Design: A Materials and Processing Approach* (Dieter, 2000) and a YouTube video entitled *What is Math Modeling? Video Series Part 1: What is Math Modeling?* (Society for Industrial and Applied Mathematics, 2016). Once again, this mockup focused on the content for the engineering textbook (see Figure 8.5 and 8.6).



Modeling and Simulation

Chapter 7

Models play an important role in engineering design. They can be either descriptive or predicative, static or dynamic, deterministic or probabilistic. We can identify three classes of engineering models: iconic models, analog models, and symbolic models. Iconic models are models that look like the real thing. Analog models are models that behave like the real thing. Symbolic models are models based on abstraction, usually mathematics. The wide use of digital computers in engineering design has greatly enhanced and increased the use of mathematical modeling.

Sand area, A

Simulation involves subjecting models (of all types) to various inputs or experimental conditions to observe how they behave, and thus explore how the real-world design might behave under similar conditions. The testing of physical models in this way is called simulated service testing. Exercising a mathematical computer model in this way is computer simulation.

Figure 8.5. Mockup of engineering textbook content.

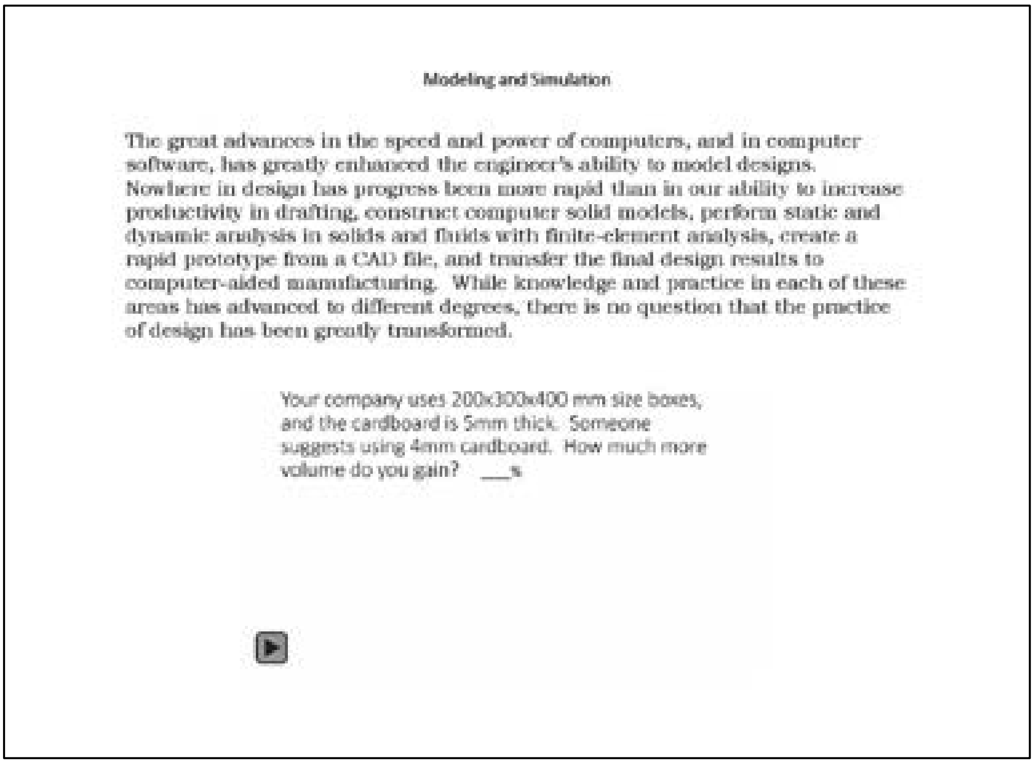


Figure 8.6. Mockup of engineering textbook equation.

8.5.3 Full Prototype

While data triangulation does answer many questions and validated the findings, there was still a major limitation, which leads to the next step that was completed. While students may report favoring particular reading habits or certain aspects of electronic textbooks, these reports are not necessarily reliable. Simon (2001a) dubs this the “fickleness gap”. In his study, he found discrepancies of 20-30% between actual usage and preference for components.

To validate the design recommendations, working prototypes needed to be created which contained these different recommendations. After these prototypes were developed, modified TAM questionnaires were used to identify if the reported perceptions were valid and interactions, habits, and the general task are affected and consequently influence the adoption of electronic textbooks. Other limitations associated with the methods were acknowledged and their influence was minimized through careful implementation and design.

The full prototypes were created using the Unity engine and C# was the programming language used. A simplistic design aesthetic was used, as the overall purpose was to gain insight in to whether the components will meet the task of the student, if they are acceptable, and how they influence the task of reading. The content remained the same from the content mockups detailed in Section 8.4.2.

8.5.4 Evaluation of Prototype

Two of the most important aspects in relation to e-learning, student attitude, and subsequent adoption of the technology in the student population are perceived usefulness and perceived ease of use (Park, 2009). Prototypes are made for many different reasons and to elicit many different results. In this case, the low-fidelity full prototype and its subsequent evaluation focused on assessing the selected component's abilities perceived value in relation to user task requirements and ease of use. This type of evaluation is common in interaction design where a low-fidelity prototype is tested to "assess how well a design fulfills users' needs and whether users like it" (Sharp et al., 2007).

The main purpose of the prototype evaluation was to identify if the guidelines truly represented the academic reading task and student needs in relation to that task. A full TAM questionnaire could not be used to evaluate the prototypes. This was due to several reasons. First, the evaluation was set to validate the guidelines and not the exact design choices chosen for the prototype as the guidelines are set for flexibility in final interface design. Secondly, this was a low-fidelity prototype, thus any full TAM questionnaire would be skewed because of this. Instead, a minimal and modified TAM questionnaire was developed to meet the validation requirements with special emphasis placed on the appropriateness of the components for the reading task and student perception of components (see Appendix E).

Short prototype evaluations were setup in a quiet lab environment to allow students to find a comfortable space for their reading task. Students were only allowed to evaluate the prototype from their disciple. Each session was approximately 20 minutes. The session started with an explanation about the available components. Following that, the participants were allowed to freely explore the prototype and use all of the functions. Finally, a modified TAM questionnaire regarding the perceived appropriateness of the components and perceived ease of use was administered. The final section allowed for comments to be made regarding the components evaluated and if any changes needed to be made. Only subjective measures were taken as the prototype evaluation was used as validation for the appropriateness of the guidelines.

Only five participants from each discipline were required to gain an understanding of the appropriateness of the components for the task (Nielsen, 2012; Virzi, 1992). Additionally, the small sample size is appropriate due to the fact that the interface presented in the prototype was not mature (Sauro & Lewis, 2012). Double the number of students were chosen to balance any bias related to habits and to better identify major problems (Faulkner, 2003), yet no major skew in the data was found. The participants were recruited via email and word of mouth. All perceptions were collected on a 5-point Likert scale (where 1 was always negative and 5 was always a positive response) while the recommendations and comments section were open ended short answer.

8.5.5 Results

Evaluation of the prototypes were conducted with 21 participants. Of these 21, 11 of these participants were from Engineering and 10 from Design. Eight of the respondents from Engineering were male while three were female; eight of the respondents from Design were female and two were male. These results were deemed not bias as the ratio of male to female is heavily skewed towards female in the design discipline and male in the engineering discipline. The average age of participants from Engineering was 21 with a standard deviation of 2.1 and 21 with a standard deviation of 1.1 for Design.

The perceived usefulness of the seven total components was investigated with a 5-point Likert scale (see Table 8.2). A score of 1 was strongly disagree and a score of 5 was strongly agree with the usefulness. Overall, both groups of students reported to agreeing that the five common components were important to them. Notetaking received a 4.0 average for both disciplines. Engineering students gave the component a 4.1 and design students gave the component a 3.9. The highlighting component received a mean score of 4.6, with engineering students giving it a 4.7 and design students a 4.5. The tested dictionary component was given a mean rating of 4.3. Engineering students gave it a mean score of 4.2 while design students assigned a mean of 4.4. Video was also agreed as important to students with an average rating of 4.1. Students from Engineering rated the component with a 4.0 and design students a 4.2. Students from both disciplines stressed the importance in the video content being highly related to the text content and that if it was not it lost its value. Similarly, manipulatable images were given a 4.2 average rating. Engineering students rated them 4.3 and design students 4.2. The two discipline specific skills were also perceived as generally useful. Design students rated the Tagging feature a 3.6 (neutral to agree). The slight decrease in score is related to reported personal use. Students who rated it neutral felt that they personally might not use it frequently but felt that their classmates would. Engineering students were more decisive with their discipline specific component of Interactive Equations as it is often required in their courses. The component received a mean rating of 4.4.

Components	Average Score Engineering	Average Score Design	Average Score Total
Notetaking	4.1	3.9	4.0
Highlighting	4.7	4.5	4.6
Dictionary	4.2	4.4	4.3
Video	4.0	4.2	4.1
Images	4.3	4.2	4.2
Tagging	---	3.6	---
Interactive Equation	4.4	---	---

Table 8.2. Perceived Usefulness of components.

The perceived ease of use of the seven total components were investigated with a 5-point Likert scale (see Table 8.3). A score of 1 was very difficult to use and a score of 5 was very easy to use. Overall, both groups of students reported to agreeing that the five common components would be easy to use. Notetaking received a 4.3

average for both disciplines. Engineering students gave the component a 4.6 and design students gave the component a 4.0. The highlighting component received a mean score of 4.6, with engineering students giving it a 4.8 and design students a 4.3. The tested dictionary component was given a mean rating of 4.6. Engineering students gave it a mean score of 4.5 while design students assigned a mean of 4.6. Video was also agreed as important to students with an average rating of 4.3. Students from Engineering rated the component with a 4.2 and design students a 4.5. Similarly, manipulatable images were given a 4.2 average rating. Engineering students rated them 4.3 and design students 4.1. The two discipline specific skills were also perceived as generally useful. Design students rated the Tagging feature a 4.1. Engineering students gave the component Interactive Equations a mean rating of 4.5. This enthusiasm is in line with past literature regarding interactive equations in Math students (Bode et al., 2014).

Components	**Average Score Engineering**	**Average Score Design**	**Average Score Total**
Notetaking	4.6	4.0	4.3
Highlighting	4.8	4.3	4.6
Dictionary	4.5	4.6	4.6
Video	4.2	4.5	4.3
Images	4.3	4.1	4.2
Tagging	---	4.1	---
Interactive Equation	4.5	---	---

Table 8.3. Perceived Ease of Use of components.

In addition to the modified TAM questionnaire, screenshots of interaction with the prototypes were taken to identify potential student behaviors with a similar electronic textbook (see Figure 8.7). Participants actively took text based and visual notes in the margins of the prototype and also took visual notes on the interactive images. Many students also attempted to take notes on the videos. They expressed displeasure when they found out they could not and it was one of the requests for the future design.

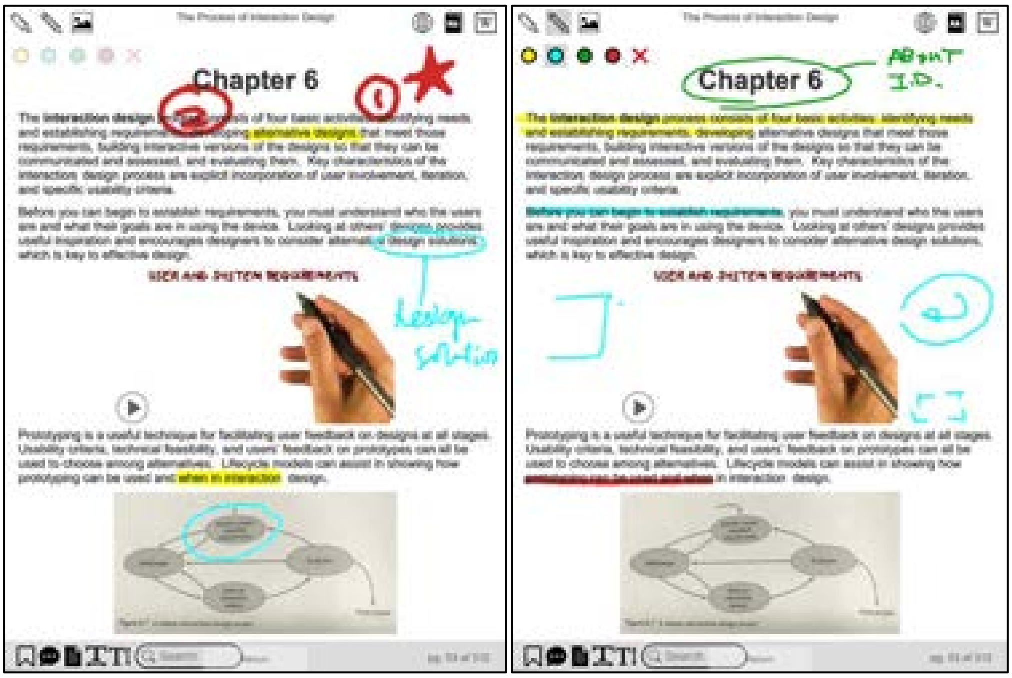


Figure 8.7. Examples of student interaction with design textbook prototype.

Similarly, engineering students frequently took notes in the margins of the prototype. Many of these notes related to equations (see Figure 8.8). Additionally, students used the naturalistic input of the annotation feature to take notes in the blank space under the interactive equations; also drawing images to help them visualize the problem (see Figure 8.9).

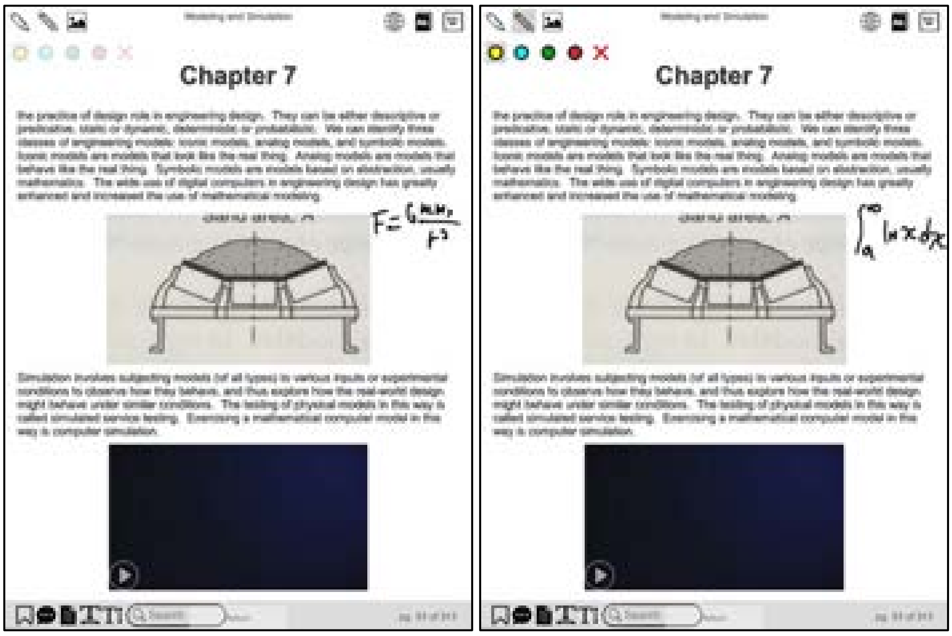


Figure 8.8. Examples of student interaction with engineering prototype.

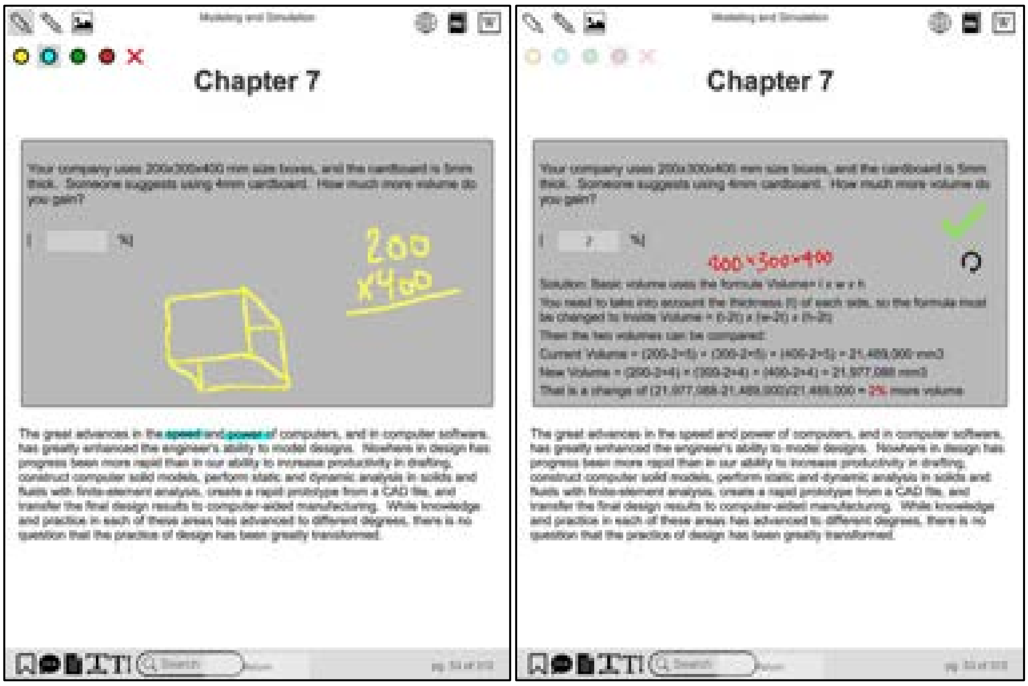


Figure 8.9. Examples of interaction with equation component in engineering prototype.

Generally, respondents were comfortable with the changes made to the components. Yet, they desired these components to be able to do more than the prototypes' technical restrictions allowed for. Annotation tools were requested to be expanded and used in every area of the prototypes. Students wished to pause and take notes in the videos and then access them again later by watching them appear with the video or through a text interface accessed in the video menu. The descriptions students used are similar to those already employed in many community-based online video and music streaming services. Respondents also frequently requested video components to include more things such as related videos, transcriptions, and detailed in navigation buttons. Annotation was also requested to be manipulated with the images. Overall, student responses called for more flexibility in components, content heavily focused on only relevant information, and electronic textbooks to take full advantage of the current and future technology.

8.6 Final Guidelines

The following guidelines are the core guidelines for all disciplines based on the TAM questionnaire data and based on the academic reading task across disciplines.

Text

Text remains core to the future electronic textbook. The text content will be highly relevant to the purpose of the electronic textbook and will be kept short and to the point. Only the most vital content will be represented in short blocks of text with additional text of explanations and examples minimized with an expanded option so that the additional text can be viewed if chosen.

Visually, text shall be manipulatable. Users can change the font, spacing between the words, spacing between the lines, and spacing between the paragraphs. Additionally, text color and background can be changed to suit the visual preference of the user.

Multimedia

Multimedia will act as a supplement for the shortened text. Only multimedia that is highly relevant to the content will be included. Various types of multimedia can be included based on the relevancy. Some examples of multimedia that could be included are videos, audio, podcasts, images, and animations. Multimedia shall be embedded within the textbook and allow for interaction with the annotation, highlighting, and bookmarking components.

Visual and audio multimedia will have advanced internal navigation such as pause, skip, stop, and play where applicable and time bars so that interaction with the content can be efficient. All multimedia will include transcripts where applicable.

A subset of multimedia, images, should be presented in a way, which is most appropriate to support the content. All images should be expandable to full screen and rotatable in orientation. Images will be able to be manipulated and are represented in 3-D to facilitate learning. The images can have layers removed, spliced, and rotated so that the full information can be understood, especially when representing complex systems.

Highlighting

Highlighting tools assist in students locating information they previously deemed important. Highlighting tools need to allow a free form input rather than one that only selects text. While this component is selected over text, it will automatically correct for small imprecise movements of the hand or stylus, but if moved drastically or selected in an open space, it will remain a naturalistic input.

This tool will allow for users to select from a range of colors that fit their needs and have a high level of transparency so as to not impede reading. If multiple colors are selected, an option to create a legend or key to apply meanings, which can later be referenced to the colors shall be available. Highlighting tools will allow for students to edit the highlights easily without creating gaps or requiring the entire highlight to be changed. Highlighting components shall be able to be used in all sections of the textbook including but not limited to resource lists available through tagging; equations; multimedia; and translation, dictionary, and encyclopedia content.

Annotation

Annotation tools are tools, which allow students to add their own notes to their textbooks so that they may find them quickly at a later date and deeper connections may be made by the student.

Annotation will allow free form input with a finger or stylus to mimic physical notetaking. Naturalistic input will allow for visual notetaking styles to be supported. In addition, annotation components will allow for the insertion of pictures, graphs, and other charts. Annotation tools will allow for spelling and grammar to be checked if desired by the user. In addition, the annotation component will display the notes where they are taken and a variety of colors will be available for users to choose from. Margins can be expanded to accommodate longer notes. If this is necessary, the notes will be resized to accommodate normal viewing of the page efficiently and then expanded again when selected.

All annotations, whether text or visual, shall be easily accessible for later viewing by students. Students should be able to print, project, or find annotations that they made without searching page by page. Annotation components shall be able to be used in all sections of the textbook including but not limited to resource lists available through tagging; equations; multimedia; and translation, dictionary, and encyclopedia content.

Translation, Dictionary, and Encyclopedia

Translation, Dictionary, and Encyclopedia options will be available for all text in the electronic textbook and come from only trusted and professional sources. Translation shall be available for any amount of text from a single word to the entire body of text. These components will assist students in understanding the concepts described in the text. These options will allow for integration with highlighting and annotation components.

Bookmarks

Bookmarks allow students to return to areas of their work that they feel are important or where they left off.

Bookmarks should be presented in a way which is easy for students to see and can be placed not only on pages, but also on exact words students left off at. This component can also be integrated into multimedia content.

8.6.1 Multiple Discipline Component Guidelines

The following guidelines are specific for the disciplines of design and engineering.

Integration with other Programs

Electronic textbooks should have integration with other programs. These programs may be learning based such as Moodle or Blackboard where students can access their notes or easily switch between the two if necessary.

In addition, integration with communication programs are important as well. This integration will allow for group discussions to be facilitated with video call or text messaging programs. Integration with social media may be necessary, for example an image in Pinterest may be imported as an annotation.

Additionally, links to experts for questions via email or other means is also vital. This will allow for immediate clarification of concepts and will also be useful for content creators for revisions. Moreover, links to other primary sources so that students may explore any concepts cited in the text is vital to comprehending the material.

Adaption with Various Devices

Electronic textbooks should work with all devices a student may use and synchronize across them without student intervention. This will allow for a streamlined use of the material and reduce cognitive load and stress.

Supplementary Materials

Supplementary Materials in the form of exercises, PowerPoints, and quizzes will be available with the electronic textbooks as appropriate to the content. These materials will include any answers fully worked out if necessary. This will facilitate student learning and classroom instruction for professors. The supplementary materials will be highly relevant to the content of the electronic textbook.

Hide Unimportant Aspects

Similar to the expanded section of text outlined in the text guideline, students shall be allowed to hide sections of text they deem as not relevant to their studies. The hiding action will not be permanent and hidden material can be reselected at any time. This component will allow for faster and more focused revision.

Accessibility Technology

Speech to Text and Text to Speech will also be included for students with various impairments. Speech to Text will allow users who are not able to use a naturalistic input or text input to use the annotation tools. Text to speech will read the selected text to the user, which is beneficial for those users with visual impairments.

8.6.2 Discipline Specific Guidelines

The following guidelines are specific to the disciplines of design or engineering only.

8.6.2.1 Engineering Specific

Equations

The use of equations is a common requirement in the study of some content. Equations presented in electronic textbooks will allow for more interaction with the user. These equations will allow for users to work out the equations themselves in the textbook equation box and then will automatically highlight any wrong steps. Detailed solutions will be provided to users and multiple strategies to achieve the solutions will be displayed if applicable. Annotation and highlighting shall be available for use with questions and solutions.

View of Multiple Materials

The ability to view multiple electronic textbooks at once is beneficial to users when working on projects or during revision. Interfaces will allow for multiple textbooks to be viewed and interacted with at once in a clear way that makes a distinction between the various materials.

8.6.2.2 Design Specific

Concept Orientation

Concept orientation to allow for flexibility and freedom in understanding the concepts presented are important when making connections that supports deeper reading.

Strategies such as tagging and search functions shall be used to do this in a nonlinear way whereas table and contents and indexes shall do it in a more traditional and linear way. Clicking on a tagged concept will show not only where the concept is within the book, but also will give links to other resources such as textbooks and journal articles on the same content. The links provided should reflect nonbiased representations of the concepts through varied and critical opinions. Search functions should allow for easy searching of any concepts within the text, not only those that are tagged as more important. All strategies will have integration with highlighting and annotation components.

8.6.3 Breakdown of Methods from Which Guidelines were Derived

The following table (Table 8.4) contains a breakdown of which research methods from which the final guidelines draw. When a guideline was influenced by the relevant literature, that is also listed.

Guidelines	Research Methods
Text	Survey, Focus Group, Experiment, Literature, Prototype Evaluation
Multimedia	Survey, Focus Group, Interview, Literature, Prototype Evaluation
Highlighting	Survey, Focus Group, Experiment, Literature, Prototype Evaluation
Annotation	Survey, Focus Group, Interview, Experiment, Literature, Prototype Evaluation
Translation, Dictionary, & Encyclopedia	Survey, Focus Group, Prototype Evaluation
Bookmarks	Survey, Focus Group, Prototype Evaluation
Integration w/ Programs	Survey, Focus Group, Interview
Adaption w/Various Devices	Survey, Focus Group
Supplementary Materials	Survey, Focus Group, Interview, Literature
Hide Unimportant Aspects	Survey, Focus Group, Interview
Accessibility Technology	Survey, Focus Group, Interview, Literature
Equations	Survey, Focus Group, Literature, Prototype Evaluation
View of Multiple Materials	Focus Group
Concept Orientation	Survey, Focus Group, Interview, Prototype Evaluation

Table 8.4. List of methods from which individual guidelines were derived.

8.7 Comparison of Guidelines to Existing Applications

In order to fully understand the future of electronic textbooks, an overview of the current situation should be made. Four standards for electronic textbooks and one online interface (Vital Source) for electronic textbooks were evaluated based on how they support the guidelines presented in this chapter (see Table 8.5). At this time, no electronic textbook fully follows all of the guidelines, nor do they take full advantage of the current technological advances. Since not every electronic textbook in existence can be investigated in relation to compliance with the guidelines outlined in 8.6, current application restrictions and capabilities are used as the metric. While some applications may list partial compliance, their compliance may differ substantially. For example, Kindle books allow for some audio and video with extreme restrictions whereas iBooks allows for more freedom in interaction such as rotatable 3D images.

	Kindle	**iBooks**	**Google Play Books**	**Vital Source**	**PDF**
Text	+	+	O	+	X
Multimedia	O	O	O	O	O
Highlighting	O	O	O	O	O
Annotation	O	O	O	O	O
Translation, Dictionary, and Encyclopedia	O	O	O	O	O
Bookmarks	X	X	X	X	X
Integration with other Programs	X	X	X	O	X
Access to Annotations and Images	O	O	O	O	X
Adaption with Various Devices	O	O	O	O	X
Supplementary Materials	O	O	O	O	X
Hide Unimportant Aspects	X	X	X	X	X
Accessibility Technology	+	+	+	+	+
Equations	X	X	X	X	X
View of Multiple Materials	X	X	X	X	O
Concept Orientation	O	O	O	O	O

Note: Compliance is outlined with the following symbols: X, O, and +. X denotes that it is noncompliant. O denotes partial compliance and + denotes full compliance with the guidelines.

Table 8.5. Comparison of guidelines to existing interfaces.

Several projects for electronic textbook standardization have been created and discussed, but they are often related to one specific format of textbook (Hoel, 2013; ISO/IEC JTC 1/SC 34, 2013) or are quite general (Arenas & Barr, 2013; Belfanti & Gylling, 2014). None have presented a holistic approach to future electronic textbooks that allow for flexibility for technological advances in the future as those presented in this dissertation.

Chapter 9. Conclusion and Future Work

9.1 Conclusion

The research outlined in the previous chapters found that designing future electronic textbooks based on discipline will better meet students' academic reading requirements and assist in the acceptance of the new medium. Individual disciplines have different requirements for the students to assist in the learning of the material and this needs to be taken into consideration, something that was reflected in both student and professors responses. The singular design of electronic textbooks that is currently the norm, will not work for all students. In the past, it has been requested that future textbooks become more coherent and content is tailored based on the reader group utilizing them (Hartley, 1990).

The work outlined in this dissertation also investigated the supporting activities these students feel are necessary for success. Similar to previous research, this work found that students most commonly employed highlighting and notetaking (Schilit et al., 1998; Liu, 2005). Students did not consider the supporting components currently employed in electronic textbooks appropriate for their academic reading task and were unhappy with the current interaction requirements. In addition, students felt electronic textbooks do not fully take into account the capabilities of new technology to support the learning of material. Through analysis of the needs and current interactions, it was found that in-app components need to be designed to support academic reading requirements. It was this information that was utilized during the creation of the guidelines, subsequent testing with the basic prototypes, and iteration of those guidelines outlined in Chapter 8. Finally, by presenting the components outside of the restrictions of a specific piece of technology, yet taking into account the effect of layout on cognitive load and the task of academic reading, will allow for more flexibility in future technological applications.

9.1.1 Major Findings

The work outlined in this dissertation contributed to the research area by providing new insights on the effects of electronic textbooks on academic reading, including input from students, to help design future electronic textbooks based on the academic reading task and presenting components outside of technology while taking into account cognitive load to allow for more flexibility and longevity. Major findings from the methods outlined in the chapters above are as follows:

- Several core components were identified as necessary to support the academic reading task in all future electronic textbooks regardless of discipline or education level. These core components are: text, highlighting tools, bookmarks, multimedia, translation capabilities, dictionaries, and encyclopedias.
- In the future, electronic textbooks need to be discipline specific, include less text with highly relevant multimedia to support the limited text, and be more interactive.
- Students and professors from different disciplines have varying views of the purpose of electronic textbooks and the tools needed for academic success. Members of the design discipline view textbooks as a starting point for the

understanding of material and members of the engineering discipline believe that textbooks are only for learning the assigned material.

- It was found that professors and students from the same disciplines mirror each other's views regarding the role of electronic textbooks in education and generally have the same view on the components necessary for future electronic textbooks. Findings showed that professors believe students did less academic reading than they actually report doing. This is related to when the students complete the readings, as many students complete readings well after the professors assigned them.
- It was found the smartphone screen size negatively affected the perception of reading. Moreover, that the frequently employed supporting activities of highlighting and notetaking are not sufficiently supported in current electronic textbooks. In addition, uses of these activities significantly decreased when moving from paper to the electronic medium. As these supporting activities are vital during the revision process, a negative effect on academic performance and perception can be hypothesized.
- Several areas of ergonomic concern and possible paths to solutions were identified using the Hexagon-Spindle Model. Areas of concern include component design, muscular-skeletal issues, and a lack of policies.
- Finally, content and interface guidelines were created for content creators and electronic textbook designers to facilitate the design of future electronic textbooks. These guidelines were specific for the support of the academic reading task and are presented outside the restrictions of current technology.

9.2 Scope of This Work and Future Work

The research outlined in this dissertation was limited with only two disciplines, Design and Engineering, and only one education level, undergraduate. In the future, guidelines for other disciplines and education levels should be developed through similar research methods. The findings from that research will also assist in informing and refining the core guidelines. In addition, this research should be repeated as technology advances. Although the research outlined above was undertaken outside a specific form of technology, future technology may influence student perceptions and acceptance of future components.

The improvements in current technology and future technological advances will only create different environments for students to study. Additionally, full case studies with prototypes based on these guidelines should be conducted in classrooms, which is outside of the scope of the work presented in the previous chapters. The effects of the implementation in classrooms are important to identify any ergonomic risks, both physical and cognitive, or negative effects on academic performance. Findings from a long-term case study such as this will assist in making guidelines better and developing corresponding technology to support academic reading.

Focus needs to remain on successfully supporting students in their endeavors to succeed educationally. This support has to be done on a discipline specific level. To successfully do this, an understanding of the underlying reasons why the components are chosen by the disciplines and not simply a presentation the components are necessary. The guidelines presented in the last chapter are not tied to a specific form of technology and must be adapted based on future technological advances whether those advances come in tablets, virtual reality devices, or any other technology. To allow for the success of future students, designers and content creators cannot allow electronic textbooks to become stagnant, as education must change with the future needs and all educational tools should be taking advantage of the technological advances to facilitate learning.

Appendix A

Survey Questions

Survey can be accessed online at:

https://docs.google.com/forms/d/11q8K67DWr627NDXSkCxajwOWmv3SNepqBw_dLo7nak/viewform

Future of Electronic Textbooks

This survey is a part of my ongoing research on the future of electronic textbooks. As part of this study, this survey aims to explore what functionality current university students wish to see implemented in electronic textbooks. It also sets to identify useful tools related to students' individual field.

Please only fill out this form if you are a current university student. The survey has a deadline of January 15, 2015. It should take only 10-15 minutes to complete.

All information gathered through this survey will be kept confidential and you may skip any question that you do not feel comfortable answering. By submitting this survey you agree to take part in this project. If you have any questions, please contact me at kimberly.sheen@

* Required

What is your gender?

- Male
- Female

What is your age range?

- Under 18
- 18-24
- 25-34
- 35-50
- 50+

What is your nationality?

What is your current year at University?

- Undergraduate
- Higher Diploma
- Masters
- PhD

Which discipline do you study?

Have you ever used an electronic textbook?

Note: An electronic textbook should be defined as a traditional textbook that can be accessed on an electronic device such as a computer, tablet, or mobile phone.

- ○ Yes
- ○ No

What percentage of the time do you use electronic textbooks?

When compared to physical textbooks.

- ○ Never
- ○ 1-25%
- ○ 26-50%
- ○ 51-75%
- ○ 76-100%

Now thinking to the future of electronic textbooks, please check all of the features you would want in an electronic textbook.

Do not focus on what may or may not be possible with current technology. Check as many as you wish.

- ☐ Text
- ☐ Multimedia (videos and podcasts)
- ☐ Manipulatable and 3-D images
- ☐ Interactive equations
- ☐ Highlighting Tool
- ☐ Annotation Tool
- ☐ Bookmarks
- ☐ Integration with eLearning platforms (Blackboard or Moodle)
- ☐ Synchronization across devices
- ☐ Project or print annotations
- ☐ Translation, Dictionary, and Encyclopedia
- ☐ Link to experts for answers to questions
- ☐ Text to speech
- ☐ Speech to text
- ☐ Time Management System
- ☐ Supplementary materials (powerpoints, chapter summaries, and quizzes)
- ☐ Hide unimportant aspects of the book
- ☐ Other: ______

Please rank the features from most important (1) to least important (17). *

Every feature must have a different rank.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Text	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○

Multimedia (videos and podcasts)	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Manipulatable and 3-D images	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Interactive equations	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Highlighting Tool	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Annotation Tool	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Bookmarks	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Integration with eLearning platforms (Blackboard or Moodle)	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Synchronization across devices	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Project or print annotations	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Translation, Dictionary, and Encyclopedia	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Link to experts for answers to questions	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Text to speech	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Speech to text	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Time Management System	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Supplementary materials (powerpoints, chapter summaries, and quizzes)	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Hide unimportant aspects of the book	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○

Are there any features you would not want to see in your electronic textbook? Check as many as you wish.

☐ Text

☐ Multimedia (videos and podcasts)

☐ Manipulatable and 3-D images

☐ Interactive equations

☐ Highlighting Tool

☐ Annotation Tool

- [ ] Bookmarks
- [ ] Integration with eLearning platforms (Blackboard or Moodle)
- [ ] Synchronization across devices
- [ ] Project or print annotations
- [ ] Translation, Dictionary, and Encyclopedia
- [ ] Link to experts for answers to questions
- [ ] Text to speech
- [ ] Speech to text
- [ ] Time Management System
- [ ] Supplementary materials (powerpoints, chapter summaries, and quizzes)
- [ ] Hide unimportant aspects of the book
- [ ] Other:

Submit

Never submit passwords through Google Forms.

Appendix B

Semi-Structured Focus Group Questions for Students

Part A

1. What percentage of your time doing academic reading, per week, is spent with physical textbooks? What percentage in electronic textbooks?
2. On average, how long do you normally spend reading your physical textbook in any given day?
3. Location-wise, where do you do most of your reading in a physical textbook?
4. What time of day do you do most of your reading in your physical textbook?
5. What type of activities do you do to support your readings in your physical textbook, for example highlighting or note taking?
    a. Follow up question based on answer (ex. Do you do the highlighting directly in the book? Do you take notes in a physical notebook or on a word processor?)

Part B

6. Moving on to electronic textbooks, how would you define an electronic textbook? [Activity with poster paper and brainstorming]
7. Why did you decide to use electronic textbooks?
8. What types of electronic devices do you use to access your electronic textbooks?
    a. Follow up question based on the answer (ex. What do you think is easiest to use with your electronic textbooks? Why?)

9. What type of activities do you do to support your electronic textbook reading, for example highlighting or note taking?
    a. Follow up question based on answer (ex. Do you highlight using the application in the electronic textbook? Do you take notes in a word processor or in a physical notebook?)
10. On average, how long do you normally spend doing school reading in an electronic textbook?
11. Location-wise, where do you do most of reading in an electronic textbook?
12. What time of day do you do most of your academic reading in your electronic textbook?
13. How different is using an electronic textbook from using a physical textbook?
    a. Why do you believe this is so?

Part C

14. Now, let's look towards the future of electronic textbooks, would changes in electronic textbooks to make them more interactive make you more or less likely to use them over physical textbooks?
15. In your opinion, what would make electronic textbook reading on a tablet more desirable?
16. Looking at these components that were listed by students in your department as desirable, why do you think they are useful or not useful?
17. Including but not limited to those components, what components should be part of an electronic textbook? Which components cannot be a part of it? What is the right way to organize it? What is the wrong way? [Activity to

organize them into columns and discover interaction -- WHAT cognitive mapping]

18. Can you think of anything else you would want to add or change?

Appendix C

Semi-Structured Interview Questions for Professors

1. How many years have you been teaching at the University level?
2. How do you see electronic textbooks fitting in your teaching practices?
3. How do you think your students should be engaging with electronic textbooks?
4. What do you believe the differences are between physical and electronic textbooks?
5. Looking at these components that were listed by undergraduate (engineering/design) students as desirable/undesirable, what are your views on this?
6. What do you think should be included in future electronic textbooks? (examples: audio, video, anything outside of the current technology)

Appendix D

Data Sheets for Experiment

Participant Number: Setting:

Education Level: Discipline:

Age: Gender:

Score on Pretest: /9

IN EACH SETTING:

Condition 1:

Time Spent Reading:

Number of times paged backwards:

Reading Style:

Condition 2:

Time Spent Reading:

Number of times paged backwards:

Reading Style:

Condition 3:

Time Spent Reading:

Number of times paged backwards:

Reading Style:

Condition 4:

Time Spent Reading:

Number of times paged backwards:

Reading Style:

Pretest Questions

Passage:

Well, we were not all sure in those days if that was what we wanted; after all, perhaps it was some sort of scandalous trick. Still, we persisted, putting up with the long hours, poor working conditions, low pay, and dangerous environment in the hope that someday we too could improve our lives and move beyond this social void.

What was the pay like?

A) High pay
B) Normal pay
C) Low pay

What were the working conditions?

A) Dangerous
B) Safe
C) Normal

Who does the author speak on behalf of?

A) Workers in poor working environments
B) Mothers of disabled children
C) Newly wealthy members of society
D) Sportsmen at retirement age
E) Environmental advocates

Passage:

Ask any modern astrophysicist and he will tell you that the future of physics is found in string theory. Ask that same physicist to explain how string theory works and he will certainly not be able to. See, string theory is one of those hyped-up, overrated movies that are endlessly promoted and may very well do poorly. Sure, it's a great idea on paper, but it is still a theory and there exist many logical conflicts with string theory. Just take what "experts" tell you with a grain of salt.

The main idea or focus is that:

A) String theory has yet to mature.
B) In science, there are many questions to be asked but few are answered.
C) Science is hyped-up and overrated
D) String theory is fundamentally flawed
E) String theory is only a theory

Beauty is in the eye of the beholder, or so the cliche states. It is probably an accurate one, for beauty is a concept with a short-lived definition. In fact, beauty varies from culture to culture - some African cultures find women with large noses particularly attractive, while in the West we favor the standard blond. Those who try to enforce beauty typically come up short - just ask Hitler how his Aryan race is doing these days. The fact of the matter is that beauty is something to be appreciated and not understood.

Which of the following examples corresponds to the "blond" on line 8?

A) a diamond in the rough
B) reflective beauty
C) conflicting perceptions
D) typical perceptions
E) loud personality

Preference Questions Paper

For each of the questions below, circle the response that best characterizes how you feel about the statement.

	Very Large	Large	Ideal	Little	Very Little
1. The amount of text presented on the average page was	1	2	3	4	5

For each of the questions below, circle the response that best characterizes how you feel about the statement on the scale.

	Very Difficult	Difficult	Neutral	Easy	Very Easy
2. Turning pages was	1	2	3	4	5

	Very Bad	Bad	Neutral	Good	Very Good
3. The format of the text on the page was	1	2	3	4	5

	Very Bad	Bad	Neutral	Good	Very Good
4. The readability was	1	2	3	4	5

5. Do you have any other comments?

Preference Questions Screen

For each of the questions below, circle the response that best characterizes how you feel about the statement.

	Very Large	Large	Ideal	Little	Very Little
1. The amount of text presented was	1	2	3	4	5

	Very Small	Small	Ideal	Large	Very Large
2. The screen size was	1	2	3	4	5

For each of the questions below, circle the response that best characterizes how you feel about the statement on the scale.

	Very Difficult	Difficult	Neutral	Easy	Very Easy
3. Switching pages was	1	2	3	4	5

	Very Bad	Bad	Neutral	Good	Very Good
4. The format of the text was	1	2	3	4	5

	Very Bad	Bad	Neutral	Good	Very Good
5. The readability was	1	2	3	4	5

6. Do you have any other comments regarding the tools or text display?

Preference Questions Screen (Group B)

For each of the questions below, circle the response that best characterizes how you feel about the statement.

	Very Large	Large	Ideal	Little	Very Little
1. The amount of text presented was	1	2	3	4	5

	Very Small	Small	Ideal	Large	Very Large
2. The screen size was	1	2	3	4	5

For each of the questions below, circle the response that best characterizes how you feel about the statement on the scale.

	Very Difficult	Difficult	Neutral	Easy	Very Easy
3. Switching pages was	1	2	3	4	5

	Very Bad	Bad	Neutral	Good	Very Good
4. The format of the text was	1	2	3	4	5

	Very Bad	Bad	Neutral	Good	Very Good
5. The readability was	1	2	3	4	5

	Very Difficult	Difficult	Neutral	Easy	Very Easy
6. Highlighting was	1	2	3	4	5

7. Do you have any other comments regarding the tools or text display?

Preference Questions Screen (Group C)

For each of the questions below, circle the response that best characterizes how you feel about the statement.

	Very Large	Large	Ideal	Little	Very Little
1. The amount of text presented was	1	2	3	4	5

	Very Small	Small	Ideal	Large	Very Large
2. The screen size was	1	2	3	4	5

For each of the questions below, circle the response that best characterizes how you feel about the statement on the scale.

	Very Difficult	Difficult	Neutral	Easy	Very Easy
3. Switching pages was	1	2	3	4	5

	Very Bad	Bad	Neutral	Good	Very Good
4. The format of the text was	1	2	3	4	5

	Very Bad	Bad	Neutral	Good	Very Good
5. The readability was	1	2	3	4	5

	Very Difficult	Difficult	Neutral	Easy	Very Easy
6. Note taking was	1	2	3	4	5

7. Do you have any other comments regarding the tools or text display?

Post Reading Questions

Post reading questions **Passage 1**
(pg 47-49)

1. Why were the first slaves brought to the US?
   a) To clean houses
   b) To work plantations
   c) To sing songs
   d) To run cities

2. Why are the people who established the colonies called founders instead of immigrants?
   a) They arrived first
   b) They were all from the same country
   c) They set the laws and customs
   d) They conquered the area

3. Which group thought they would create a "city on a hill"?
   a) The Middle Class
   b) The Church of England
   c) The Aristocrats
   d) The Puritans

4. Why didn't all the colonies speak the same languages?
   a) They were founded by different countries
   b) Freedom to speak their native languages
   c) For religious reasons
   d) Slavery

5. What was the largest driving force behind the quick expansion of the colonies?
   a) Money
   b) Religion
   c) Politics
   d) Slavery

Post reading questions **Passage 2**
(pg 51-53)

1. How did the article define "Stage Migration"?
   a) To ride on a stage coach
   b) To move homes using a stage coach
   c) To move to a city and then a foreign country
   d) To move cities within a country

2. What made migration safer?
   a) Steam ships and trains
   b) The new police system
   c) A lack of pirates
   d) New health safety practices

3. Who caused the most problems related to discrimination and racism?
   a) Native-born Americans
   b) Old Immigrants
   c) New Immigrants
   d) Native Americans

4. What was the main reason for the acts of discrimination and racism?
   a) Nativism: The dislike of people and things foreign.
   b) Bigotry: The intolerance towards those who hold different opinions from oneself.
   c) Classism: The prejudice against people belonging to a particular social class.

5. There were several times in American history where unity between the people minimized the instances of discrimination and racism, what caused this?
   a) Immigration
   b) War
   c) Religion
   d) Education

Post reading questions **Passage 3**
(pg 74-77)

1. The forced separation policy did what?
   a) Moved Native Americans to reservations
   b) Didn't allow Native Americans inside their colonies
   c) Forced Native Americans to give up their culture
   d) Kept colonists in their cities

2. What was the main reason for reoccurring issues between colonists and Native Americans?
   a) Mistreatment
   b) Money
   c) Land
   d) Slavery

3. What was the reason for the initial peace between the Native Americans and the English Colonists?
   a) The trading possibilities
   b) Lack of knowledge
   c) Marriages
   d) There was enough land for everyone

4. To this day, Native Americans mistrust the American Government. What historical instance caused this?
   a) New disease
   b) Foreign technologies
   c) Mass killings
   d) Enslavement
   e) Loss of land

5. During the struggles between the Native Americans and the colonists, both sides received help from people who could be considered enemies. Why did they accept this help?
   a) The limited benefits it would bring to them
   b) To wipe out their enemy
   c) They were treated fairly in comparison
   d) Fear of falling to their enemies
   e) To avoid future conflict

Post reading questions **Passage 5**
(pg 286-287)

1. The majority of Americans believe that the media should act as what?
   a) An educator
   b) A government watchdog
   c) An entertainer
   d) An agenda pusher

2. Generally, people are confident that what they hear in the media is correct.
   a) True
   b) False

3. How do media outlets decide what they will report on?
   a) The government tells them what to report
   b) Local people tell them what to report
   c) Journalists decide what they want to report
   d) Business men tell them what to report

4. Personal privacy is considered to be in danger because of the media.
   a) True
   b) False

5. The media is considered bias by many people. What is the main influence of this bias?
   a) Money
   b) Religion
   c) Politics
   d) Entertainment

Appendix E

Modified TAM Questionnaire

Scale	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
	1	2	3	4	5

Perceived Usefulness

Notetaking component with natural input with stylus	1	2	3	4	5
Free highlighting in multiple colors with stylus input	1	2	3	4	5
Encyclopedia/Dictionary	1	2	3	4	5
Imbedded multimedia	1	2	3	4	5
Movable images	1	2	3	4	5
Additional references for selected keywords	1	2	3	4	5

Perceived Ease of Use

Notetaking component with natural input with stylus	1	2	3	4	5
Free highlighting in multiple colors with stylus input	1	2	3	4	5
Encyclopedia/Dictionary	1	2	3	4	5
Imbedded multimedia	1	2	3	4	5
Movable images	1	2	3	4	5
Additional references for selected keywords	1	2	3	4	5

Comments or Suggestions

Notetaking	
Highlighting	
Encyclopedia/Dictionary	
Multimedia	
Movable images	
Keywords	

Scale	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
	1	2	3	4	5

Perceived Usefulness

Notetaking component with natural input with stylus	1	2	3	4	5
Free highlighting in multiple colors with stylus input	1	2	3	4	5
Encyclopedia/Dictionary	1	2	3	4	5
Imbedded multimedia	1	2	3	4	5
Movable images	1	2	3	4	5
Interactive Equations with steps	1	2	3	4	5

Perceived Ease of Use

Notetaking component with natural input with stylus	1	2	3	4	5
Free highlighting in multiple colors with stylus input	1	2	3	4	5
Encyclopedia/Dictionary	1	2	3	4	5
Imbedded multimedia	1	2	3	4	5
Movable images	1	2	3	4	5
Interactive Equations with steps	1	2	3	4	5

Comments or Suggestions

Notetaking	
Highlighting	
Encyclopedia/Dictionary	
Multimedia	
Movable images	
Interactive Equations	

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