

SpokenText Reader:  
Testing a Study Support Mobile Application for  
Visually and Learning Impaired University Students

by

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A thesis submitted to the Faculty of Graduate and  
Postdoctoral Affairs in partial fulfillment of the requirements for  
the degree of

Master of Arts

in

Human Computer Interaction

Carleton University  
Ottawa, Ontario

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## **Abstract**

This study evaluated SpokenText Reader, a smartphone application to aid the print disabled who study from audio recordings. Based on a literature review and usability test, conducted with print disabled university students, it was determined they could be better accommodated using SpokenText Reader while studying.

Additionally, a model emerged for a hybrid design, which blends features offered by SpokenText Reader with those offered by current smartphone e-text readers designed for the print disabled. The new model proposes a design, which has e-text under the hood but offers two interfaces: one with a user experience biased to interacting with the e-text and the second with a user experience biased to audio generated from the e-text in real-time.

## Acknowledgements

Being a person with a print disability this thesis represents a monumental undertaking and many hours of physical and emotional pain. The journey was overwhelming at times and has been the hardest thing I have ever done, but the end-result was worth it. Few disabled people are ever able to achieve a master's degree. I am grateful that I was one of them and would like to thank the following people who help me achieve this lifelong goal and who supported me throughout the four yearlong journey it took to complete my master's coursework and this thesis.

I would like to thank my graduate supervisor Professor Alex Ramirez for his guidance, support and wisdom as he encouraged me to take this program because I have spent my whole life designing and customizing interfaces to meet my needs. And he was right. It was the best choice of the options I was considering.

My loving wife Kimberly Fish was there for me when I needed support and advice. She helped to take care of our three children when I needed to study, which I appreciated immensely.

My three beautiful girls: Teagan McKay, Avery McKay and Madeline McKay you are the reason why I get up every day and push forward trying to improve myself. All three of you gave me the time to work, when I know you wanted me to play with you and for this, I will be eternally grateful.

Finally, it is said that behind every successful disabled person is a parent who was there to fight for them and make sure they had the best chance at a rich and fulfilling life. For me, this person is my mother Anna Stewart. She saw that a computer would benefit me in my schoolwork so purchased one for me. I was 12 years old. This started a lifelong passion for and an eventual career in computing. The Tandy 1000 my mother scraped up the money to buy for me was extremely expensive by today's standards as it was not common for people to have a computer at home. This was during the early days of personal computers when they were just entering businesses and wealthy home hobbyists were playing with them at home. The fact that as a 12-year-old child I had my own PC for my schoolwork was incredible when you consider how rare and expensive they were in 1986. As a single working mother of two, she sacrificed to ensure I had what I needed to succeed in school and has always been there for me when I needed her! For this, I will always be in her debt and will make sure that I show this unconditional love to my children.

If you read this thesis and want to discuss accessibility, my findings, the methods I used or need advice on a similar research project, please do not hesitate to contact me at [mark@spokentext.net](mailto:mark@spokentext.net). This area of research is not well-studied, so I will help anyone who asks with the aim of giving back to the community, which has given me so much over my lifetime.

## Table of Contents

<b>Abstract.....</b>	<b>ii</b>
<b>Acknowledgements .....</b>	<b>iii</b>
<b>Table of Contents .....</b>	<b>iv</b>
<b>List of Tables .....</b>	<b>viii</b>
<b>List of Illustrations.....</b>	<b>ix</b>
<b>List of Appendices.....</b>	<b>xi</b>
<b>1 Chapter: Introduction .....</b>	<b>12</b>
1.1 Motivation .....	13
1.2 Why I undertook this research topic? .....	13
1.3 Research Question.....	14
1.4 Defining the print disabled .....	14
1.5 Contribution.....	15
<b>2 Chapter: Literature Review.....</b>	<b>16</b>
2.1 Digital talking books .....	17
2.1.1 Conclusions Digital talking books .....	21
2.2 Audiobooks .....	21
2.2.1 Conclusions audiobooks.....	23
2.3 E-text .....	23
2.3.1 Conclusions E-text .....	26
2.4 App review .....	26
2.5 Gap in the Literature.....	29
<b>3 Chapter: SpokenText Reader Prototype .....</b>	<b>30</b>
3.1 Introducing SpokenText Reader.....	32
3.2 Some challenges faced when designing SpokenText Reader.....	33

3.3	SpokenText Reader prototype history .....	34
3.3.1	Initial prototype screenshots .....	35
3.3.2	Second major revision prototype screenshots .....	35
3.3.3	Screenshots (final revision prototype before changes made for usability testing)	36
3.3.4	Technology used to create the prototype.....	37
3.3.5	Why I used these technologies to create the prototype .....	38
3.3.6	Prototype development process.....	38
3.3.7	Strengths of this prototyping technology .....	38
3.3.8	Weakness of this prototyping technology .....	39
3.3.9	Prototype changes made before testing began .....	39
<b>4</b>	<b>Chapter: Usability Test .....</b>	<b>41</b>
4.1	Challenges faced as a visually impaired researcher .....	42
4.2	Participants .....	43
4.2.1	Description of participants .....	43
4.2.2	Recruiting participants from the Paul Menton Centre (PMC) .....	43
4.2.3	How participants were accommodated .....	44
4.2.4	Challenges with finding participants to study .....	44
4.2.5	Challenges with usability testing with visually impaired people .....	45
4.2.6	Challenges faced by participants when trying to navigate to the usability testing room	45
4.3	Consent form .....	46
4.4	Usability test introduction .....	46
4.5	Introduction which was provided orally to participants before the usability testing tasks were read aloud to participants .....	48
4.6	Tasks.....	49

4.6.1	Task walkthrough.....	51
4.7	Close out message said orally to all participants .....	58
4.8	Device used for testing .....	58
4.9	Testing room setup .....	59
4.10	Custom testing sled designed for testing with visually impaired people.....	62
<b>5</b>	<b>Chapter: Analysis.....</b>	<b>63</b>
5.1	Pre-test questionnaire findings .....	63
5.1.1	General participant demographics.....	63
5.1.2	Technology used to help in school.....	66
5.1.3	e-Text formats used by participants .....	67
5.1.4	Approaches to taking notes .....	69
5.1.5	Discussion .....	69
5.2	Usability test findings.....	71
5.2.1	Time on task.....	71
5.2.1.1	Discussion.....	76
5.2.2	Task completion success rates .....	77
5.2.2.1	Discussion.....	80
5.2.2.1.1	Setting in and out points for audio clip notes .....	80
5.2.2.1.2	Control labels causing confusion.....	82
5.2.2.1.3	Issues with using ‘Voice Over’ with hybrid applications.....	82
5.2.2.1.4	Challenges with the Swipe Me controller.....	82
5.2.2.1.5	Challenges with the sled.....	83
5.3	Post-test questions findings .....	83
5.3.1	Discussion .....	86
5.4	Ethnographic research methods used to analyze comments made by participants	87

5.4.1	Observational findings .....	87
5.4.2	Discussion .....	90
<b>6</b>	<b>Chapter: Discussion .....</b>	<b>92</b>
6.1	Low usage of mobile devices for studying.....	93
<b>7</b>	<b>Chapter: Conclusion and Future Study.....</b>	<b>94</b>
7.1	Summary .....	94
7.2	Potential for Future Work.....	94
	<b>References .....</b>	<b>96</b>
	<b>Appendices.....</b>	<b>99</b>
	Appendix A Study Consent Form .....	99
	Appendix B Email attachment sent out by Paul Menton Centre in MS Word format	101
	Appendix C Custom testing sled .....	103
	Appendix D Pre-test questions .....	114
	Appendix E Post-test questions .....	116
	Appendix F SpokenText.net project background .....	117

## List of Tables

Table 1: List of usability testing tasks	49
Table 2: Participants disability and experience with mobile technology	64
Table 3: Time on task values by participant for all users in minutes and seconds	74
Table 4: Time on task values by participant excluding those for P1 in minutes and seconds	75
Table 5: Time on task values by participant for all users in minutes and seconds excluding times for failed tasks	76
Table 6: Time on task values by participant excluding failed tasks and times for P1 in minutes and seconds	76
Table 7: Task Completion rate percentages by participant and by task	79
Table 8: Task pass or fail by Participant	79

## List of Illustrations

Figure 1: From left to right: Voice Dream Reader, Read2Go and iBooks .....	27
Figure 2: Example of text being highlighted on a page while studying .....	33
Figure 2: Initial prototype screenshots.....	35
Figure 3: Second major revision prototype screenshots .....	36
Figure 4: Final revision of prototype before changes made for usability testing .	36
Figure 5: Primary SpokenText Reader screen flow diagram.....	50
Figure 6: Annotated Library screen .....	50
Figure 7: Annotated Player screen.....	51
Figure 8: Library screen of SpokenText Reader.....	52
Figure 9: Player screen with a recording being listen to.....	53
Figure 10: Player screen showing a paused recording.....	54
Figure 11: Shows the main player screen (left) and the Add new note screen (right) which is shown after the Add new note icon is pressed on the player screen. ....	56
Figure 12: View all notes screen (left) View note screen (right).....	57
Figure 13: Edit note screen .....	58
Figure 14: Usability testing room setup for testing session.....	60
Figure 15: Layout of equipment used for the usability testing sessions. ....	61
Figure 16: Screen capture of recording being made of test session.....	61
Figure 17: Participant age ranges.....	64
Figure 18: Total participants by Faculty.....	65
Figure 19: Current year of study.....	65
Figure 20: Participant course load per term.....	66

Figure 21: Technology used to help in school .....	67
Figure 22: e-Text formats used by participants .....	68
Figure 23: Time on task for P1 and P4 .....	72
Figure 24: Time on task for P2, P3 and P5 .....	73
Figure 25: Task pass or fail percentage by task .....	78
Figure 26: Task pass or fail percentage by participant .....	78
Figure 27: How easy did you find SpokenText Reader to use?.....	84
Figure 28: Would you use SpokenText Reader to study, if you could? .....	85
Figure 29: Would you be willing to pay to use SpokenText Reader? .....	85

## List of Appendices

Appendix A Study Consent Form .....	99
Appendix B Email attachment sent out by Paul Menton Centre in MS Word format	101
Appendix C Custom testing sled .....	103
Appendix D Pre-test questions .....	114
Appendix E Post-test questions .....	116
Appendix F SpokenText.net project background .....	117

# **1 Chapter: Introduction**

Visually Impaired and learning disabled students have few options to overcome their limitations in an increasing digital world of academic resources. They are constantly trying to keep up and read the material needed to succeed in their chosen field.

This thesis project seeks to evaluate a mobile application to support students with low vision and learning disabilities who depend on audio to study and those who could benefit with an audio-based learning aid. The goal is to assess among those sampled if, after using SpokenText Reader, they see the benefits of having audio as a means to study.

The application allows users to mark-up audio files with notes, highlights and comments just like a person would write on or highlight parts of a printed document, while studying. Users will be able to mark-up audio files while studying and then have the ability to review their notes and edit them if needed.

The aim being to make it more efficient and effective for visually impaired and learning- disabled university students to study from audio recordings and write research papers, study for exams or create presentations.

Chapter 2 discusses literature published in the disciplines of psychology, computer science, library sciences and education, relating to digital talking books, audio books and e-text. Chapter 3 discusses the SpokenText Reader prototype evaluated as part of this thesis. Chapter 4 provides details on the usability test that was used to evaluate SpokenText Reader. Chapter 5 presents findings from the usability test discussed in Chapter 4, along with an analysis of key findings. Chapter 6 offers an overall discussion of findings, reflections and insights gained during the process of conducting this thesis research project.

Chapter 7 presents final conclusions and offers potential avenues for future research in the area of accommodating the print disabled.

## **1.1 Motivation**

I built SpokenText Reader to aid me in my studies. While it helped me, I wanted to know if other people with a similar disability to mine would be able to use it and find it of use.

## **1.2 Why I undertook this research topic?**

This project was created initially to aid me in my studies. I knew that as a master's student I would be expected to critically read a large number of research articles, reflect on them, sight portions of them in presentations and papers and discuss them in class.

This was in some ways an overwhelming situation to be faced with for someone with my visual disability. After sometime and reflection I concluded that I could potentially create an approach and application to aid me in my studies and possibly help others with similar needs to myself.

The application has been designed to meet my needs, but also contains features that I think might be of use to others who have a need to study from audio and may like to take notes in different ways. This is why I have added support for image, sound and video notes to support different learning styles and approaches.

This thesis project seeks to determine if my approach to dealing with converting printed text to audio and custom mobile application to consume the generated audio files might be of use, provide value and be usable by people with low vision and learning disabilities.

### **1.3 Research Question**

If a study resource is available as an audio file, how easy is it for visually or learning disabled students to take notes from it and to navigate the audio file by using SpokenText Reader? It works well for me but how well will it work for other visually impaired or learning impaired students? This is what I set out to determine.

### **1.4 Defining the print disabled**

Visually impaired and learning disabled people are often referred to by the term the print disabled which includes the physically disabled as well.

The Centre for Equitable Library Access (CELA) founded in late 2013, is a Canadian national not-for-profit organization created by Canadian public libraries and the Canadian National Institute for the Blind (CNIB), Canadian Urban Libraries Council (CULC) and the Canadian Library Association (CLA). CELA offers library services to any Canadian with a print disability.

CELA defines print disability as follows: a learning, physical or visual disability that prevents a person from reading conventional print (“CELA - What is a print disability?,” n.d.). They go on to further define these three areas as:

- Learning disability: An impairment relating to comprehension
- Physical disability: The inability to hold or manipulate a book
- Visual disability: Severe or total impairment of sight or the inability to focus or move one’s eyes

CELA’s definition of print disability is taken from the Canadian Copyright Act The term used in the act is “perceptual disability”.

For the remainder of this thesis print disability will be used to refer to both visually and learning disabled people when something being discussed relates to both groups.

## **1.5 Contribution**

This research provides interesting insights to consider when designing for both blind and sighted users. It demonstrates the importance of clearly labeling form controls for users of screen readers. As well, it clearly demonstrates that hybrid applications, which appear to look like native applications to sighted users, do not provide the necessary contextual information needed in a timely manner by blind users to allow them efficient and effective use of an application.

Lastly, it proposes a new hybrid approach for applications designed to read e-text to print disabled people. One that favors a user experience around consuming the audio output over the consumption of the e-text.

## **2 Chapter: Literature Review**

Accessing printed material has been a problem for people with print disabilities for a long time. However, strides are being made to improve print disabled peoples access to information for education and leisure.

The literature review sought to explore how print disabled people were being supported and accommodated in regards to their access to printed material. A keyword search was conducted using Scopus online search library along with searches made of the ACM digital library, ERIC online search and searches made via Google scholar.

At first the phrase “text to speech” was used to initiate the search. Then the search within feature if available was used to further search by “print disabled”, “audio books” and “digital talking books”.

There are two main types of recorded books. The version created for the print disabled are called talking books while the version created for the general population are called audiobooks. These two formats differ in some key ways. The first way they differ is that talking books are usually created by not for profit corporations where audiobooks are created by for profit corporations thus from the start each will have different motivations and goals.

The talking books created for the print disabled are designed to be a faithful representation of the printed book they represent. The narrators read in a consistent, even manner and they do not interpret the text for the reader. There are no sound effects or other embellishments. Typically, only one reader narrates the book.

Audiobooks are very different because publishers perceive them as an adaptation of the original work, similar to a film or play. Therefore, their audio books might have

significant differences from the original book they are based on. They typically have dramatization where voice actors interpret the text, may include sound effects, and have often in the past been abridged. They commonly have one voice actor read the book with a different voices inflection for different characters. Or hire many different voice actors to narrate the book, with each actor playing a different character (Irith Getz, 2003).

## **2.1 Digital talking books**

The term digital talking book is most commonly associated with a specialized format called Digital Accessible Information SYstem (DAISY), which was first developed in Sweden in 1994 specifically for the print disabled. DAISY is now an open format controlled by the DAISY Consortium and used all over the world.

DAISY is a standard consisting of an XML schema designed specifically for the creation of digital talking books for the print disabled. DAISY formatted documents can include both sequential and hierarchical navigation and synchronized audio and structured text along with images. DAISY material can be distributed on CD, memory card or downloaded directly from the internet (Kerscher, 2001).

DAISY's key features are its support for navigation by heading, page or a segment of text, ease of transformation to other formats, synchronizing of audio to segments of text, bookmarking and its support for customized display of text.

There are six types of DAISY books. However, most often only three of them are used by publishers of DAISY material: (1) text only which contains only the digital text of the book. (2) Structured audio, which contains the headings of the book as text and audio recordings of the rest of the books textual content. (3) Audio and full text, which offers both the text of the book and recorded audio of the books textual content. Additionally,

DAISY books can contain a navigation file specifying how the books content can be navigated.

(Morley, 1998) conducted a usability evaluation of the prototype DAISY playback software for desktop PC's to read DAISY and found that the playback software was relatively easy to use and supported a range of users working with books for different tasks for both work and leisure reading. Users could easily navigate by heading, segment (typically a sentence) or segment group (typically a paragraph) by pressing dedicated keyboard commands.

She makes note of some serious navigational problems when users try to navigate by headings and sub headings due to the lack of structural information about where the headings are in relation to each other and their relation to other text of the book. She then offers a potential solution to these problems in the way of the use of additional non-speech sounds.

DAISY's ability to be transformed into alternative forms of presentation is a critical feature of this format. It can be accessed via braille, which offers a more in depth reading experience for students who have the ability to read braille. Braille literacy rates are typically under 4% of the visually impaired population, but it is still a very powerful means to read and interact with print. For a detailed review of how braille based learning materials can help students see (Hartz, 2000)

LpPlayer the first commercially available desktop PC software application for reading DAISY books was reviewed by (Kimbrough, 2001) who found that navigation support was limited since the books they tested did not contain the full text of the book but were instead structured audio DAISY books.

This type of DAISY book contains the text of page numbers or chapter headings, allowing you to conduct a keyword search on this text, but you cannot just jump to the text for any part of the book. With this type of DAISY book there is no way to move directly to a specific paragraph or sentence and no means to move back or forward by a few words or sentences. This could be frustrating for a person who wanted to reread a passage. To accomplish this, they would need to navigate to the top of the page and listen until the passage they wanted to hear was read out. In addition, the play command did not start at the point a reader left off but instead started at the top of the next page, which was an additional challenge.

One interesting feature of LpPlayer was that it supported both audio and text based notes. Nevertheless, its lack of full text search led the author to conclude that it was much better suited for casual readers of novels or straightforward fiction than for serious students.

One key point Kimbrough mentions that has been over looked in other literature I have reviewed regarding digital talking books is, that it would be good to have a fast forward or rewind feature. This is a key aspect that was lost when talking books moved from tape to digital audio. It became more about the words and less about the audio. This is one of the main reasons why I have rarely ever used DAISY formatted books and players. Instead preferring digital audio files and the audio control interface offered by an Apple iPods click wheel or the interface I designed for SpokenText Reader, which will be discussed in detail in a later chapter.

DAISY talking books can be played back using custom devices for the blind, which can also play and record digital audio (Melorose, Perroy, & Careas, 2010). These devices

typically cost well over \$400 CDN and can make you stand out from your peers. Because they are not mainstream devices and are typically designed for function not aesthetics.

Scotland's Royal National Institute for the Blind (RNIB) conducted a DAISY pilot from 2001 to 2002 with five schools and colleges in Scotland. They found that DAISY was an effective tool for educational material in a structured learning environment. DAISY formatted material was found easy to use by members of the pilot program, enabled students to keep up with the rest of their class mates, promoted a sense of achievement, was motivational, helped with social inclusion and help parents to be more involved with their child's school work. This all held true for both visually impaired and students with communication or moderate learning difficulties (McCreath & Cuthbertson, 2005).

The RNIB of Scotland then proceeded to fund a second 18-month pilot to develop more DAISY formatted material for ages 5 and older. The project team consisted of three RNIB staff, a small number of volunteers, 2 Transcription Officers and a Project Manager. The projects goal was to develop 60 new DAISY books over an 18-month period.

After 12 months, the new pilot had developed 39 books. The DAISY format allows for the creation of six different types of book, which range from plain audio with no navigation to books with text and graphics with no audio files. Due to demands from their partner organizations, they only created type 2 (audio only with structure) and type 4 full text with synchronized audio books.

By only producing 39 books in 12 months, it clearly shows that developing DAISY books in this manner is not scalable. This issue of cost of converting text to alternative formats was explored by (Whitehouse, Dearnley, & Murray, 2009) who had one respondent

to their survey report paying £750 to have sections of just one book converted into DAISY format.

We see this lack of access to DAISY formatted material still being discussed in 2011 by (Itani, 2011) but Itani cites Melanie Lauckner from WHO Press, who says that EPUB3 a widely used open eBook standard will include DAISY, which means that in the future, print disabled people will have access to publications produced in this format. Thereby, giving them access to an extremely large number of publications, much more than was ever available in DAISY.

For a detailed review of the literature on digital talking books the interested reader is directed to (Lundh & Johnson, 2015)

### **2.1.1 Conclusions Digital talking books**

DAISY books helped to move things forward in regards to equal access to print for people with print disabilities, but their complexity and cost to develop slowed their mass adoption. With the merger of DAISY into EPUB 3, an open and mainstream format used by many of the world's leading publishers, the future looks promising for the print disabled ability to access printed material in an accessible format.

## **2.2 Audiobooks**

By far, one of the easiest formats for people with print disabilities to use is printed books recorded as audiobooks. There are many formats of audiobooks and means to play them back for example as an MP3 audio file on an iPod or using a custom app like Audible.com offers, but in the end, they are all the same. They have limited support for navigation, but provide you with a very simple means of consuming information without having to read it with your eyes.

(Moyer, 2012) conducted a thorough review of the available literature on audiobooks and eBooks up to 2012 and noted that the line between the two formats is blurring as eBooks are offering text to speech functions. Additionally, Moyer discusses trends seen in her review of the literature in this area: as MP3, players became more popular and services like Audible.com started to gain traction in the market along with libraries offering more audiobooks in their collections the use of audiobooks by the public grew. The public preferred unabridged audiobooks over abridged audiobooks and some teachers and librarians might have a bias towards printed books over audiobooks, which could be slowing down audiobook adoption. This bias can be seen in whether or not a teacher encourages their students to listen to audiobooks or how and where this type of material is located in a library.

Moyer recommends that students should be encouraged to listen to audiobooks. Since some children are better at listening comprehension versus reading comprehension. As well, Moyer recommends that audiobooks be placed next to the printed book in libraries when possible and that librarians familiarize themselves with the collection of audiobooks in their library so that they can help patrons of the library discover new audiobook titles.

One possible means to encourage more reading of audiobooks is using audiobook clubs. Audiobook clubs were found to be beneficial by (Jeff et al., 2013), improving kids literacy skills and helping to make struggling readers discover a new found love of reading.

The social acceptance of Assistive Technology (AT) (Nees & Berry, 2013) is one area where audiobooks and main stream devices might make the lives of students easier as many students at the time of writing this thesis are bringing mobile devices to school every day to use in the classroom. These modern mobile devices support audiobooks, have full

screen readers and magnifiers and are made by popular mainstream companies like Apple and Google. So no longer do print disabled children need to bring proprietary, ugly and hard to use devices to school to help them in class. They can now use the same mainstream device as all of the other kids and just enable the built in accessibility features as required.

### **2.2.1 Conclusions audiobooks**

From the review of the literature, it is clear that listening to printed material can benefit not just print disabled readers but all readers by helping them to expand their vocabularies, listening comprehension skills and tackle reading material at a higher-grade level than they can handle if just reading the text alone. Whenever possible students should be encouraged to listen to books, if they so desire.

### **2.3 E-text**

E-text, electronic text or digital text has been a revolution in many ways for print disabled people giving them access to more content than ever possible before.

Electronic text is malleable (Anderson-Inman & Horney, 2007) as it allows for font face, size, and color to be changed. Text can be read aloud, portions of text can be explained in detail via links to supportive information or dictionary definitions and multiple illustrations can appear at the same time along with video or simulations of concepts presented in the text.

By far the most popular format of highly accessible electronic text that can be accessed by print disabled people is HTML, the format used by the internet. However, over the years EBUB has become a viable format in addition to HTML and the aforementioned DAISY format.

Along with HTML, eBooks, eText Books and electronic documents in the form of Adobe Acrobat Portable Documents (PDF), Microsoft Word or plain text files are popular with print disabled people for both reading tasks and use in their study processes. For the last few years with the advent of eBook readers and tablets like the iPad, eBook formats such as EPUB have become a viable option for print disabled people.

(Engelen, 2010) reports that even in 2010 there were still issues around main stream eBook formats being accessible with many publishers not allowing their books to be read by text to speech software. Engelen does not provide a motivation for the Publishers not allowing their books to be spoken by text to speech software but my assumption is that it is over fears of counterfeiters using the access to the books content required by text to speech software, to circumvent the Digital Rights Management (DRM) used to secure their books against copyright infringement.

Even if the eBook is accessible, students might still encounter issues accessing the book via a publishers eBook delivery platform (McNaught, Evans, & Ball, 2010). McNaught, Evans, & Ball reviewed nine platforms and found that many of the platforms were inaccessible to keyboard and screen reader users. Many of the platforms could be fixed with some effort, but one they reported on might need a complete rewrite to make it fully accessible.

Accessibility barriers can still exist with any of the major e-text formats such as HTML, PDF or EPUB, but if the WCAG standards (Caldwell, Cooper, Reid, & Vanderheiden, 2008) are followed all of these formats can be fully accessible to a print disabled person. For an in-depth review of the most popular eBook formats and eBook readers see (Ranti Junus, 2012) who also states that Open eBook formats such as EPUB

and DAISY are generally more accessible than closed formats such as MOBI and AZW which are used by Amazon and its eBook readers. When it comes to devices for reading eBooks, Apple offers the most accessible out of the box experience compared to devices offered from Amazon or Barnes and Noble. Neither of the latter two devices offer a text to speech option at all or a user must add it themselves. This is not the case with Apple devices, which have a screen reader, called Voice Over installed by default. Apple also offers a high quality screen magnifier and other accessible options to aid disabled people use its devices. One item which was missing from the review done by Ranti Junus was a review of Android based eReaders. There is mention that Google's online eBook site supports a version of EPUB with additional Google digital rights management (DRM) included, but does not provide a review of the popular Android based devices for reading eBooks.

Even with this oversight, in my experience having used both Apple and Android based devices. Android has made advances since 2012, but the user experience of reading on an Apple device, is still superior in many ways.

Many of the issues we see with making eBooks accessible should be resolved as publishers move towards XML work flows for the creation of eBooks and when they adopt EPUB3 as their final export format (McNaught & Featherstone, 2012).

Textbooks are just starting to be seriously converted to an electronic format similar to what we have seen with eBooks (Johnston, Berg, Pilon, & Williams, 2015). As with eBooks issues around accessibility, access to these new eTextbooks are being discussed and worked through. Many of the issues relate to supporting the needs of students to

access the material as they see fit and publishers fears around copyright protection and illegal copying of the content in their textbooks.

### **2.3.1 Conclusions E-text**

There is no doubt that E-text has made a major difference in the lives of the print disabled and their access to print. Nevertheless, challenges remain as seen from the review of the literature done above. Students still face many challenges acquiring material they need to read in e-text and must still find a means to have it read to them.

Many of the solutions to have the text read to the print disabled involve the use of text to speech systems but these require students to navigate the text and select a starting point to read from, which can be challenging for students with low vision.

The interaction patterns are based around the text. I would argue that this is not ideal and an interface should be designed to let students navigate the text more like an audio file is navigated since this is the preferred means of consuming the textual information used by many print disabled people.

### **2.4 App review**

As part of writing up and reflecting on the results of the literature review, I started to wonder if I should personally revisit using the DAISY format and PDF format to read a book and journal article. To this end, I found a book on academic writing on BookShare.org and a journal article in PDF format that I wanted to read. The aim was to see how much, if anything had changed, since I had last evaluated the use of these two approaches for accommodating my print disability.

In the past, I had evaluated and experimented with DAISY and various e-text solutions such as PDF. While I had kept up with changes and advancements, I had not utilized them since I was happy with the SpokenText Reader App.

I used a Google search to find the most popular iOS applications for reading DAISY books on an iPhone. My research led me to Read2Go<sup>1</sup>. It sells for \$27.99 CDN (developed in partnership with BookShare.org). I also found Voice Dream Reader<sup>2</sup>, which sells for \$20.99 CDN (mentioned by two of my test participants and highly ranked in the Apple app store). I purchased both, downloaded them to my phone and started using them on my daily commute to work on the bus (Figure 1).

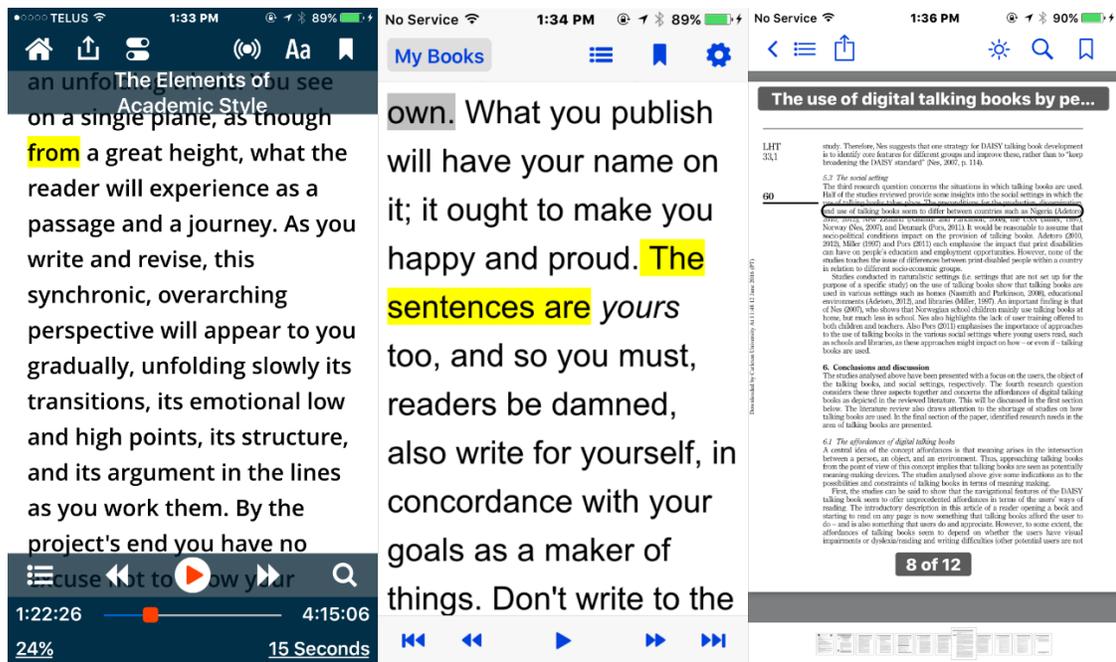


Figure 1: From left to right: Voice Dream Reader, Read2Go and iBooks

<sup>1</sup> Read2Go, DAISY reader for iOS <https://itunes.apple.com/ca/app/read2go/id425585903?mt=8>

<sup>2</sup> Voice Dream Reader, DAISY reader for iOS <https://itunes.apple.com/ca/app/voice-dream-reader/id496177674?mt=8>

I tried Read2Go first and then tested out Voice Dream Reader. Of the two, I prefer Voice Dream Reader over Read2Go because Read2Go kept pausing at strange points, as it read out the words of the book. Thinking that maybe the book had been designed to function this way, I inspected the XML markup used to define the books structure and found that there was no DAISY markup present to tell Read2Go to pause while in mid-sentence or read some sentences one word at a time. The user interface of Read2Go is not as user friendly as the interface of Voice Dream Reader. Often while trying to play or pause the speech playback, I would hit the button to move to the next section of text or often even jump back a page, which was incredibly frustrating to say the least. Voice Dream Reader's play and pause control is better designed than the same control in Read2Go. With ample space around the play and pause control, I never accidentally hit another button, while trying to play or pause the audio output.

In the end with Voice Dream Reader's superior user experience and its ability to read DAISY books without issues, I decided to drop Read2Go and only evaluating Voice Dream Reader.

When it came to reading the journal article in PDF format I explored using 'Voice Over' and the iPhones built in PDF viewer and tested with iBook's and 'Voice Over' (Figure 1) to read PDF files out loud to me. Using either the PDF viewer or iBook's, it was hard to rewind back a few seconds of audio, which had just been spoken to me by 'Voice Over', causing me to reread whole paragraphs, when all I wanted was to just hear the last few seconds. Voice Dream Reader was better than using 'Voice Over' to speak e-text to me, since it has dedicated rewind buttons, but both approaches had one main flaw that came to me; they are all about the text. Their interfaces favor interaction patterns

around interacting with text. Audio output is secondary to the tasks related to presenting and interacting with the e-text, such as selecting e-text, scrolling e-text, viewing e-text, highlighting the e-text etc.

For me, the learning disabled students in my study, and many other print disabled people, I would suspect it is all about audio. We want interfaces with a bias towards interacting with audio, not interfaces where audio is an afterthought.

This insight was a huge revelation to me. One which only came about because I undertook the literature review and personally used and reflected on the various approaches to accommodate my print disability and the potential biases I might have had from my past experiences with the DAISY format and e-text.

## **2.5 Gap in the Literature**

From the review of the literature and mobile e-text related apps, we can see that there has been a lot of progress made to provide better access to print material for print disabled people. However, there is little research around how to support students trying to use audio created from printed material for study purposes. Regardless of whether it is audio generated in real time or prerecorded audio in the form of audiobooks.

To add to the literature in this area, this thesis set out to research a solution to help students take notes and annotate audio they were using to study.

### **3 Chapter: SpokenText Reader Prototype**

Identifying the limitations and challenges faced by visually impaired people and people with learning disabilities who are trying to study from audio material, was something that came naturally to me because I have both a visual impairment and a learning disability. As well, I have helped and worked with visually impaired and learning disabled people to find accommodations to aid them at school or work for over 25 years.

Along with my deep experience and knowledge of the challenges faced by the print disabled, my knowledge of Human Computer Interaction (HCI) is quite extensive, having worked in software design and development for 20 plus years.

My knowledge of HCI and experience with the challenges faced by the print disabled population comes from both a personal perspective and from the time I have spent helping others. The latter was about helping them find solutions to the challenges they have faced with reading large amounts of printed material, along with my technical skills in the area of software development allowed me to conceive of and develop SpokenText Reader.

In the past I have used recordings made of printed material to read books and articles, typically the printed material was in PDF format or was a printed book I scanned and converted to e-text and then saved in the PDF format. The conversion to audio was done using SpokenText.net an online Text to Speech (TTS) web site I started in 2006 which takes e-text as an input and provides users with an MP3 file as an output.

SpokenText.net was advantageous in that it let you easily convert text to speech and then using a computer transfer the audio recording to an iPod for listening to it. With the click wheel present on an Apple iPod, you could easily rewind or fast-forward the

recording enabling you to hear again a part of the recording you were listening to previously.

Nevertheless, as seen in the literature review section of this thesis, there were still issues with this approach. The main issues being: note taking, bookmarking (automated and on demand) and annotating an audio file you were listening to. I explored using DAISY formatted material but the amount of current material available in this format is limited. Furthermore, most university accommodation services provide their clients with e-text in PDF format, so DAISY was not a viable solution.

Next I explored using e-text with a screen reader to speak the text but as noted by (Kimbrough, 2001) with this solution I lost the ability to easily rewind or fast forward the audio output I was listening to. This is a key interaction I use all of the time when listening to recorded audio. The reason for this is many fold. It is sometimes because I did not understand the material and need to hear it again. However, sometimes it is due to noise from the environment around me drowning out the audio as I listen, while walking in the city or taking the bus.

With the above in mind I designed and developed SpokenText Reader to allow users to overcome the issues I found with the existing solutions on offer to print disabled people specifically: note taking, bookmarking (automated and on demand) and annotating an audio file.

### 3.1 Introducing SpokenText Reader

The SpokenText Reader prototype is a hybrid iOS native application. The user interface was written in JavaScript and HTML which was then bundled together using Apache Cordova<sup>3</sup> and deployed to an iOS device.

SpokenText Reader uses JavaScript Application Program Interfaces (API) provided by Cordova to talk to the phones native APIs to allow recordings to be downloaded to the device along with supporting the capturing of audio, images and videos, which can be used as notes within SpokenText Reader

SpokenText Reader allows users to listen to recorded audio, take notes, bookmark key points in the recording, if you leave a recording and reenter the recording it starts from where you last left off and it provides a form of annotation to “mark-up” audio files in a similar way. Figure 2, shows how people who study with print, highlight, underline and write notes in the margins.

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<sup>3</sup> Open source framework to develop mobile apps with HTML, CSS & JS, which supports multiple platforms with one code base. <https://cordova.apache.org/>

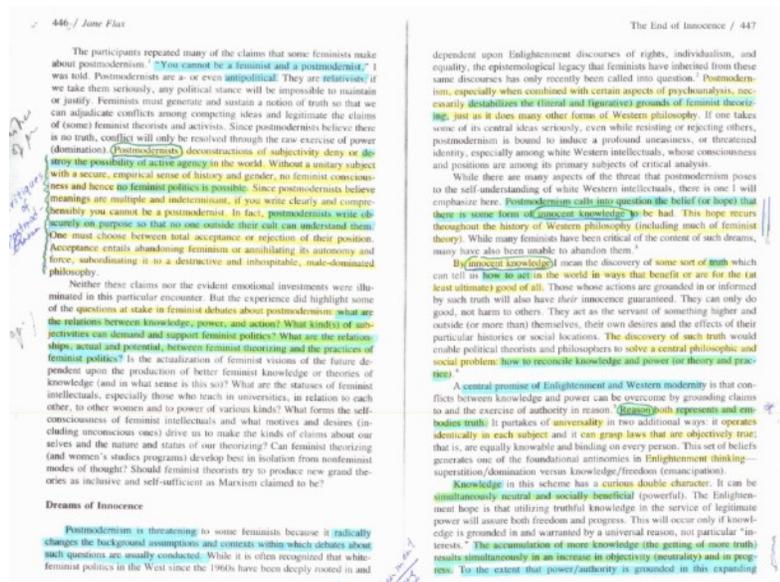


Figure 2: Example of text being highlighted on a page while studying

Based on the example page shown in Figure 2, how would people who need to study using the audio version of this text highlight, take notes and annotate the audio file?

This thesis project involved evaluating a potential solution to this problem.

### 3.2 Some challenges faced when designing SpokenText Reader

When you are listening to an audio stream, you have many challenges when it comes to navigation and note taking. If you need to leave the application you are utilizing to listen to recordings to take a note this can break your sense of flow (Csikszentmihalyi, 1975) and in addition to this you have the added complexity of developing a means to link the note back to the point in the recording to which it relates. Highlighting parts of a recording to use for citations later can be difficult when you only have an audio stream.

Since one of the target groups of SpokenText Reader is users with low or no vision, its interface and the design patterns used had to be fully accessible to both people. Those who can see the interface with a moderate level of clarity and it needed to work for people

who could not see the interface and relationships between controls at all. This was a huge challenge when it came to designing the user experience for SpokenText Reader.

With SpokenText Reader, users can take notes and annotate sections of audio to sight later when talking in class, writing papers or giving presentations. In addition, hopefully in so doing, help in a meaningful way, to reduce the gap between print disabled students and their non-disabled peers.

### **3.3 SpokenText Reader prototype history**

Starting in the summer of 2012, in preparation for my first master's class I started working on a very early prototype of SpokenText Reader. This early prototype then evolved during this first course. Upon using this initial prototype for a period and reflecting on its strengths and weaknesses, I modified and made improvements to how the prototype functioned. I then used the revised prototype for my own coursework, which I used on a daily basis to accommodate myself and make it possible for me to participate fully in my Masters courses.

From time to time, the refactoring I had to do to add new features or refactoring required by Apple to enable the application to be installed on a newer version of Apple's mobile operating system iOS caused the application to break. Thus making it not available to me as a tool to accommodate my needs. During these times, I really missed having access to SpokenText Reader, which provided me with encouragement that I might be creating something that others might find of value.

In 2014, I took a directed study where I explored and expanded the capabilities of the prototype, adding the ability to take audio, image and video notes in addition to the text notes that had been first developed.

It was at this point that I had the idea to merge all of the note types into one note screen, whereas originally I thought that it would be best to take a text note separately from an image, sound or video note. Seeing that there was a lot of similarity between the note types and that you would probably want to name or describe a clip, image, audio or video note, I concluded it would be best to have one note type. This change was implemented in my next round of iteration on the prototype and it greatly simplified the user interface.

### 3.3.1 Initial prototype screenshots

The following screen shots are from the initial prototype I created. At this point, you could only take a text-based note synced to a point in the recording and the annotation feature had not yet been added.

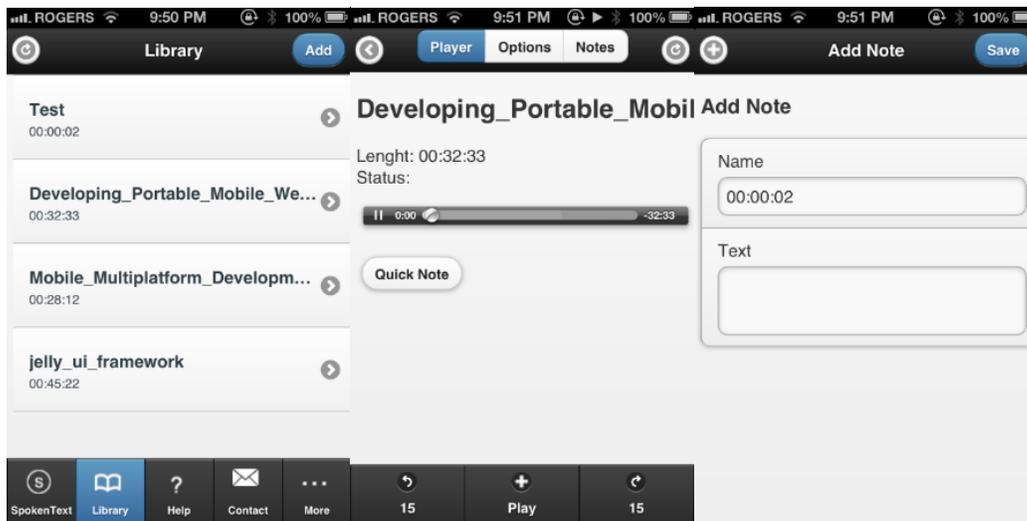


Figure 3: Initial prototype screenshots

### 3.3.2 Second major revision prototype screenshots

This revision saw some major changes to the user interface. SpokenText Reader now contained the ability to annotate audio files, the “Swipe me” controller was added which lets you control the key features of SpokenText Reader using gestures and the menu system was updated to be more in keeping with modern mobile phone applications.

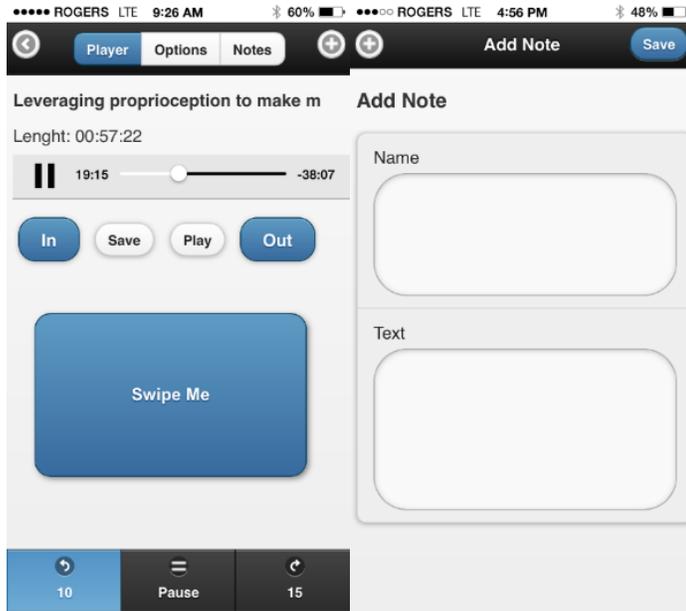


Figure 4: Second major revision prototype screenshots

### 3.3.3 Screenshots (final revision prototype before changes made for usability testing)

This revision had only minor changes. The play button at the bottom of the screen was removed. And the rewind 10 seconds and fast forward 15 seconds buttons were enlarged to fill the space to create a well a balanced aesthetical look.

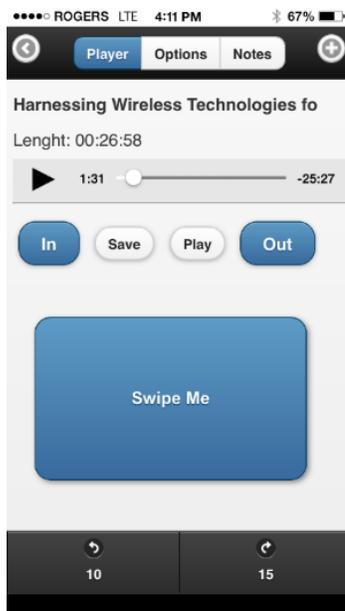


Figure 5: Final revision of prototype before changes made for usability testing

### **3.3.4 Technology used to create the prototype**

SpokenText Reader is a hybrid application. It uses Apaches Cordova framework, which allows developers to create cross platform HTML, and JavaScript based applications that can be installed onto a user's mobile device or placed into an App Store and downloaded to a user's device. Applications built this way can look very similar to a native application built for a given platform. Cordova supports many mobile platforms, but for this project, just the functionality relevant to Apple iOS was used.

JQuery and JQuery mobile JavaScript libraries were used to give the interface a more native look and feel. Numerus jQuery based helper libraries were used to ease and speed up the development of the prototype.

Once the HTML and JavaScript code was ready to be tested on an iOS device it was placed into a Cordova project and compiled using Xcode running on an Apple Mac Book Air. Xcode took care of installing the compiled application on to the iPhone used for testing during development.

REST API's were developed for SpokenText.net. These were specifically designed for and to be used by SpokenText Reader. These API's allowed SpokenText Reader to access a user's account and determine which recordings were ready to be downloaded to SpokenText Reader via the download functionality built into SpokenText Reader.

Source code for the project was kept in a GIT repository during development to allow for easy role back and code development.

### **3.3.5 Why I used these technologies to create the prototype**

When I started this prototype in 2012, Objective C was the language Apple officially supported for iOS developers to use, but it is very complex, time consuming to learn and it does not lend itself to quickly trying out ideas and making changes.

With a background in web development technologies such as HTML, JavaScript and PHP, it was much easier to work with these technologies. It is for the aforementioned reasons that I chose to build the prototype using programming languages, which I already knew and used.

### **3.3.6 Prototype development process**

One main benefit of the approach taken to develop this prototype was that much of the development could be done just using a text editor and the Google Chrome web browser. There was no need to compile the application every time you wanted to determine if the last piece of code you added was functioning as intended. This saved a lot of time during the initial stages of developing the prototype.

When it came time to developing the code to download recordings or to take pictures, video or audio to be added to a note the process changed and the code had to be compiled every time using Xcode. This was a very slow and time-consuming process, which was, made worse by the lack of integrated support for HTML and JavaScript based Cordova applications with in Xcode.

### **3.3.7 Strengths of this prototyping technology**

This prototyping approach based around a hybrid application had a lower initial learning curve than learning Objective C Apples language for native application development.

In many ways, it was very fast to try out new ideas since I could find libraries, which could be easily integrated and tested in a web browser without having to compile the application repeatedly.

### **3.3.8 Weakness of this prototyping technology**

The development tools used to develop and build the prototype were not mature. This led to a very slow development process since not all of the various tools required to develop and debug the application were integrated, as is the case for a true native iOS application written in Objective C.

Debugging issues and fixing bugs was very time consuming and sometimes very difficult since it was not always easy to determine which part of the code was not functioning as intended. There was limited to no support for JavaScript debugging in Xcode resulting in the code containing many log messages. These log messages were then used for debugging of the code.

Occasionally when all else failed Safari was used to debug the JavaScript code. However, this could only be done after the application was first compiled using Xcode and running in the iOS simulator. All of this took time and made the code, test and fix process time consuming.

### **3.3.9 Prototype changes made before testing began**

Before I could conduct the usability, testing sessions using the prototype I needed to make some updates to it.

Over the last four years, while working on the prototype, each time I changed phones I had to update the prototype to compile and deploy onto the new phone with a new

version of iOS. This required upgrading it to work with and compile under Cordova 3.5 and iOS 9.

Since the iPhone 6 Plus to be used during the testing session had a larger screen size than the iPhone 4s and 5s used for previous versions of the prototype, I customized the interface to look and function well on a larger sized phone.

Once I had SpokenText Reader running again on the iPhone 6s Plus, which would be used during the usability testing sessions, a few weeks of trial and error testing was necessary to ensure features required for the usability testing sessions still functioned. Upon successful completion of this phase, I was ready for usability testing to begin.

## 4 Chapter: Usability Test

The SpokenText Reader prototype was evaluated using a usability test. The usability test consisted of three parts: a list of pretest questions, a list of tasks to be performed and a list of three post questions to gauge the participant's overall impressions of the prototype based on their experiences during the test.

To find out if the tool meets basic Human Computer Interaction standards and to overcome the researchers own biases it needed to be tested by other users. After all, if the researcher designed around his own limitations, this could pose a problem, for other users. At the same time, the great advantage of being a member of the target population added an incredible advantage in that many designers lack a continuous user involvement at every step of the design process. This is something that most of the time is not possible. Therefore, to see if the advantages outnumber the biases, a usability test was necessary. From this perspective, the analysis chapter will make a case of looking at the qualitative data generated.

The usability test was conducted in a lab setting and was guided by the extensive guidelines for conducting a usability test outlined by (Dumas, J. S. and Redish, 1999), (Nielsen, 1993, 1994) and (Rubin J., 1994)

In the end 5 students completed the usability test which is not ideal. Nevertheless, given the small number of students attending Carleton who have a visual or learning disability it is quite a good result and is still in keeping with (Nielsen, 2000) who states that you can achieve valuable insights regarding a software products usability with just 5 participants, if they are used wisely.

During the usability test participants were asked questions and the prototype system was shown to each participant on an iPhone 6s Plus. The participant tried to complete the assigned tasks and their experiences, opinions and ideas for improving the prototype system were noted. Each was asked a series of questions after the test, with the aim of determining how usable they found the prototype system and if they would use it, if given the chance.

The sessions were both audio and video recorded to aid me when trying to review results of the sessions and discover insights.

#### **4.1 Challenges faced as a visually impaired researcher**

It can be challenging to have a visual impairment and conduct a usability testing session. Often during a usability testing session the researcher will sit off to the side of the participant being tested in order to not disturb the participant, make them feel uncomfortable by invading their personal space or further interfere with the participant's ability to forget that they are in a testing session. The aim is to make the whole process as natural as possible, while still being capable of observing the process.

With my low vision, the typical approach to observing during a usability testing session would not work, so I set out to develop a process that would allow me to be fully involved while also not interfering with the participant's comfort and ability to feel at ease.

The end result is the approach outlined in the following sections of this thesis. It involved the use of a 60-inch television for me to observe the video feeds from the cameras I had setup. The resulting high quality recording of each session could then be reviewed later. In the testing room, the large screen was situated off to the side of the participant and not directly in their field of vision.

## **4.2 Participants**

The following sections describe the studies participants and challenges faced with finding and working with them.

### **4.2.1 Description of participants**

In total five participants took part in the usability test, four females and one male. Three of the participants (P1, P2 and P4) had no vision or very limited vision, while the other two (P3 and P5) were learning disabled and had normal vision.

### **4.2.2 Recruiting participants from the Paul Menton Centre (PMC)**

I contacted the PMC representative who deals with students who have learning and visual disabilities to determine the process I needed to follow, if I wanted to have them reach out to potential students to participate in my research. I was informed that after ethics approval was granted I would need to send them a document outlining my study. Once they reviewed and approved it, they would contact potential students from their membership who might be interested in participating. The students would then get in contact with me to schedule their sessions.

With my study outline document approved by both the ethics review board of Carleton University and the PMC, the PMC contacted students who were registered with the PMC, informing them about the study and what they needed to do to participate. PMC then forwarded the information I provided about my study along with my contact information to interested students by email.

The participants then contacted me by email or phone and we scheduled a time for them to participate in my study. Since the sample, size of potential participants was so small I really went out of my way to accommodate the participant's time schedules.

### **4.2.3 How participants were accommodated**

It was very important to me that all accommodations possible were provided to participants taking part in my study.

I asked each participant over the phone or by email before the session was to take place to determine if they had any requests for accommodation. I offered to read all printed material to participants. If they wanted me to do so, I did. I helped them to sign consent forms, if needed and I made a large print version available of the consent form and of the usability test just in case during a testing session it was requested by a participant.

### **4.2.4 Challenges with finding participants to study**

According to statistical data I received from the PMC in 2014-2015, they had 38 students out of 2,082 who were blind or had low vision. This was roughly 1.8% of students registered with PMC. Unfortunately, the PMC does not break down their numbers according to severity of impairment. In contrast, there were 718 learning disabled students. Of this, only five learning disabled students used material converted to MP3 to study.

The PMC does not actively encourage students to study from MP3 files due to their belief that MP3 files lack navigational ability, which they feel students require, but instead encourage students to use e-text in PDF format and a desktop software designed for the learning disabled. This could account for the low number of students who request MP3 files of their printed material.

One limiting factor with the approach used by the PMC, is that students are stuck studying from a desktop or laptop and cannot easily study while in-transit or from a mobile

device. This severely limits their options when it comes to where and when they can study from printed material.

#### **4.2.5 Challenges with usability testing with visually impaired people**

It was not known how many visually impaired participants might sign up for the testing or at what level; they might be able to see a mobile device. Moreover, since some people with low vision prefer occasionally to look closely at a mobile device to use it, the testing setup needed to consider this. The testing process needed to not get in the way of a user holding the phone right next to their face, while still allowing for recording of the highest quality video and audio possible for use later during analysis. These needs informed the design of the custom usability testing sled I built to mount a camera to the iPhone 6s Plus used during the usability testing sessions.

#### **4.2.6 Challenges faced by participants when trying to navigate to the usability testing room**

Disabled people can be very sensitive when asked about their abilities and where they struggle. It is very personal and we live in a culture where people judge you by their perceptions of your limitations. No one wants to show weakness or that they are not as good as their peers. With this in mind, I was careful with how much support I offered to participants to find the testing room.

The usability testing sessions took place at Carleton University between February 23, 2016 and March 2 2016, in the Azrieli Pavilion building, which a few students mistook for the Azrieli Theater. This confusion on the part of participants with low vision was not helped by the fact that there are no braille signs or raised print in the tunnel system that connects all of the buildings at Carleton University leading to blind students having no idea

which building they are entering when leaving the tunnel system. Nor are any classroom doors marked with braille or raised print, so even if they get into a building they need to ask someone if they are in the correct classroom until they have become used to visiting a particular classroom and have counted their steps or the number of doors leading to the classroom they want. All of these issues were potential challenges for the blind students when trying to find the testing room I had setup for them.

Knowing some of the challenges faced by blind people when trying to navigate to a new location, I had offered to help anyone who needed assistance finding the classroom where the testing session was to take place. However, to respect them the offer was made only once via email and in a manner. I thought would not offend anyone.

One participant mentioned to me that this difficulty with navigating around the campus faced by many blind students might be limiting the number of participants agreeing to take part in my study, especially with it being winter.

#### **4.3 Consent form**

A consent form, see Appendix A , was signed by all participants before testing began. Each participant was offered to have the form read to him or her if they desired. For those participants who requested help they were offered help in signing the form, which typically involved me putting the pen on the signature line and the participant, then signing. If the participant had an aid to help sign documents, I would line up the aid over the signature area of the form. Each participant was asked if they wanted me to date the form for them. If requested, I put the current date on the form for the participant.

#### **4.4 Usability test introduction**

Hi, participants name. My name is Mark McKay, and I am going to walk you through this session today.

Before we begin, I have some information for you, and I am going to read it to make sure that I cover everything.

You already have a good idea of why I asked you here, but let me go over it again briefly. We are asking people to test a mobile application to help people with visual impairments and learning disabilities called SpokenText Reader with the aim being to improve the design of SpokenText Reader. The session should take about an hour.

The first thing I want to make clear right away is that I am testing the SpokenText Reader prototype, not you. You cannot do anything wrong here. In fact, this is probably the one place where you do not have to worry about making mistakes.

As you use the SpokenText Reader prototype, I am going to give you a few tasks and ask you as much as possible to try to think aloud. Please say aloud what you are looking at, what you are trying to do, and what you are thinking. This will be a huge assistance to me.

Also, please do not worry that you are going to hurt my feelings. I am doing this to improve the design of SpokenText Reader, so I need to hear your honest reactions.

If you have any questions as we go along, just ask me. I may not be able to answer them right away, since I am interested in how people do when they do not have someone sitting next to them to ask for help as they go. Nevertheless, if you still have any questions when we are done, I will try to answer them then. In case, you need to take a break at any point just let me know.

You might notice that there is a camera present in the room. With your permission, I would like to record what happens while you are evaluating the SpokenText Reader prototype and our conversation. The recording will be used to help us figure out how to improve the design of SpokenText Reader, and it will not be seen by anyone except the people working on this project. I am going to ask you to sign a consent form for me. It says that I have your permission to audio and video record you and that the recording will only be seen by the people who are working on the SpokenText Reader project.

#### **4.5 Introduction which was provided orally to participants before the usability testing tasks were read aloud to participants**

SpokenText Reader was designed to let you easily listen to an audio recording and take notes synced to points in a recording. You can also mark sections of a recording similar to how people highlight printed text when studying.

When listening to a recording you can easily rewind, fast forward, play, and pause recordings. The application will also remember your last position within a recording.

SpokenText Reader works with SpokenText.net a website that makes it easy to convert text to mp3 files. All files used during this test were converted to speech using SpokenText.net and then downloaded to the Library screen of SpokenText Reader.

SpokenText Reader has many different features. Today's test will just involve looking at a portion of the overall feature set of SpokenText Reader. We will start our test on the Library screen of SpokenText Reader, where files show up once they have been downloaded from SpokenText.net

## 4.6 Tasks

Table 1, lists the tasks used during the usability testing sessions. The tasks were focused on the key screens of SpokenText Reader. The screen flow shown in Figure 6 provides an overview of the flow between the parts of SpokenText Reader that were evaluated during the usability test. Figure 7 and Figure 8 provide an overview of two key screens that were available to participants when taking part in the study.

<b>Task</b>	<b>Description</b>
<b>1</b>	How would you listen to a recording?
<b>2</b>	How would you pause a recording?
<b>3</b>	How would you play a recording?
<b>4</b>	How would you rewind a recording?
<b>5</b>	How would you fast-forward a recording?
<b>6</b>	How would you set an in-point for a note?
<b>7</b>	How would you set an out-point for a note?
<b>8</b>	How would you take a note?
<b>9</b>	How would you review a note you had taken?
<b>10</b>	How would you edit a note you had taken?

**Table 1: List of usability testing tasks**

### Primary SpokenText Reader Screen flow

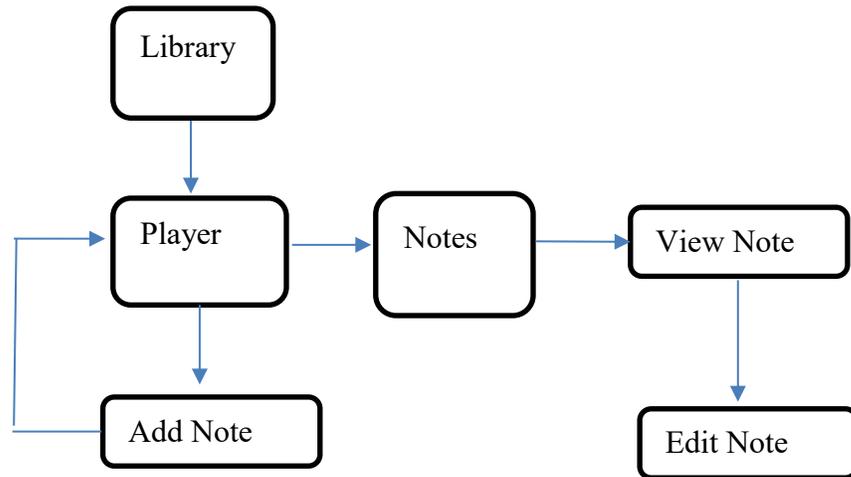


Figure 6: Primary SpokenText Reader screen flow diagram

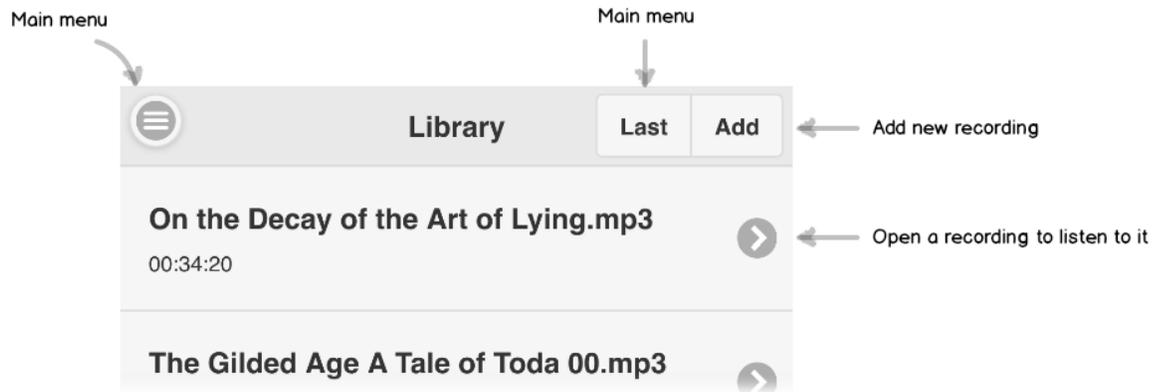
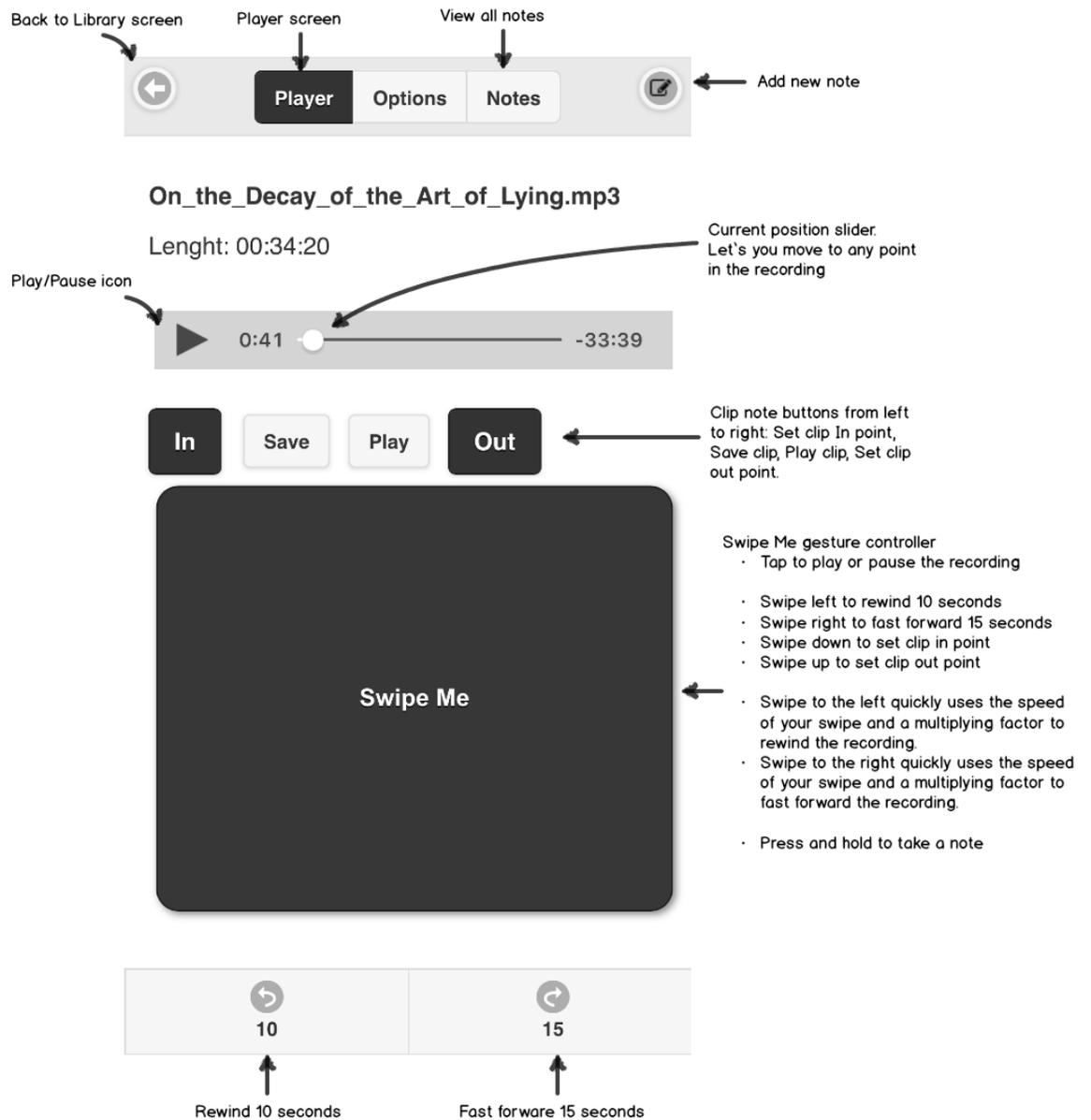


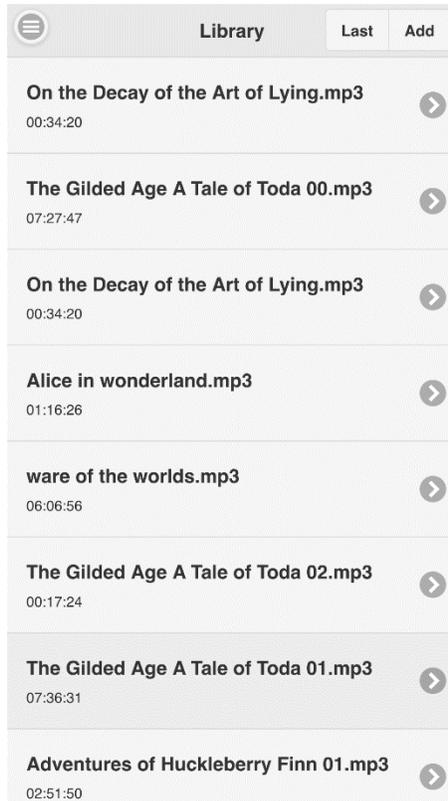
Figure 7: Annotated Library screen



**Figure 8: Annotated Player screen**

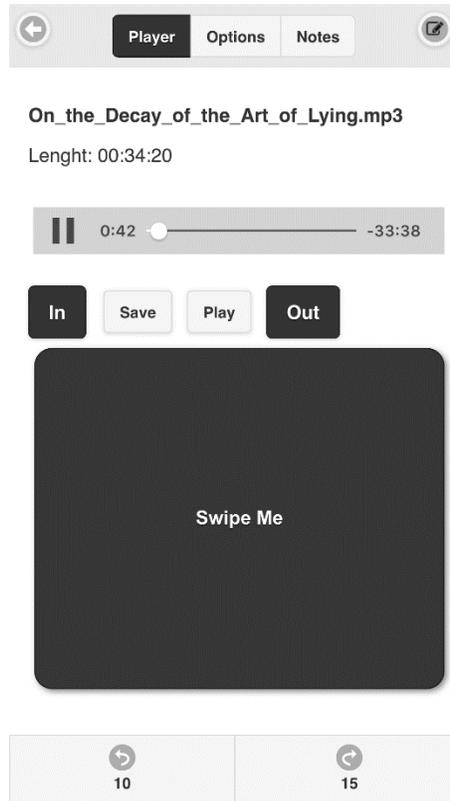
### 4.6.1 Task walkthrough

Task one, involved users using the screen shown in Figure 9. This screen lets a user switch between recordings or select a recording to listen to it. During the test, session the participant was placed on this screen then asked the task. The goal was to have them tap on one of the recordings shown in the list. Once they did this, the player interface would appear and the recording would start to play automatically.



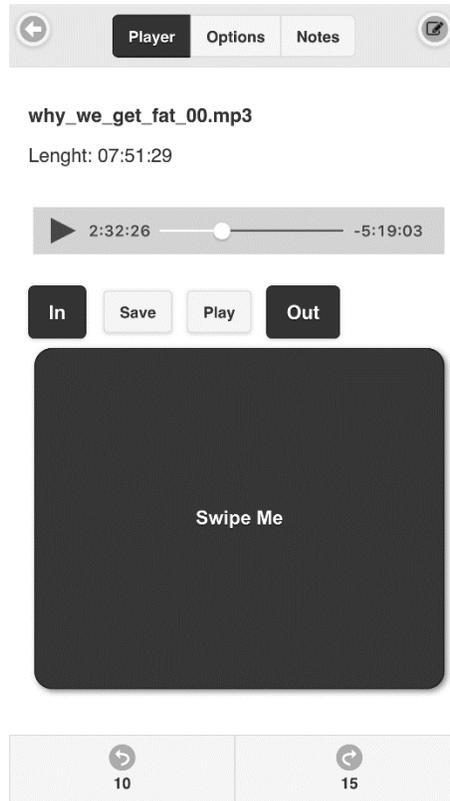
**Figure 9: Library screen of SpokenText Reader**

Task two, starts on the screen shown in Figure 10. This screen is the main screen used to listen to audio recordings and initiate other features of SpokenText Reader. The version shown in Figure 10 demonstrates how SpokenText Reader would appear when a recording is currently being played. The goal of this task was to have them press the pause icon or tap with one finger on the Swipe Me gesture controller.



**Figure 10: Player screen with a recording being listen to.**

Task three; involve testing how easy participants found it to play a recording once it had been paused. The participant was asked to complete this task based on the recording they used for task 2. The goal was to have them press the play icon or tap with one finger on the Swipe Me gesture controller, both of which can be seen in Figure 11.



**Figure 11: Player screen showing a paused recording**

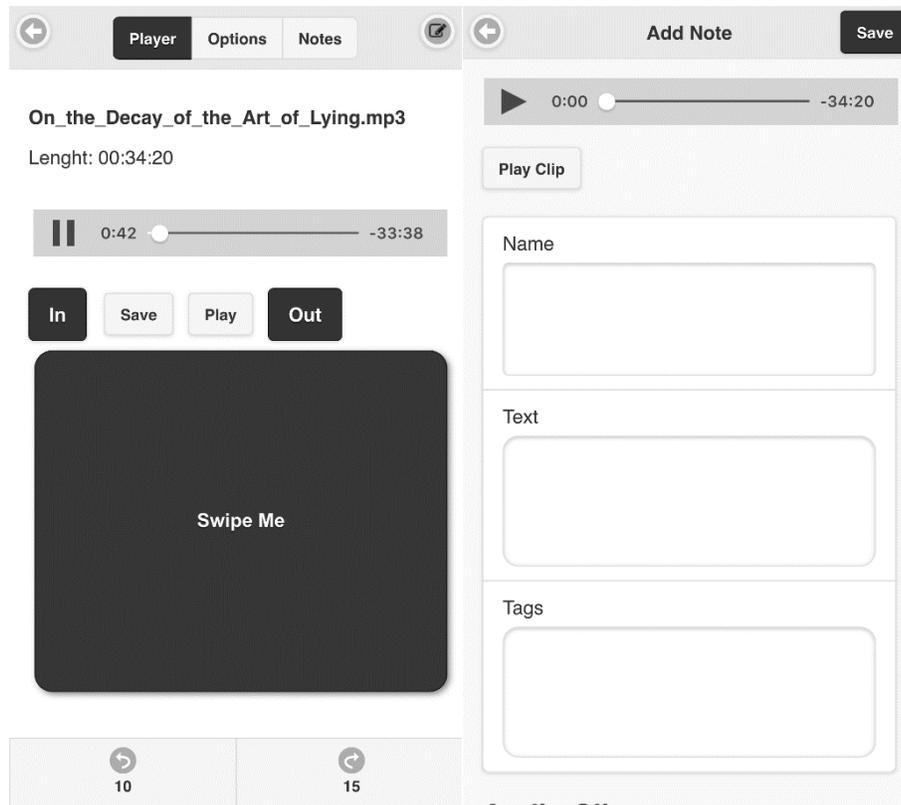
Task four, involved asking participants how they would rewind a recording that was currently playing. There were many ways they could have done it. Either press the rewind 10 seconds button, swipe left on the Swipe Me gesture controller or slide the current position slider to the left. All of these controls can be seen in Figure 10.

Task five, involved asking participants how they would fast-forward a recording that was currently playing. Similarly, there were many ways they could have done it. By pressing the fast-forward 15 seconds' button, swipe right on the Swipe Me gesture controller or slide the current position slider to the right. All of these controls can be seen in Figure 10.

Task six, involved setting an in point for a clip note. The goal was to have users click the Set clip in point button. By setting a clip in point, users can set the point they want the highlight or audio annotation from which they can start. This button can be seen in Figure 10.

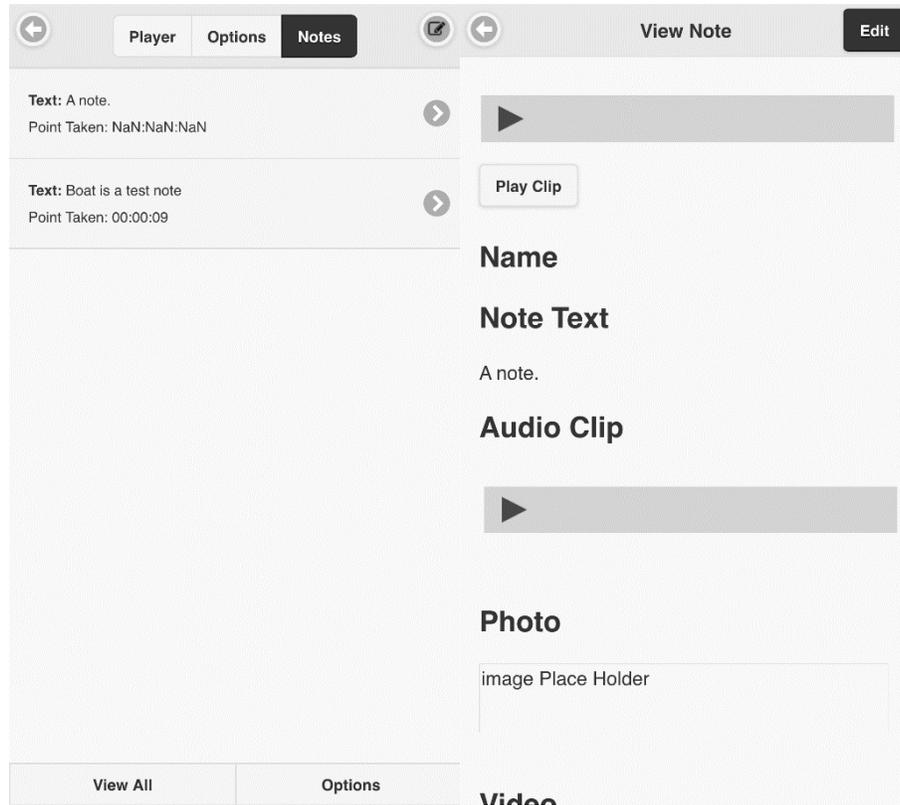
Task seven, involved setting an out point for a clip note. The goal was to have users click the Set clip out point button. By setting a clip out point, users can set the point they want the highlight or audio annotation to end. This button can be seen in Figure 10.

Task eight, asked participants how they would take a note when listening to a recording. The goal was to have participants tap the Add new note icon in the top right corner of the screen, enter a note and press the save button in the top right corner of the Add note screen. The following figure shows both the Player and Add Note screens as they appeared during the testing sessions.



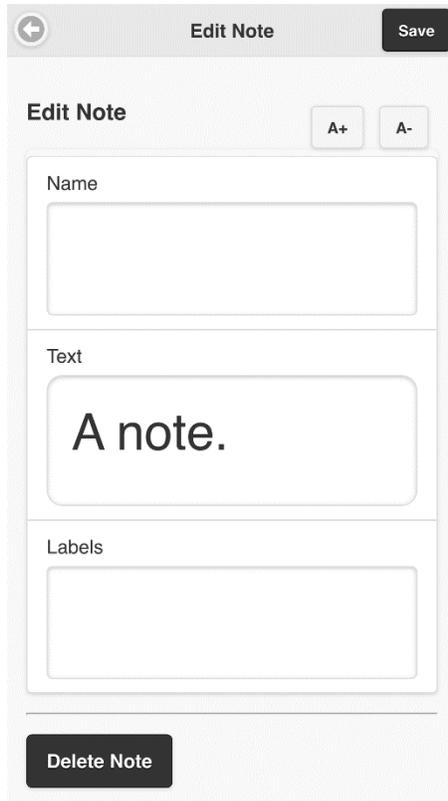
**Figure 12: Shows the main player screen (left) and the Add new note screen (right) which is shown after the Add new note icon is pressed on the player screen.**

Task nine, asked participants to review the note they had taken in task 8. The goal was to have participants tap the Notes button at the top of the screen shown in Figure 13, which displays a list of all notes that have been taken for a recording. The participant could then tap on a note in the list to view it.



**Figure 13: View all notes screen (left) View note screen (right)**

Task ten, builds on task nine but instead of viewing a note they are asked how to edit the note they viewed in task nine. The goal was to have them click the Edit button in the top right corner of the second screenshot in Figure 13. After tapping the Edit button, they would see Figure 14.



**Figure 14: Edit note screen**

#### **4.7 Close out message said orally to all participants**

Thank you for taking part in this usability test. If you have any questions you want to ask me, please ask them now. Moreover, thanks for your participation.

#### **4.8 Device used for testing**

An iPhone 6 Plus running iOS 9 was used by all participants during the test. SpokenText Reader was installed on the device. I launched it and navigated the application to the Library screen.

This device was used for the testing since it was the one I was most familiar with and used by the majority of participants who owned a mobile phone. This is important as screen readers used by people with visual impairments vary between

the various platforms, so it was important to use a device that could accommodate these participants and one for which they would also be quite familiar.

#### **4.9 Testing room setup**

The testing room was setup to be comfortable for participants and to allow me to see the actions taken by each participant during the testing sessions. Additionally, it was designed to allow for high quality recordings of both audio and video to be captured. The 60-inch television was connected to a MacBook Air via an HDMI cable. This allowed me to see in detail what any given participant was doing. The television and MacBook Air were angled as much as possible so that they were not in the direct line of sight of a participant. This was done to help mitigate any issue participants might have with seeing themselves while participating in the usability testing session, while at the same time accommodating for the researcher's disability.

The MacBook Air, captured the video feed coming from the USB webcam placed on the testing sled, which pointed at the iPhone 6s, Plus's screen and the second video feed coming from the USB webcam that was pointed at the participant and placed on the desk. The MacBook Air then recorded the whole screen using QuickTime's built-in screen recording feature and sent a mirror copy of the full desktop to the 60-inch television via an HDMI cable.

A second HD video camera and iPhone 5s were used as a backup in case the main recording system malfunctioned. The HD video camera captured both audio and video, whereas the iPhone 5s just captured audio using the built in voice recorder application.

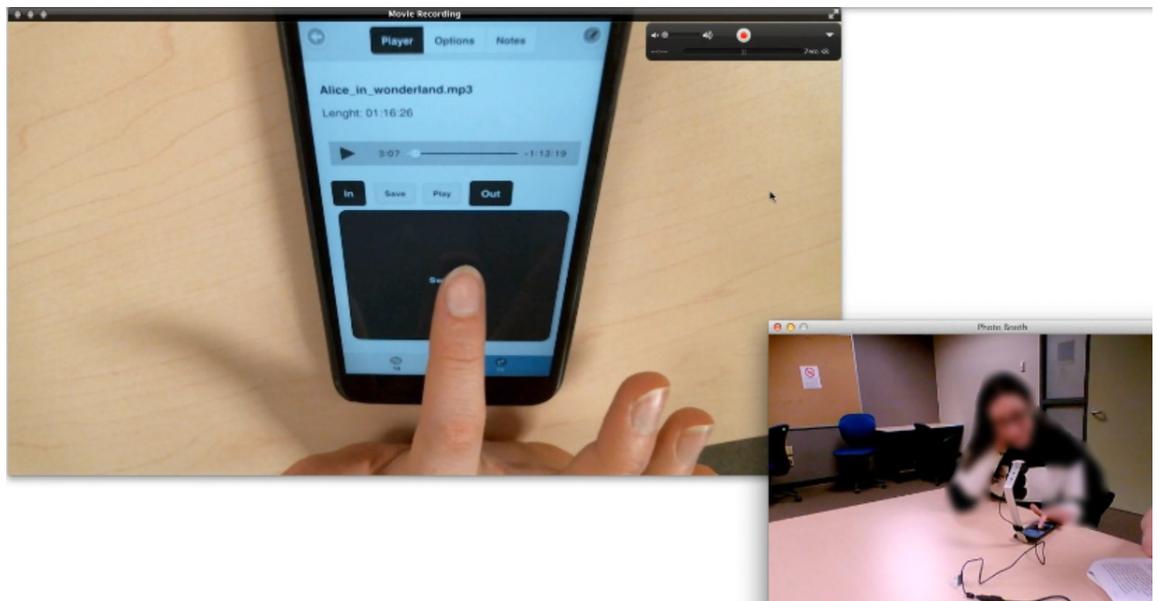
The desk was positioned in the room in such a way as to ensure that the overhead lights did not reflect off the screen of the iPhone 6s Plus.



**Figure 15: Usability testing room setup for testing session**



**Figure 16: Layout of equipment used for the usability testing sessions.**



**Figure 17: Screen capture of recording being made of test session**

#### **4.10 Custom testing sled designed for testing with visually impaired people**

To facilitate the testing, a custom usability testing sled was designed and developed. It allowed for high quality video and audio to be captured from the testing sessions, while still allowing users to act in as normal a way as possible no matter what their visual acuity.

The development of the sled is discussed in detail in Appendix C .

## **5 Chapter: Analysis**

The limited population of visually impaired and learning disabled students who use e-text or MP3 files to study from printed material as noted in section 4.2.4 of this thesis, played a key determining factor in selecting how best to analyze and present the results of the study without revealing the identity of the participants. They were offered anonymity and it is our duty to guarantee it. It would not take much information about a participant, for example, their degree program or if they use a guide dog to potentially make it possible for a reader of this thesis to guess the participant's identity. It is for these reasons that details are omitted about each participant. Great care was taken to ensure that the anonymity of all participants was maintained.

With the above in mind, data gathered during the study was analyzed using two approaches: the first approach involved analyzing answers to the pre and post questionnaires along with a time on task analysis and an analysis of task completion rates from the usability testing sessions. The second approach utilized the story telling method typically used in ethnographic research to analyze comments made by participants during the study.

### **5.1 Pre-test questionnaire findings**

The following sections present data and insights gathered from the pre-test questionnaire.

#### **5.1.1 General participant demographics**

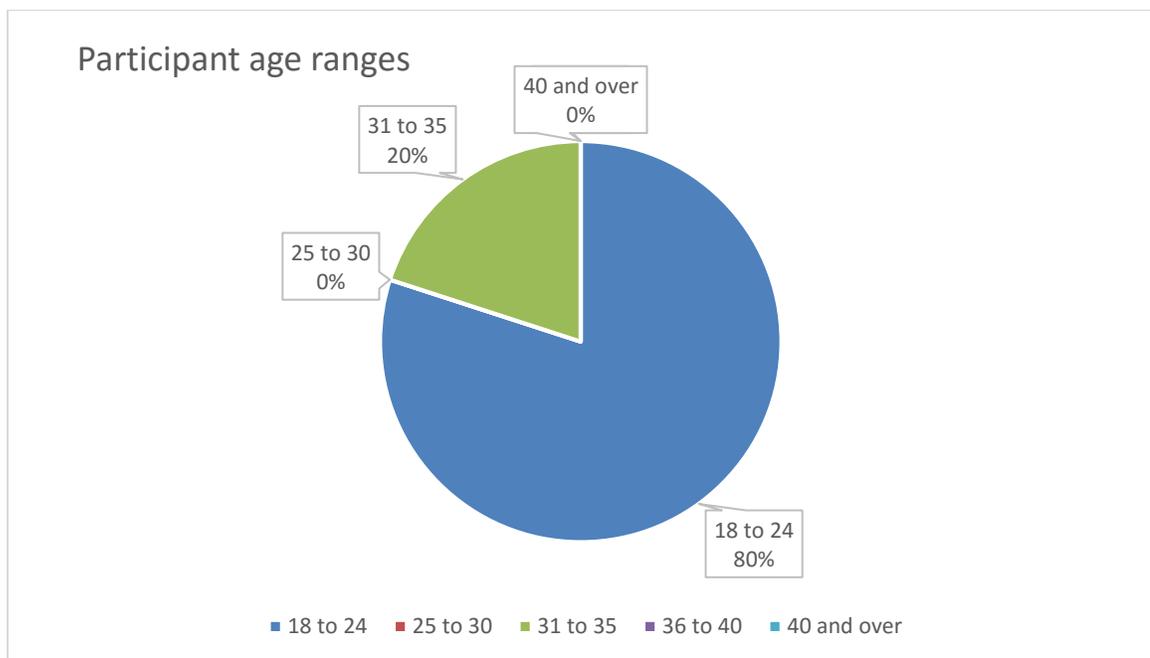
In total five participants {Table 2} took part in the usability test, four females and one male. Three of the participants (P1, P2 and P4) had no vision or very limited vision, while the other two (P3 and P5) were learning disabled and had normal vision. All participants

except for P1 had extensive experience with mobile technology. Where P1 had very limited exposure to mobile technology and did not own a smartphone.

Disability	Disability	Experience with mobile technology
P1	Visually Impaired	Very limited
P2	Visually Impaired	Extensive
P3	Learning Disabled	Extensive
P4	Visually Impaired	Extensive
P5	Learning Disabled	Extensive

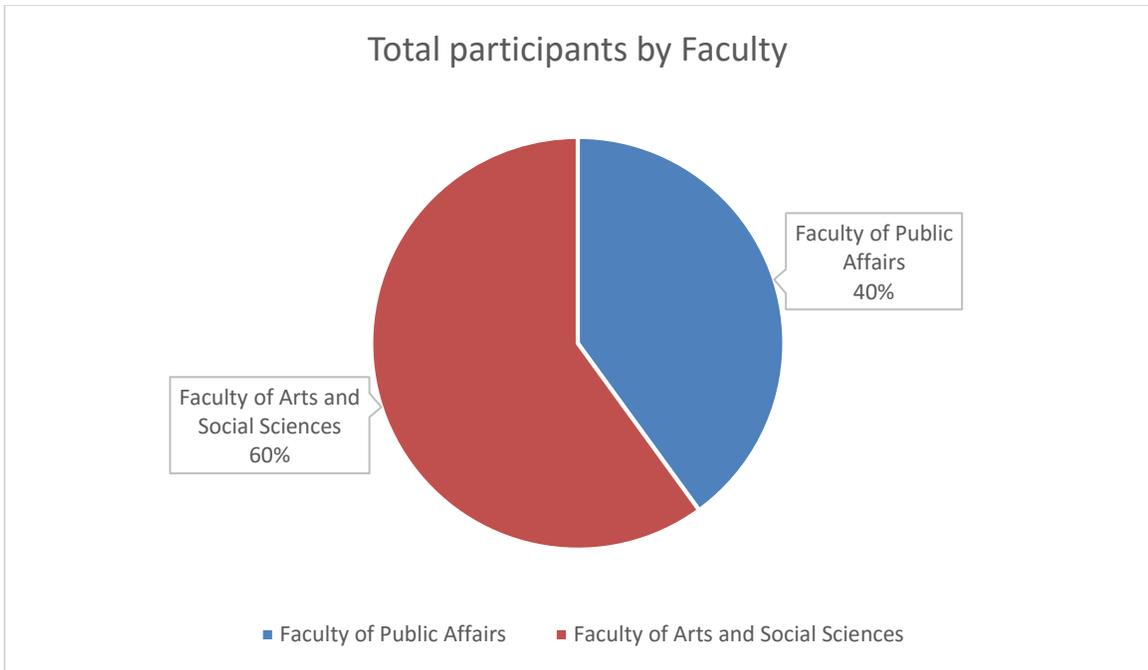
**Table 2: Participants disability and experience with mobile technology**

Figure 18, shows the age ranges of participants who took part in the study. All but one participant was between the ages of 18 to 24 the remaining participant was between the ages of 31 to 35. There were no participants between the ages of 25 to 30 or 40 and over.



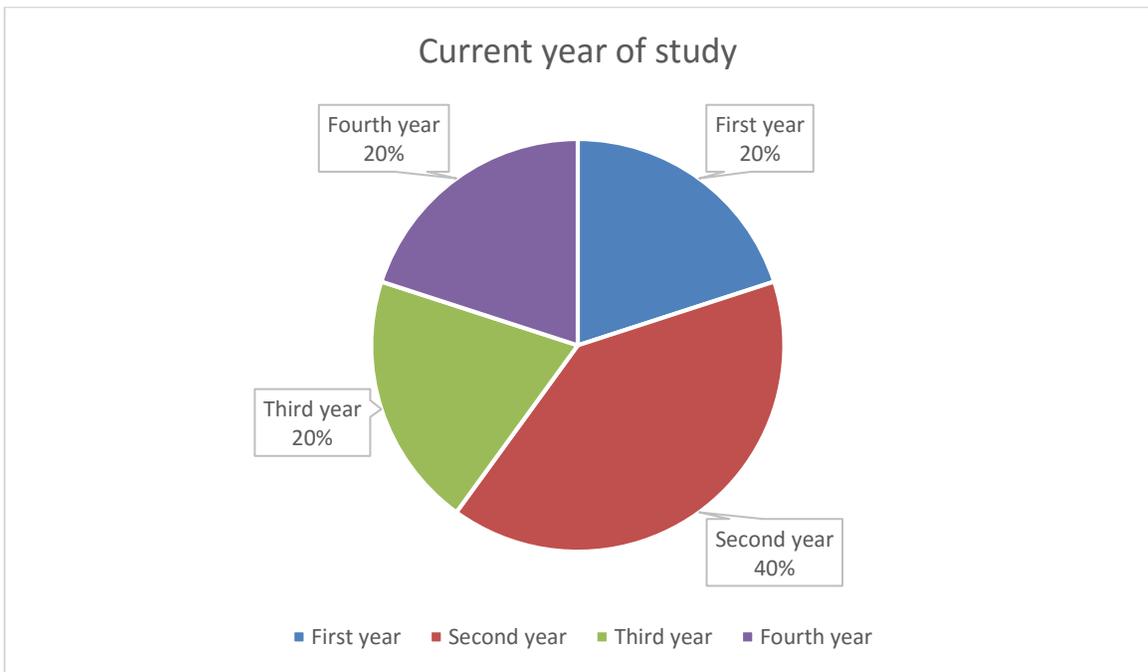
**Figure 18: Participant age ranges**

Participants (Figure 19) were split between the faculties of Public Affairs and the Faculty of Arts and Social Sciences, 60% belonging to the Faculty of Public Affairs and 40% belonging to the Faculty of Arts and Social Sciences.



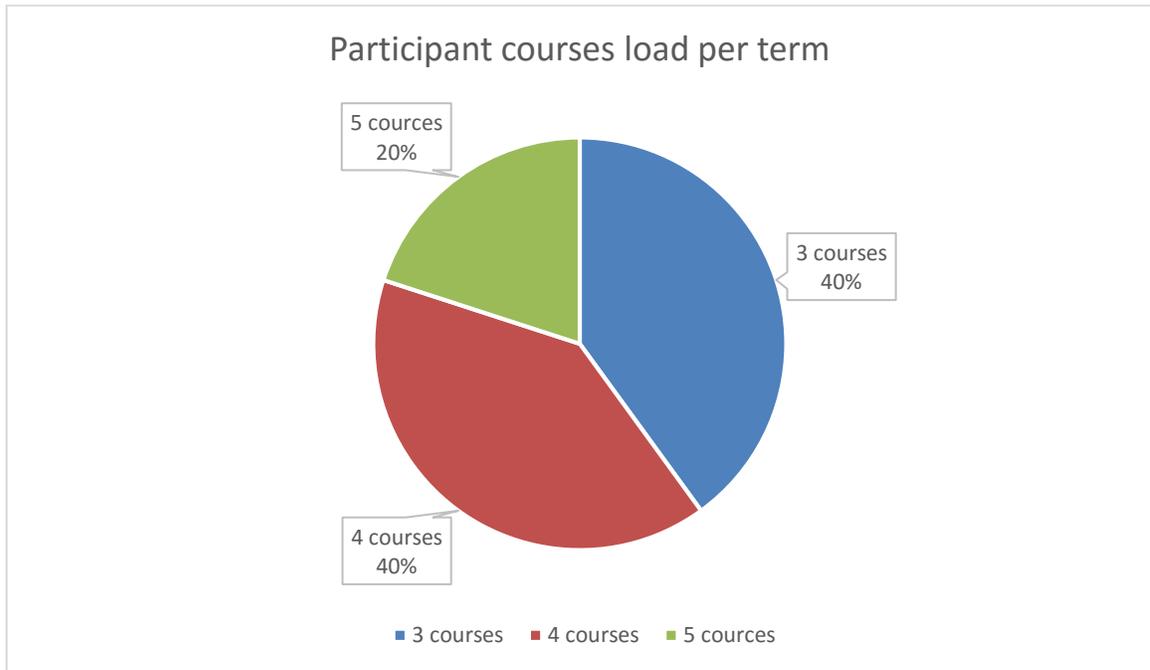
**Figure 19: Total participants by Faculty**

When it came to the current year of study for participants, 40% were in second year while the remaining participants were in first, third or fourth year, Figure 20.



**Figure 20: Current year of study**

Regarding total course load per term (Figure 21) only one participant took a full course load of five classes per term, with the rest preferring to take three or four classes per term.

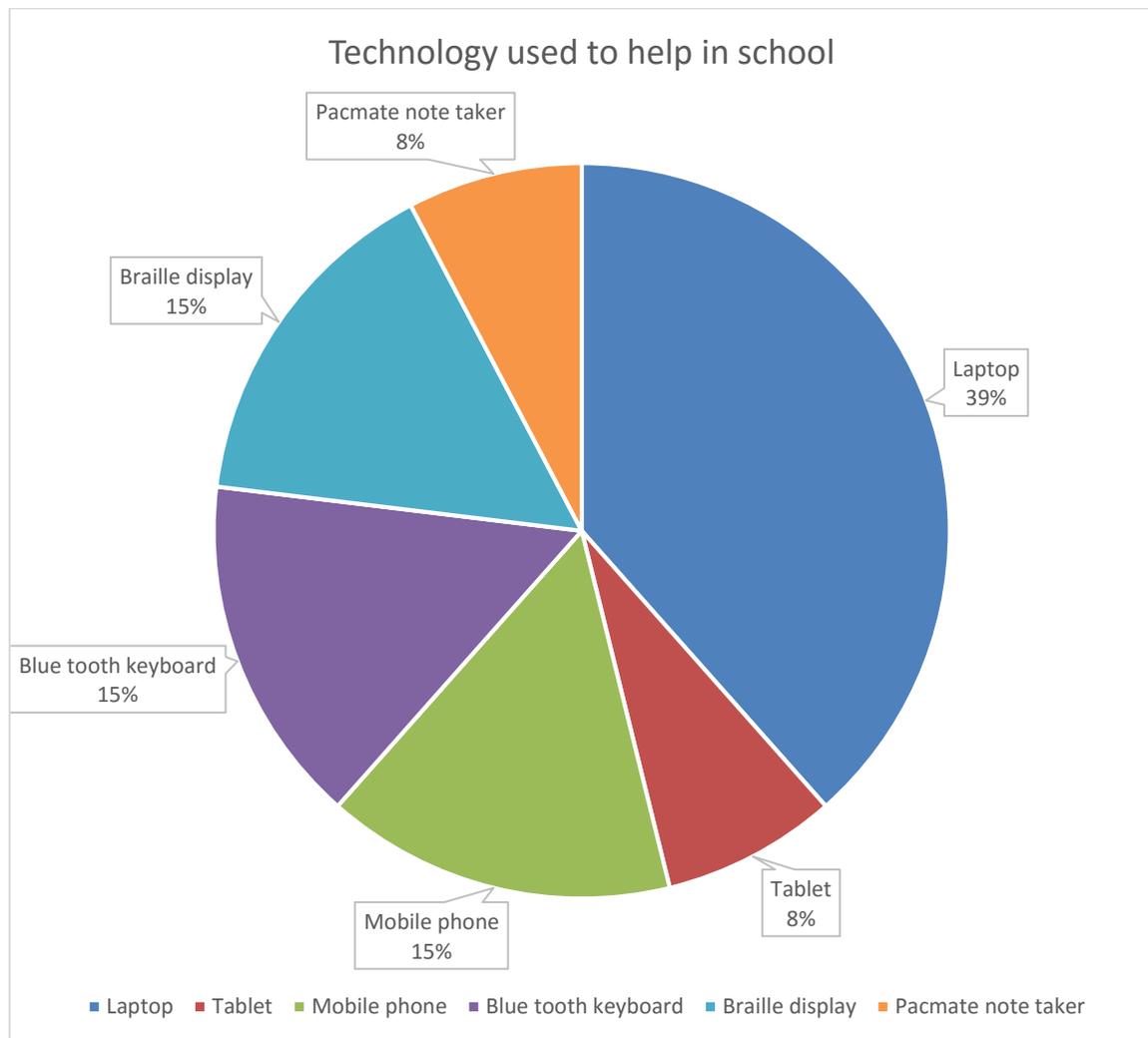


**Figure 21: Participant course load per term**

### **5.1.2 Technology used to help in school**

Figure 22, shows the technology participants reported they used to aid them in their studies. Overwhelmingly participants preferred to use their laptops for reading or listening to material they needed to study for a course. All but one student owned a smartphone but even if they owned a smartphone, participants still preferred to use their laptop as the primary piece of technology they used when studying for a class. Some of the reasons given for this indicated that it helps them to stay organized; many received their material from the PMC via email and thus found it was just easier to use a laptop to organize and interact with the material they received from the PMC. Additionally many participants

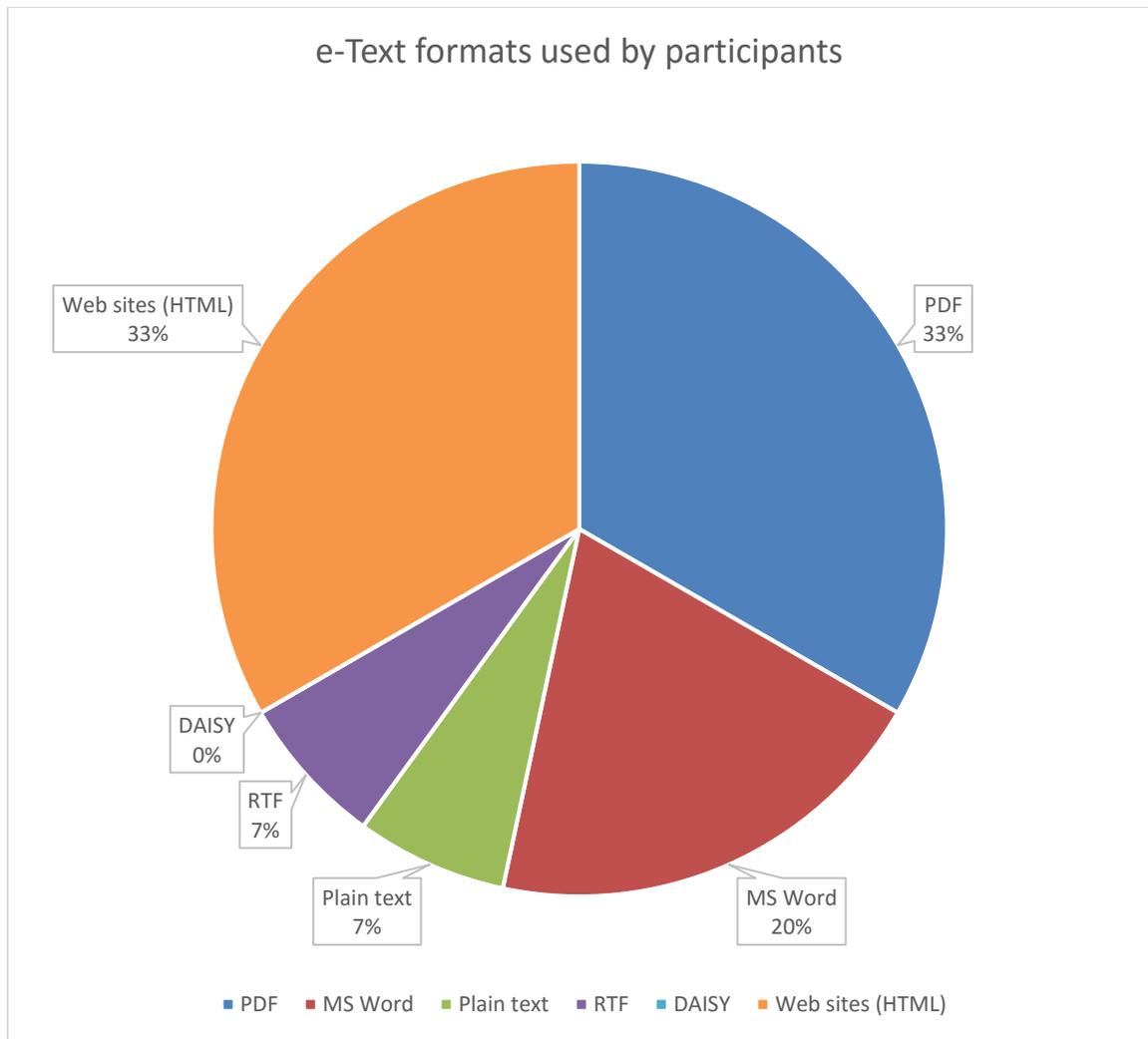
reported that they found it hard to get the material on to their mobile device, so just did not bother transferring material to their mobile device, since the friction was too high.



**Figure 22: Technology used to help in school**

### **5.1.3 e-Text formats used by participants**

The most popular e-text formats utilized by students for studying were MS Word, Adobe PDF and web sites (Figure 23). The reason why these formats were the dominate formats used by participants is many fold and varied by vision impaired versus learning disabled.



**Figure 23: e-Text formats used by participants**

PDF is the default format offered by Carleton University library and the PMC when offering e-text to print disabled students, so it is understandable that it is one of the formats used most often by participants. PDF has its challenges for users who have low vision since it often does not interact well with their access technology (AT). All three low vision participants reported having issues with reading PDF files and their preference for reading material in MS Word format, whenever possible or material they found on the internet in HTML format.

PDF worked fine for the students with learning disabilities. They did not require their material to be converted to MS Word format.

#### **5.1.4 Approaches to taking notes**

The approaches used by participants to take notes when conducting research were quite varied but they did have a common theme in that all but one of them used their laptops to take notes.

The participants with low vision typically preferred to take notes or bookmark passages using Kurzweil 1000<sup>4</sup> software if they owned it, take notes in a MS Word file or use a PAC mate<sup>5</sup> if they owned one.

The learning disabled participants highlighted parts of the PDF files as they read them. Afterwards, they would review these highlighted areas when studying or writing their essays or papers.

#### **5.1.5 Discussion**

Determining how many courses to take is a major decision every print disabled student must make. One participant mentioned that by taking four courses you could remain a full time student and could still get access to grants, scholarships and bursaries. I would suspect that if disabled students could take three courses and still be eligible to receive grants, scholarships and bursaries many would take this approach due to the excessive challenges many print disabled students face when trying to take many courses including a heavy reading component, all at the same time.

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<sup>4</sup> Kurzweil 1000 and 3000 are software desktop software design specifically for people with print disabilities to aid them when studying - <https://www.kurzweiledu.com/default.html>

<sup>5</sup> Pac mate: A \$4,000 dedicated notetaking device created specifically for people with low vision - <http://www.freedomscientific.com/Products/Blindness/PACMateProductFamily>

Even though the visually impaired users reported on how they took notes many said that they only went to the effort to take notes if they knew in advance that they would need to cite specific areas of the material in great detail for use later in a paper or to study for an exam or test. They did not give specific reasons for why this was, but it seemed from talking to them that it was a lot of work for them to take notes given the approach they used to take notes so they only did it if absolutely necessary. One other point to keep in mind is that for many of the participants they spend 2 to 2.5 times longer reading printed material than their non-disabled peers do. Time management is a key concern they have. Especially when considering the 20+ pages, on average, per class, per week, participants reported they are requested to read.

One emerging trend that might help students to study using mobile devices in the future, is the wide spread adoption of cloud storage services like Google Drive and Microsoft OneDrive. Google Drive offers 15GB of storage free to all users of the service and at the time of writing this thesis Microsoft is offering all students attending Carleton University, 1TB of storage on its OneDrive service. With these cloud storage services students can easily transfer or stream material they want to read, be it e-text or MP3 to a mobile device where they can consume it while on the go all with little to no effort or friction on their part.

The general impression obtained from talking to the participants, regardless of whether they are visually impaired or learning disabled, indicates that:

- They are trying their best to keep up with their schoolwork
- Often struggle with reading everything they are assigned to read for their classes, and

- Still face many challenges with the technology they must use on a daily basis to get by in school.

## **5.2 Usability test findings**

Usability test findings were analyzed using a time on task analysis and analyzing overall task completion rates.

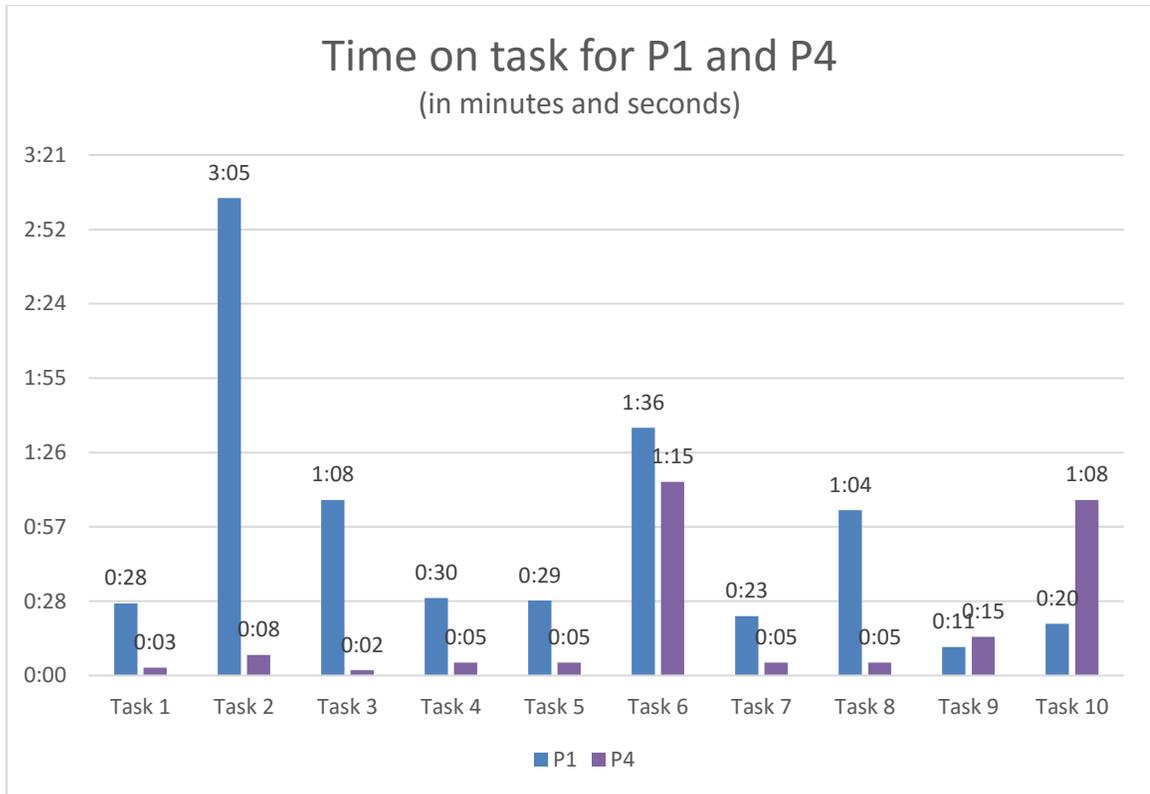
The time on task analysis was performed by reviewing the video recorded for each participant session and using a stopwatch to track how long the participant took to complete the task. Only actual time on task values are shown, if a participant stopped while conducting a task to talk about something not related to performing the task, the stop watch was stopped until they stop talking about non-task related information. It was turned back on when they returned to performing the task they were initially asked to perform.

The process to analyze the task completion rates from the usability testing sessions was as follows. Each task was scored as a pass or fail and the totals for each task were added up and then divided by the total number of participants to get a total completion percentage for a specific task.

The following sections discuss the findings from the usability test and where appropriate discuss where these findings might contain potential biased. Due to the limited sample size, participant mix or limitations of the prototype.

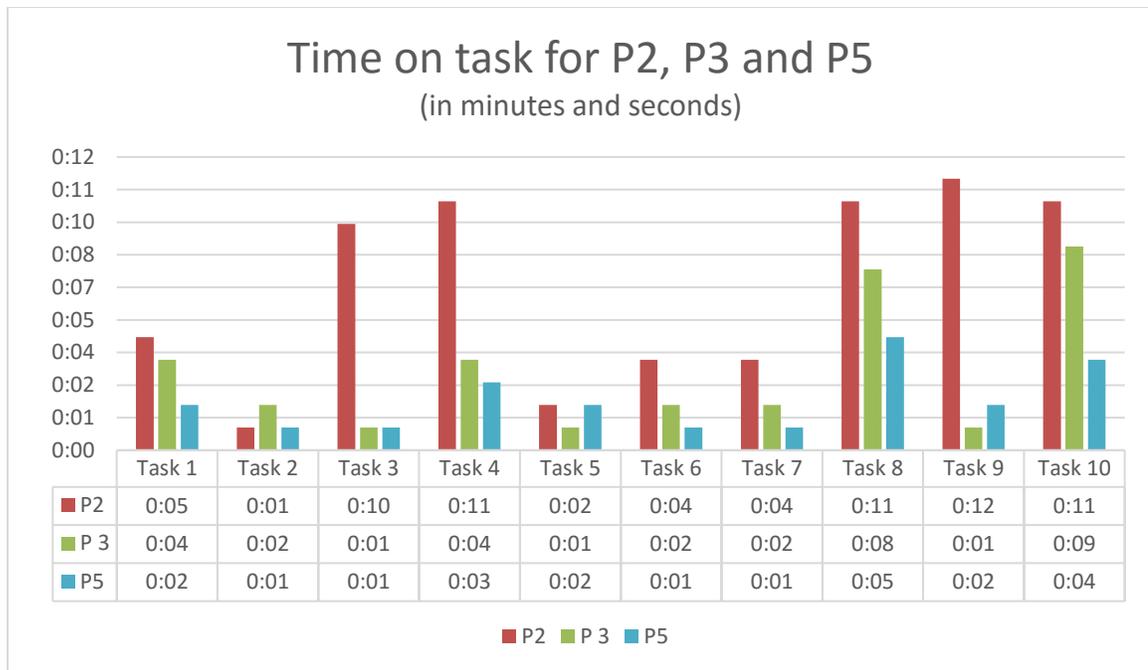
### **5.2.1 Time on task**

Figure 24 and Figure 25 present the results of the time on task analysis. The data was split into two figures to help make it easier to comprehend due to the task completion times for P1 being so much longer than the rest of the participants.



**Figure 24: Time on task for P1 and P4**

From Figure 24 we can see that P1 and P4 struggled with a few of the tasks. Task 2, 6 and 8 proved to be a challenge for P1. Task 6, proved challenging for P4, along with task 10 which they failed to complete even after trying for 1 minute and 8 seconds.



**Figure 25: Time on task for P2, P3 and P5**

From Figure 25, we can see that P2 took significantly longer to complete most of the tasks, especially tasks 3, 4, 6, 7, 9 and 10. Given that P2 is blind, was using a screen reader and could not just glance at the user interface to see all of the controls it contained and had to navigate control-by-control this is to be expected. The expectation being that given time and the visual nature of how ‘Voice Over’ works P2 and all of the other participants (P1 and P4) using Voice Over, would remember the controls each screen of SpokenText Reader offered. Thus, be able to tap on the control they wanted to activate instead of having to navigate, control by control to find the one they wanted.

Remembering a user interface is a common practice among users with low vision, since it is often much faster than having to put your face close to a screen to see it or navigate control by control when using a screen reader. There is no reason why if they found SpokenText Reader useful they would not take the time to remember it as they do for other applications they want to use. Perhaps this is something to investigate since time

and practice may give a better indication of how these users can incorporate a new technology.

One final contributing factor to the slow times of P1, P2 and P4 who all used ‘Voice Over’ was the labeling issues of some of the controls. The controls for setting «In and Out» points for clip notes and the controls for «Playing and Saving» a clip note caused some problems. It may be due to how ‘Voice Over’ did not read the extra information added to the controls in the case of the set in point and out point buttons, this issue is discussed in more detail in a following section of this thesis.

The following table shows time on task values by participant for all users in minutes and seconds. It is clear that P1 struggled on many of the tasks taking minutes to complete tasks that other participants completed in seconds., This participant neither used a smartphone before nor used ‘Voice Over’ on a mobile device before attending the testing session it makes sense that it took longer for this participant to complete each task. As they were not only learning how SpokenText Reader was structured but also trying to learn how to use ‘Voice Over’ and learn the mobile user interface design patterns employed by SpokenText Reader (which can be quite different than interface patterns used for desktop applications) all at the same time.

	T1	T 2	T 3	T 4	T 5	T 6	T 7	T 8	T 9	T 10	Mean
P1	0:28	3:05	1:08	0:03	6:57	1:36	0:23	1:04	0:11	0:02	1:29
P2	0:05	0:01	0:10	0:11	0:02	0:04	0:04	0:11	0:12	0:11	0:07
P3	0:04	0:02	0:01	0:04	0:01	0:02	0:02	0:08	0:01	0:09	0:03
P4	0:03	0:08	0:02	0:05	0:05	1:15	0:05	0:05	0:15	1:08	0:19
P5	0:02	0:01	0:01	0:03	0:02	0:01	0:01	0:05	0:02	0:04	0:02
Mean	0:08	0:39	0:16	0:05	1:25	0:35	0:07	0:18	0:08	0:18	0:24

**Table 3: Time on task values by participant for all users in minutes and seconds**

From Table 3 we can see that the total average time spent on any task was 24 seconds and that most tasks were completed in under 15 seconds when you exclude the values for P1.

Table 4 shows how the times change when you remove the values for P1. Total average time spent on any task drops to 6 seconds from 24 seconds. It is worth noting that task 6 and 10 which took P4 significantly longer to complete, 1 minute and 15 seconds for task 6 and one minute for task 10. However, even with this, the times registered were quite comparable, which is surprising given the fact that both P2 and P4 were only using ‘Voice Over’ to access SpokenText Reader and could not see the screen.

	T1	T 2	T 3	T 4	T 5	T 6	T 7	T 8	T 9	T 10	Mean
P2	0:05	0:01	0:10	0:11	0:02	0:04	0:04	0:11	0:12	0:11	0:07
P3	0:04	0:02	0:01	0:04	0:01	0:02	0:02	0:08	0:01	0:09	0:03
P4	0:03	0:08	0:02	0:05	0:05	1:15	0:05	0:05	0:15	1:08	0:19
P5	0:02	0:01	0:01	0:03	0:02	0:01	0:01	0:05	0:02	0:04	0:02
Mean	0:02	0:02	0:02	0:04	0:02	0:16	0:02	0:05	0:06	0:18	0:06

**Table 4: Time on task values by participant excluding those for P1 in minutes and seconds**

Reviewing Table 6 and Table 7 where the times for failed tasks have been omitted, reveals that over all completion times for all tasks with all users changes only slightly from an average completion time of 24 seconds for all tasks to a time of 21 seconds when the failed tasks are removed. We see a similar small improvement when looking at task completion times with P1’s times removed,. Thus the overall task completion rate improving from 6 seconds to 5 seconds.

Furthermore, where we see the biggest change is in the completion times for task 3, 7 and 10. Task 3 sees the overall average completion time fall from 16 seconds to 3 seconds. Task 7 completion times drop from 7 seconds to 3 seconds and task 10’s completion times drop from 18 seconds to 8 seconds.

	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	Mean
P1	0:28	3:05		0:03	6:57	1:36		1:04	0:11		1:54
P2	0:05	0:01	0:10	0:11	0:02	0:04	0:04	0:11	0:12	0:11	0:07
P3	0:04	0:02	0:01	0:04	0:01	0:02	0:02	0:08	0:01	0:09	0:03
P4	0:03	0:08	0:02	0:05	0:05	1:15	0:05	0:05	0:15		0:13
P5	0:02	0:01	0:01	0:03	0:02	0:01	0:01	0:05	0:02	0:04	0:02
Mean	0:08	0:39	0:03	0:05	1:25	0:35	0:03	0:18	0:08	0:08	0:21

**Table 5: Time on task values by participant for all users in minutes and seconds excluding times for failed tasks**

	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	Mean
P2	0:05	0:01	0:10	0:11	0:02	0:04	0:04	0:11	0:12	0:11	0:07
P3	0:04	0:02	0:01	0:04	0:01	0:02	0:02	0:08	0:01	0:09	0:03
P4	0:03	0:08	0:02	0:05	0:05	1:15	0:05	0:05	0:15		0:12
P5	0:02	0:01	0:01	0:03	0:02	0:01	0:01	0:05	0:02	0:04	0:02
Mean	0:02	0:02	0:02	0:04	0:02	0:16	0:02	0:05	0:06	0:06	0:05

**Table 6: Time on task values by participant excluding failed tasks and times for P1 in minutes and seconds**

### 5.2.1.1 Discussion

Time on task is a common analysis technique used in usability testing results. This study produced results that can indicate that even with the diverse nature of the test participants it is a useful measurement. The blind participants ranged greatly in their exposure and knowledge of mobile access technology and mobile technology in general, some demonstrated that they were expert users of mobile access technology and mobile technology in general and some had very little exposure to mobile access technology and mobile technology in general. All of which greatly influenced how long it took them to complete tasks. But if you exclude the results of P1 as was done with Table 4 and Table 6 and just look at the times for the rest of the participants, for the most part their times are

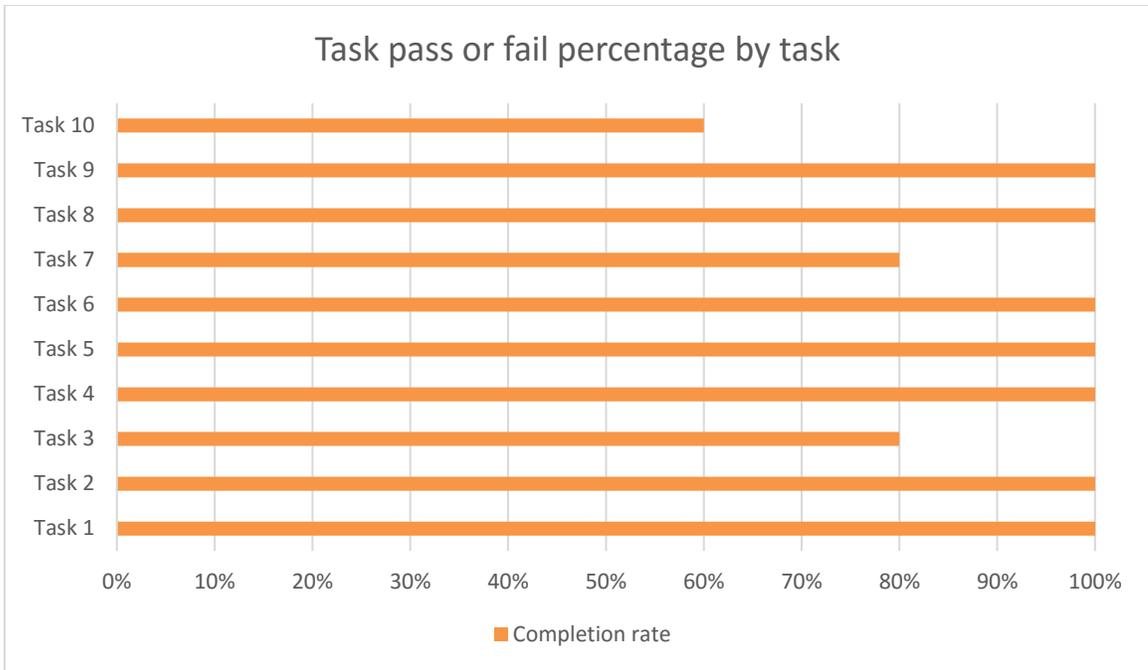
not all that different (all things being equal) and given time might improve greatly with more exposure to the application. This was a surprise to me. I thought it would not be the case when first setting out to conduct the time on task analysis.

If users of screen readers were also given more time to “look over a screen” before being asked a task they might have completed tasks in times even closer to their peers. Typically, this is not done in usability testing. But based on my experience testing with blind people, limited as it is, I think it might be a best practice to let all blind users navigate around a screen using their screen reader for a period of time to let them “see it” before asking them questions, but more research would be needed to determine this for sure. It is a worthwhile idea given the slower speed of interaction provided to screen reader users verses participants who are fully sighted who have the ability to quickly visually scan a user interface to determine the affordances it offers.

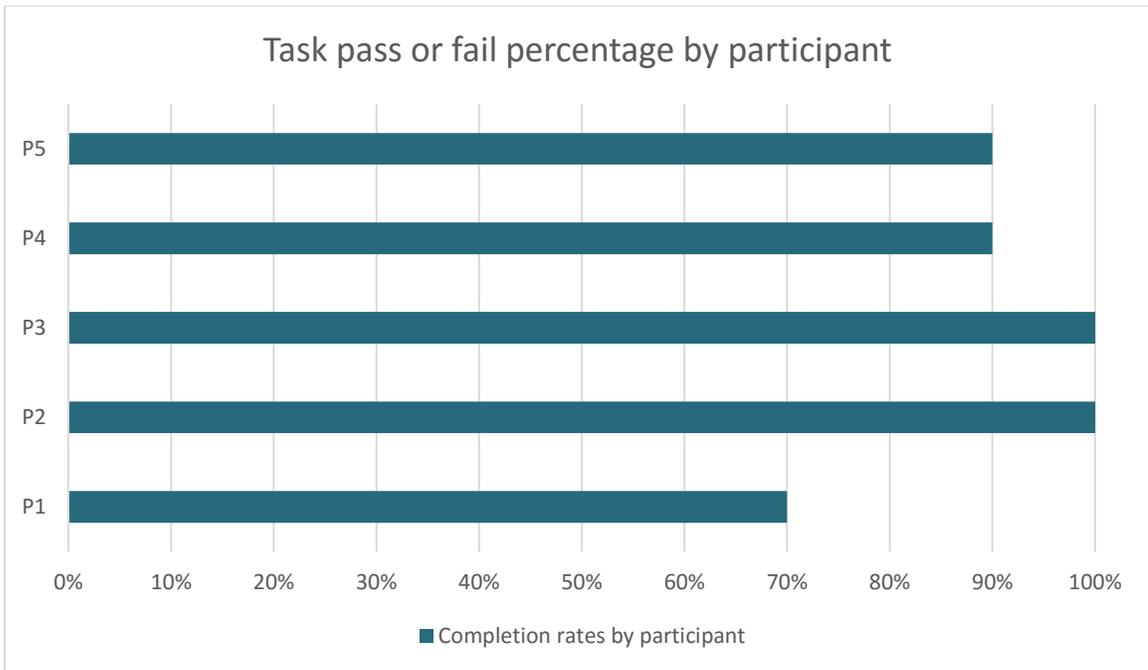
### **5.2.2 Task completion success rates**

**The overall completion rate for all tasks by all participants (Table 7: Task Completion rate percentages by participant and by task**

) was 92% and all participants (Figure 26 and Figure 27) completed task 1, 2, 4, 5, 6, 7, 8. P1 and P4 did not complete task 10, which reduced its completion rate to 60%, but I think this could be attributed to P1’s overall lack of experience with ‘Voice Over’ and/or testing fatigue. P4 navigated over the Edit note button many times, but was also showing signs of fatigue and never could quite find it.



**Figure 26: Task pass or fail percentage by task**



**Figure 27: Task pass or fail percentage by participant**

	P1	P2	P3	P4	P5	Completion rate
Task 1	1	1	1	1	1	100%
Task 2	1	1	1	1	1	100%
Task 3	0	1	1	1	1	80%
Task 4	1	1	1	1	1	100%
Task 5	1	1	1	1	1	100%
Task 6	1	1	1	1	1	100%
Task 7	0	1	1	1	1	80%
Task 8	1	1	1	1	1	100%
Task 9	1	1	1	1	1	100%
Task 10	0	1	1	0	1	60%
<b>Completion rate</b>	<b>70%</b>	<b>100%</b>	<b>100%</b>	<b>90%</b>	<b>100%</b>	<b>92%</b>

**Table 7: Task Completion rate percentages by participant and by task**

**Reviewing Table 8 Table 8: Task pass or fail by Participant**

we can see that a few hints were given to participants during their testing sessions. P1 was given a hint on task 2, 3 and 10 which given their aforementioned lack of experience with smartphones and ‘Voice Over’ is understandable. P4 was given a hint on task 6 because they were getting frustrated and P5 was given a hint on task 8 to keep them moving forward after getting confused by some sample data that was accidentally left in place after a previous testing session.

	P1	P2	P3	P4	P5
Task 1	Pass	Pass	Pass	Pass	Pass
Task 2	Pass / 1 hint	Pass	Pass	Pass	Pass
Task 3	Fail / 1 hint	Pass	Pass	Pass	Pass
Task 4	Pass	Pass	Pass	Pass	Pass
Task 5	Pass	Pass	Pass	Pass	Pass
Task 6	Pass	Pass	Pass	Pass / 1 hint	Pass
Task 7	Fail	Pass	Pass	Pass	Pass
Task 8	Pass	Pass	Pass	Pass	Pass / 1 hint
Task 9	Pass	Pass	Pass	Pass	Pass
Task 10	Fail / 1 hint	Pass	Pass	Fail	Pass

**Table 8: Task pass or fail by Participant**

### **5.2.2.1 Discussion**

Although not all participants were successful in completing all tasks presented to them during the usability test, an overall task completion rate of 92% is quite encouraging. There are a few points worth discussing in more detail that became known during the testing sessions.

#### **5.2.2.1.1 Setting in and out points for audio clip notes**

Screen reader users did take longer to complete each task as expected given that interacting with screen readers are inherently slower as they do not provide a means to glance at an interface. Instead, they need to navigate a screen, control by control inspecting each one to determine which one they want before taking action.

Given time, participants would typically learn where the controls are on the screen and their function as they created a mental model of how the application worked but this takes time and exposure to an application and a willingness within the user to commit the interface to memory.

The large delay before ‘Voice Over’ reported the extra contextual information provided to blind participants as additional context regarding a control’s purpose, blind participants accordingly took longer to familiarize themselves with the controls on the player page of SpokenText Reader. It could be argued, affected their mental model creation for how the application worked and what it was capable of doing. They could not quickly

swipe left and right but had to instead rest on a control for a few seconds to determine its purpose.

It was interesting that the sighted participants had no issues setting in and out points for a clip note. It seemed like they understood the visual relationship of how the clip note features were grouped vs the controls used to play and pause the recording.

The tasks to set in and out points for a clip note, were slower for users of Voice Over, since they had to navigate the user interface to find the controls affecting their time on task for task 6 and 7. The hybrid application also caused issues since it introduced a delay in speaking the extra contextual information only provided by 'Voice Over' after a 10 second delay. If the application had been a truly native iOS application, there would have been no delay in speaking the additional contextual information only intended for 'Voice Over' users.

'Voice Over' users initially move so fast they never heard the extra information added to these controls until they slowed down. Often navigating back and forward over all of the controls until they happened to rest on one long enough for the extra information to be reported. The learning disabled participants had no problems finding the controls needed to set in and out points and set the in and out points with ease. I think this was due to the fact that they could see the visual relationship between the various groups of controls presented on the screen, where the 'Voice Over' users were getting confused between the controls to play recordings and those used to set clip in and out points. This was exacerbated by the delay in speaking the contextual information meant to provide the clip in and out points with a more descriptive label than just in or out. It should have reported "Set clip in point" and "Set clip out point" respectively.

#### **5.2.2.1.2 Control labels causing confusion**

Having two buttons labeled «Play» confused ‘Voice Over’ users, which is understandable. The main button to play or pause the recording reported as play when navigated to by ‘Voice Over’ and so did the «Play Clip» button. The Play clip button should have been reported as «Play Clip» when navigated to by ‘Voice Over’ and not just «Play». The difference between the two buttons is visually clear but not clear from the audio stream presented to ‘Voice Over’ users.

#### **5.2.2.1.3 Issues with using ‘Voice Over’ with hybrid applications**

‘Voice Over’ reported table and ARIA information that was not relevant for a native application, but intended for web pages only. This confused the blind participants who had previous experience with ‘Voice Over’ as it was not expected since they expected to be in a native application and have ‘Voice Over’ behave as such. In addition, delays in reporting title text placed on elements caused participants to misunderstand what some controls did.

If the same interface design was delivered using a true native iOS application the aforementioned issues would not be a problem anymore.

#### **5.2.2.1.4 Challenges with the Swipe Me controller**

The «Swipe Me» controller was of no use to blind participants since ‘Voice Over’ takes control over all possible swipe gestures thus making the control nonfunctional.

It might be possible to use 3D touch to implement a similar feature but more research is needed to determine if this is the case or not. Maybe, if a user was using ‘Voice

Over` and the swipe me controller received focus they could swipe up and down to rewind and double tap to play and pause the recording. This functionality would only be provided to users of `Voice Over`.

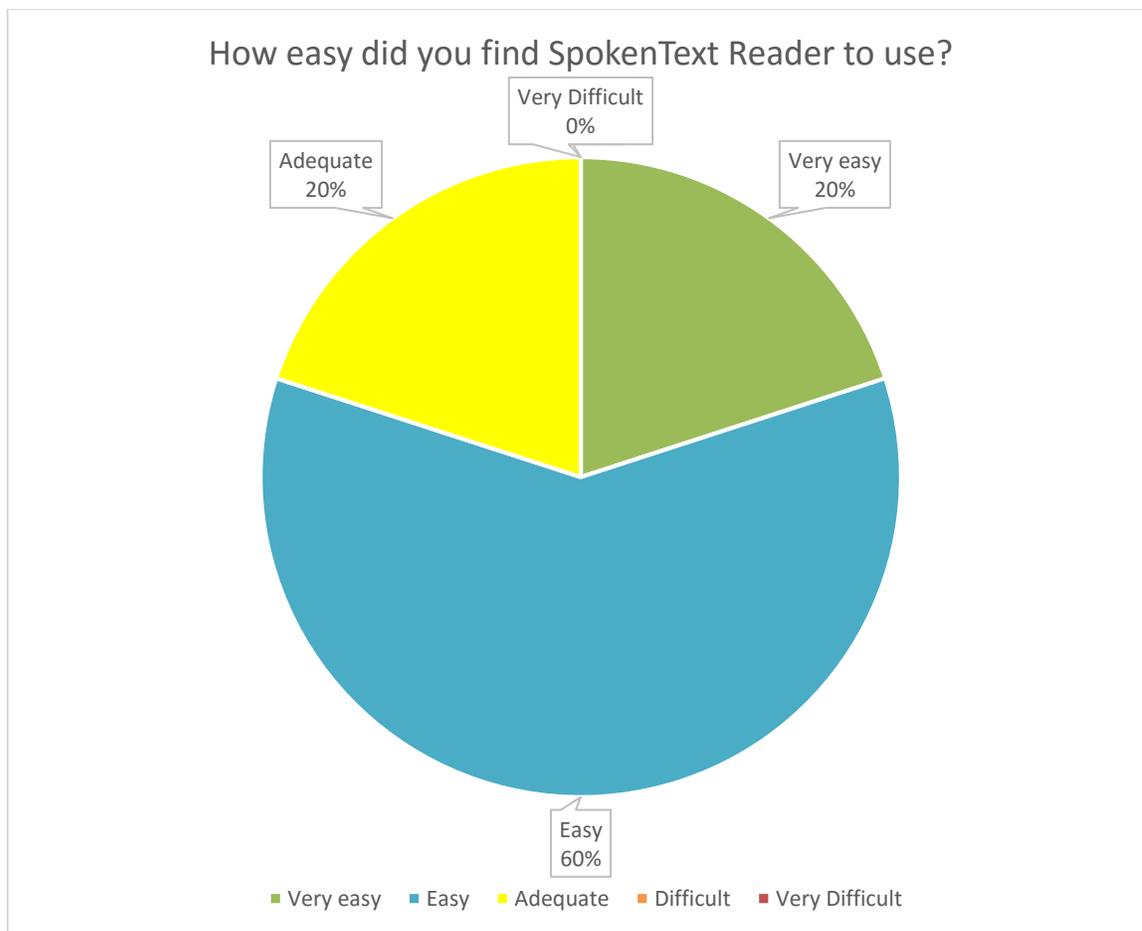
#### **5.2.2.1.5 Challenges with the sled**

For the most part the testing sled worked well. Participants were offered to hold the sled if they wanted to better simulate the typical way they would use their smartphones but most chose to leave it on the desk. This might be due to the large size of the iPhone 6S Plus and its 5.5-inch screen which is almost as large as a small tablet.

Even with them leaving the sled on the desk, there was no evidence that the use of the sled negatively affected the testing in any way.

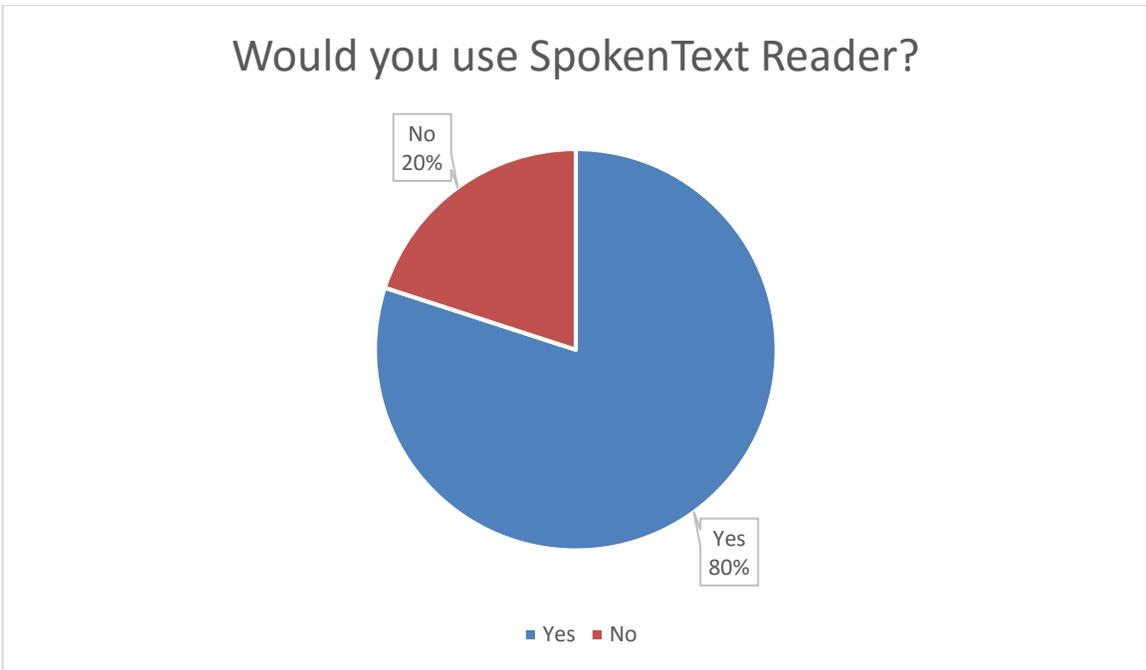
### **5.3 Post-test questions findings**

Four participants (Figure 28) indicated that SpokenText Reader was easy or very easy to use and one participant indicated it was adequate it would appear that SpokenText Reader might be usable by other people and not just me.



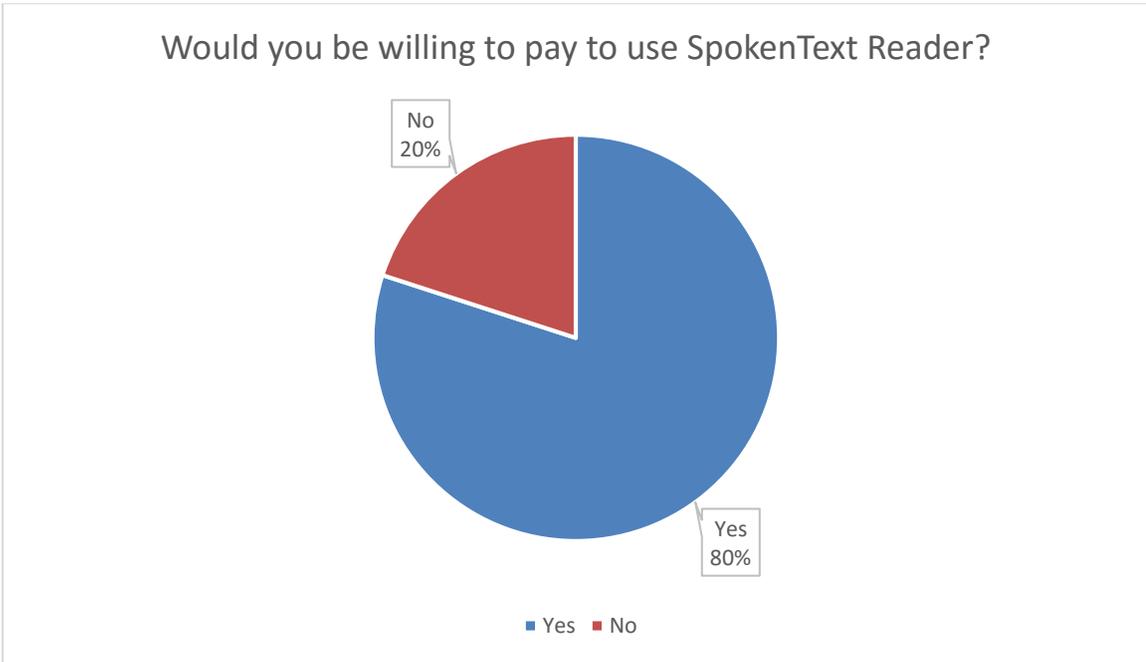
**Figure 28: How easy did you find SpokenText Reader to use?**

When asked if they would use SpokenText Reader to study if they could all but one said yes (Figure 29). The participant, who said no, owned a PAC Mate, a dedicated \$4,000 notetaking device designed for the blind, which they had been using for over 8 years, so this is understandable.



**Figure 29: Would you use SpokenText Reader to study, if you could?**

The response, from participants to the final question asked as part of the post-test questionnaire was encouraging, with 4 out of the 5 people tested saying that they would consider paying to use SpokenText Reader (Figure 30).



**Figure 30: Would you be willing to pay to use SpokenText Reader?**

### **5.3.1 Discussion**

One of the participants said they would not use the application if given a chance. Given this user had access to over \$20,000 of custom technology created for people who are visually impaired this comment is understandable. The learning disabled students who currently study using MP3 files were very excited about getting access to the application for listening too and taking notes on the readings.

Many of the participants indicating that: 1) SpokenText Reader would make their lives easier, 2) allow them to move around while studying, 3) help to keep them organized and 4) provide them with functionality not offered by any other application they had ever used; it appears that SpokenText Reader shows promise. It might be useful to other print disabled people and not just me.

## **5.4 Ethnographic research methods used to analyze comments made by participants**

My study, while not a full ethnographic research study, which are typically conducted over an extended period of time (Fetterman, 2010; Van Maanen, 2011), can still benefit from methods used in ethnographic research to analyze and interpret comments made by participants. In addition, being a member of the community of visually impaired and learning disabled people provided me with a unique insight into the participants, which would typically only be gained by an ethnographic researcher, studying a population over a long time. I have been visually impaired since birth, which gives me a unique insight into my participants that would be difficult for other researchers to have had. It gives me an understanding of them that only a member of the community could have. Using this and the story telling method used by ethnographic researchers I sought to analyze the data gathered during my research.

### **5.4.1 Observational findings**

During the usability sessions I exposed the swipe me controller to the learning disabled participants. Not as an official task but just to get their feedback after they had completed task 4 and 5. They were enthusiastic about how it would help them with the task of just rewinding or fast-forwarding a small amount of time and they talked about how they often waste time with their current approach to listening to MP3 files using iTunes on their laptops. At present they would use their mouse to try and drag the current position slider back or forward a small amount but would rarely if ever move to the position they wanted. Instead, they would overshoot and need to waste time listening to parts of the MP3 file they had just listen too. This was a huge sore point for them and is why they were excited

about having the ability to just swipe back or forward to review the audio, with the speed of their swipe helping to determine how far they were moved backwards or fast-forward.

From comments made by the visually impaired users during the usability testing sessions, it became clearer to me as to why some of them prefer solutions where they could search the text of an article for a keyword, for example policing. They would not read the whole article because it would take them too long, but would instead just search by keyword and read the sentences around the keyword looking for relevant information to cite in the essay or paper they were writing. This approach is very different from how I would have done it. I would read the whole article, for fear of missing some important nuance and then take notes of key parts for later use. All of the participants were undergraduates and I would suspect that many undergraduates might skim articles and not read them in full whether they have a print disability or not. Nevertheless, I wonder, how effective this approach would be for masters or PhD students who are expected to critically read all parts of the articles they are assigned or use as citations in a paper or essay.

Many audio applications support the speeding up of audio playback. In the past, I thought that the primary use for this feature would be to help you consume more information in less time, but from talking to the participants during the study, I learned that many of them speed up the audio to help them pay attention not to consume more information in less time. This was a new idea for me. It makes a lot of sense when you hear them say, that if they do not they tend to drift off when listening to recordings of the printed material they are studying. With many of them sitting at a desk and using a laptop to listen to the recordings or e-text, this makes sense. They are comfortable, sitting down and if the audio content were not engaging, it would be very easy to tune out.

Over the 4 years I have been working on my master's degree I have very rarely ever listened to audio material while not walking or taking the bus. So, for me, I was engaged visually while listening, whether it be while walking or riding the bus. This has led to some interesting situations. I often remember the location I was at when listening to various portions of an audio file if I ever hear that portion of the audio again in the future. One participant listens to audio files while doing actions, keeps their brain mildly distracted by coloring on paper or playing Mind Craft on their computer in easy mode so that they do not have to worry about dying, found the same thing. Seeing images of Mind Craft when they are later trying to remember parts of the audio they had been listening to, to cite in a paper they were working on. Maybe other print disabled students could benefit from listening while moving in space, but more research would be needed to determine if there is any value in this insight.

PDF files presented many challenges for the visually impaired participants, who indicated that they do not work with my screen reader or they sometimes will work and sometimes will not. I can totally understand where they are coming from since I have faced similar challenges when trying to read PDF files. I have seen the same file read amazingly well one day and not work at all the next day on the same computer using the same access technology.

Many learning disabled people benefit from seeing the text highlighted as it is read aloud to them, but not all. There was one student in my study who did not fit this typical pattern and for who, seeing the text, as it is read out, which is a common practice with solutions that use TTS systems to speak e-text undemand to the print disabled, would have made things worse for the participant, not better. This is a good example of how we can't

take a one-size-fits-all approach to accommodating the print disabled. Which seems to be the approach favored by many people trying to provide solutions focused solely on e-text for accommodating the print disabled.

E-text is a key part of the overall solution to ensuring the print disabled have equal access to printed material, but we also need solutions focused around listening to audio generated from the e-text. Audio tape had its pros and cons but it did provide functionality that was lost when we moved to e-text, specifically the ability to easily rewind an arbitrary small amount of time in units of seconds not trying to rewind based on words which is the approach used by many e-text, based solutions.

#### **5.4.2 Discussion**

Overwhelmingly, participant's comments, about the difficulties they face when trying to keep up with the reading and writing demanded of them from university level's course work demonstrate that there is still much work to be done to assist them. It is true, things are much better than in the past, when I was an undergraduate student in 2000. Much more of the material needed is available in e-text and the portable playback technology. We have today in the form of smartphones and MP3 players. All this was science fiction when I was an undergraduate. But, even with the improvements technology has provided us, pressure still needs to be placed on university decision makers to allow print disabled students the accommodations and access to new approaches to accommodate the print disabled, which are coming in the next few years through advances in machine learning, cloud computing and mobile computing.

Print disabled students, need to not just survive university, but thrive and hopefully move on to take Masters or PhD's in their chosen field of study. Which is possible, but

only if we can find ways to lessen the burden placed on them from having to survive in a world in love with the printed word over all other forms of communication or knowledge transfer.

## **6 Chapter: Discussion**

This thesis set out to evaluate SpokenText Reader to determine if the application might be usable and useful to print disabled people and not just me.

From the literature review, it was clear that there is definitely a need for a tool like SpokenText Reader. The pre-test questionnaire outcome indicated that print disabled students are still looking for ways to become more efficient and aid them in school. The usability test results showed on average 92% of all tasks being completed, with only 4 hints being provided, and only 4 task failures across all participants. Three of the failures are attributable to one participant, who had never used a smartphone before, but even with this, the student still completed seven tasks and said they would pay \$600 to use SpokenText Reader because they acknowledged its value and did not want to always be tied to a laptop. Finally, when asked, 4 out of the 5 people tested said they would use SpokenText Reader if they could, 4 out of 5 said it was easy to use and 4 out of 5 said they saw enough value in SpokenText Reader to pay to use SpokenText Reader. With all of the above, one can say that SpokenText Reader would be useful to others and not just me.

This work could be improved by either retesting SpokenText Reader once the changes that were suggested have been implemented or by testing users at another university. Even in another setting where there are a number of people who can be accommodated with SpokenText Reader if they have any type of disability where the reader can enhance their learning outcomes.

Moreover, it would improve the relevance of this research to test with users who have partial vision. The visually impaired people tested were blind or had very low vision. However, it would have been better to test with the blind or near blind and people who,

like me, are legally blind, but still have some functional vision. This group represents a larger population of the overall visually impaired community than people who are blind or near blind.

The visually impaired, who have functional vision like me, typically use screen magnifiers and sometimes screen readers to read long passages of text. Maybe the outcomes would have been different if participants from this group had been included. It is worth further investigation

### **6.1 Low usage of mobile devices for studying**

One main finding of this research that surprised me was the limited amount of time students spent studying using mobile technology, instead favoring to study from laptop computers. I expected to see them using their mobile devices more in their studies. This was not the case. Maybe if the sample size were larger the result would have been different, although it might have been a bias I brought to the research. As a parent of three young children and having a full time job, I do not have the time to dedicate to studying like a typical, single undergraduate student, so being mobile and studying on the go is a necessity for me. My free time is limited, whereas, the 18 to 24 year olds I studied with have more time to dedicate to their course work and are not being pulled, as I am, in so many different directions. Maybe in time as the students age, their behavior will change or maybe advancements in mobile and cloud computing will help them.

## **7 Chapter: Conclusion and Future Study**

### **7.1 Summary**

This thesis set out to determine if SpokenText Reader might be useful for print disabled people. Through the literature review and usability testing, it is clear that with eight tasks having a 100 percent completion rate and an average completion time of 5 seconds per task (Table 6) SpokenText Reader can easily help users with print disabilities.

More research is merited to determine the potential benefits users of SpokenText Reader might expect, specifically, testing with a larger group of print disabled people and fixing the usability barriers discovered during this research. It can be tested as a learning aid, or simply as a study support, in diverse situations. Specific pre/post tests can be designed and administered to see if SpokenText Reader helps them learn a given topic. Nevertheless, even with the above in mind, SpokenText Reader is useful to others and can be considered a viable option for print disabled people who need to study from audio recordings.

### **7.2 Potential for Future Work**

Given that the learning disabled students thought the application might be of use to them, it would be worthwhile to introduce it to learning disabled students who currently study using a desktop or laptop to option their feedback.

One issue still outstanding is how best to create audio representations of e-text in a low cost and efficient manner, while maintaining high quality. At present, often a human has to manually clean-up the e-text used to create audio for the print disabled. However, maybe it would be possible to use machine learning to improve text extraction from

documents for use in generating audio files for print disabled students. This would speed up student's access to audio versions of e-text and reduce costs for universities.

Finally, exploring new user interfaces, ones which are biased to audio and not text could potentially have a great impact on the lives of many people in the print disabled community; saving them wasted time navigating user interfaces not optimized for audio output and making it easier for them to consume and study from e-text.

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## Appendices

### Appendix A Study Consent Form

#### Consent Form:

**Title:** SpokenText Reader: Testing a study support mobile application for visually and learning impaired university students

**Date of ethics clearance:** 11/18/2015

**Ethics Clearance for the Collection of Data Expires:** 08/31/2016

I \_\_\_\_\_, choose to participate in a study on SpokenText Reader. This study aims to usability test a study support mobile application for visually and learning impaired university students. **The researcher for this study is Mark McKay in the Faculty of Engineering and Design.**

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This study involves one 60 minutes usability test. With your consent, the usability test session will be video and audio-recorded.

As this study will ask you for your thoughts and opinions only, this project should be of low risk to you. While this risk is expected to be minimal, I will take precautions to protect your identity. This will be done by keeping all responses confidential and allowing you to request that certain responses not be included in the final project. Should you experience any distress during the interview, you will be provided with contact information for counseling services available nearby.

You have the right to end your participation in the study at any time, for any reason, up until one month after the date this interview took place. You can withdraw by phoning or emailing the researcher or the research supervisor. If you withdraw from the study, all information you have provided will be immediately destroyed.

As a token of appreciation, you will receive a one year Student account with SpokenText.net valued at \$59.99. This is yours to keep, even if you withdraw from the study.

All research data, including video and audio-recordings and any notes will be password-protected. Any hard copies of data (including any handwritten notes or USB keys) will be kept in a locked cabinet at Carleton University. Research data will only be accessible by the researcher and the research supervisor.

After defense and publication of my thesis all research data will be securely destroyed. (Electronic data will be erased and hard copies will be shredded.)

If you would like a copy of the finished research project, you are invited to contact the researcher to request an electronic copy which will be provided to you.

This project was reviewed by the Carleton University Research Ethics Board, which provided clearance to carry out the research. Should you have questions or

concerns related to your involvement in this research, please contact:

**REB contact information:**

Professor Shelley Brown, Chair  
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Tel: [REDACTED]	Tel: 613-520-2600 x2397
Email: mark.mckay@carleton.ca	Email: alex_ramirez@carleton.ca

Do you agree to be audio and video recorded? \_\_\_Yes \_\_\_No

\_\_\_\_\_  
Signature of participant

\_\_\_\_\_  
Date

\_\_\_\_\_  
Signature of researcher

\_\_\_\_\_  
Date

## **Appendix B Email attachment sent out by Paul Menton Centre in MS Word format**

### **Introduction**

I am a legally blind (vision 20/200) Masters Student studying Human Computer Interaction (HCI) at Carleton University.

Over the last few years I have been developing a mobile application called SpokenText Reader which I have been using to aid me in my studies. It has helped me a lot and as part of my thesis work I am looking for other visually impaired and learning disabled student's feedback and insights about what I have created. The following sections outline my project and the research I am interested in conducting.

Hopefully you find it of interest and consider becoming a participant.

### **Research Project Title**

SpokenText Reader: Testing a study support mobile application for visually and learning impaired university students

### **Purpose of research**

Does SpokenText Reader make it easy for students to take notes from and navigate an audio file they are trying to study?

### **Overview of research project and its objectives**

This thesis project seeks to evaluate a mobile application to support students with low vision and learning disabilities who depend on audio to study and those who could benefit with an audio-based learning aid. The goal is to assess among those sampled if, after using SpokenText Reader, they see the benefits of having audio as a means to study.

The application allows users to mark-up audio files with notes, highlights and comments just like a person would write on or highlight parts of a printed document while studying. Users will be able to mark-up audio files in a similar way to how people mark-up printed documents while studying and then have the ability to review their notes and edit them if needed.

All with the aim of making it more efficient and effective for visually impaired and learning- disabled university students to study from audio recordings and write research papers, study for exams or create presentations.

### **Opportunities for student participation**

Usability test participants.

**Estimated time commitment**

60 minutes

**Compensation/Remuneration**

Each student participant will receive a free one year Student account with SpokenText.net valued at \$59.99

**To participate**

Contact Mark McKay by email at [mark.mckay@carleton.ca](mailto:mark.mckay@carleton.ca).

## **Appendix C Custom testing sled**

### **Design problem**

- Need to conduct a usability test with visually impaired and learning impaired students
- Participants
  - May need a screen reader
  - May need a screen magnifier
  - May need both a screen reader and screen magnifier at the same time or switch between he too
  - May have low vision but just hold the device close to their face
- Testing solution needs to support a visually impaired researcher while not getting in the way of participants and effecting the testing results

### **My solution**

- Custom mobile testing sled
  - Support participants putting face near device
  - Good recording of participants voice
  - Good recording of participants gestures

### **Research on mobile sled**

### **Prototype 1**





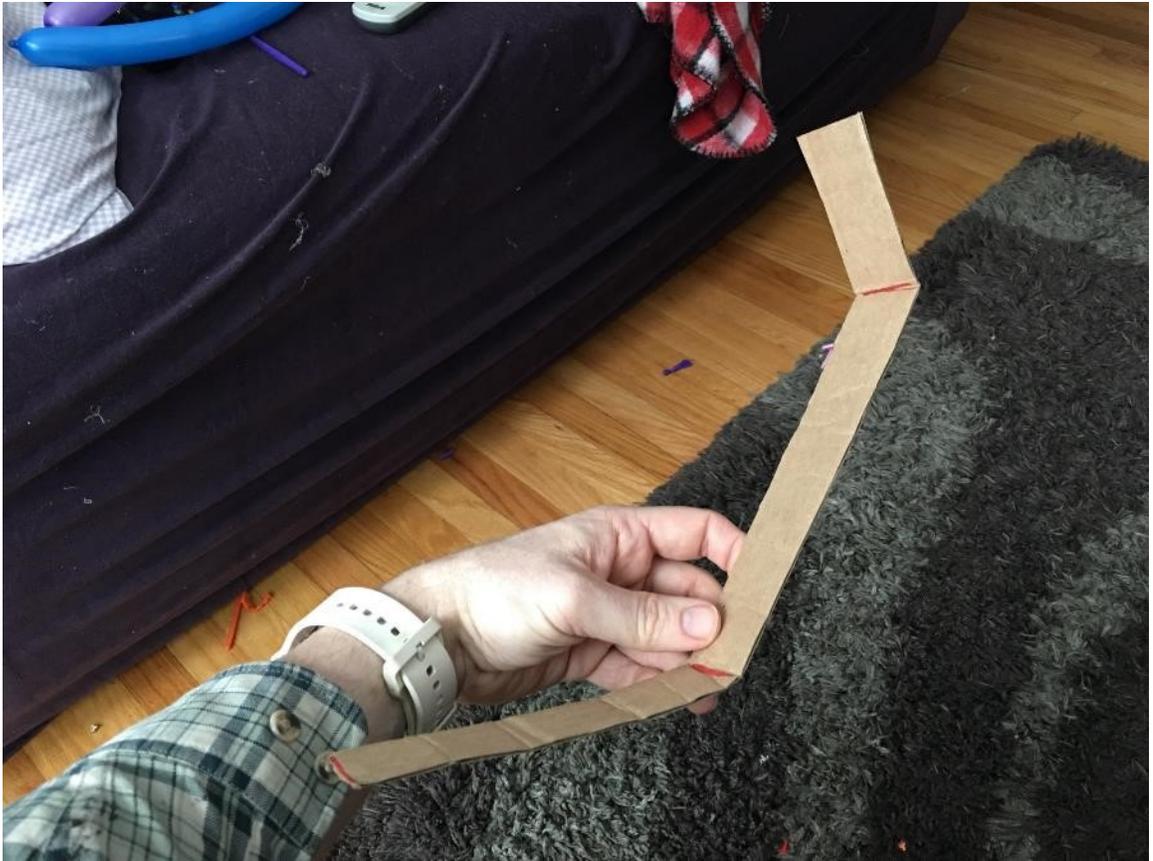
**Final sled - cardboard prototype**







Final sled – getting the angles right



Gluing on hard board





Finished product





## Appendix D Pre-test questions

The following questions were read aloud to participants and are semi-structured.

1. What age category do you fall into
  - a) 18 to 24
  - b) 25 to 30
  - c) 31 to 35
  - d) 36 to 40
  - e) 40 and over
2. What program are you enrolled in?
  - a. Current year
  - b. What is your typical course load
3. Do you use any access technology (screen reader, screen magnifier, speech to text etc.)
  - a. If so which ones?
4. How much written material do you typically need to read per class?
5. How do you typically study for a class or exam from printed material
  - a. For example, do you read it, have someone read it to you or maybe have it converted to speech?
6. What strategies do you use for studying for classes, exams etc... ?
7. What strategies do you use when writing papers and presentations?
8. Do you have written material converted to speech and then study from the audio recording of the written material?
  - a. If so, how do you take notes when listening to the audio recordings you are studying from?
9. Do you use mobile devices in your studies
  - a. Which types of devices do you use?
    - i. iOS
      1. iPhone
      2. iPad
      3. iPod
    - ii. Android
      1. Samsung
      2. Nexus
    - iii. Microsoft
      1. Phone
      2. Surface tablet
    - iv. Blackberry
      1. Phone
      2. tablet
    - v. Not sure

- vi. Other
- b. How would you classify your experience with mobile technology
  - i. Extensive
  - ii. Moderate
  - iii. Average
  - iv. Basic
  - v. Very limited
- c. How do you utilize your mobile device(s) to aid in your studies?
- d. Do you use any specific mobile applications to help you study?
- 10. How do you take notes when conducting research?
- 11. How do you study your notes?
- 12. Do you study while commuting?
  - a. For example to school
- 13. What is your biggest challenge with consuming large amounts of written material for a class?
- 14. Do you find it easy to get digital versions of the material you need to read for a class?
  - a. For example a book or article in PDF format?
- 15. How easy do you find it to get versions of material you want to read or study in an audio format?

## Appendix E Post-test questions

The following questions were read aloud to participants after the usability test session and are semi-structured. Their responses will be written down.

1. How easy did you find SpokenText Reader to use?
2. Very easy
3. Easy
4. Adequate
5. Difficult
6. Very Difficult
7. Would you use SpokenText Reader to study if you could?
  - a. If so why
  - b. If not why not?
8. Do you have any ideas for how we could improve SpokenText Reader?
9. Would you be willing to pay to use SpokenText Reader?
  - a. If so why and how much?
  - b. If not why not?

## **Appendix F SpokenText.net project background**

In 2005 while working as a consultant I read a very troubling statistic stating that only 3% of all printed material was ever converted to alternative formats like audio. The following year I was between contracts and having been involved with technology from the age of 13 I was aware of text to speech and how much it had improved over the years. And how with a little work I could create an online website to allow students to convert text to speech themselves and then listen to it on a portable mp3 player. At the time the Apple iPod was becoming very popular and Apple was offering iPods for under \$100 which meant that my solution could be used by a lot of people not just those who could afford the more expensive iPods. My research project SpokenText was born. It has allowed anyone to easily convert text to speech and then transfer it to an iPod.

With the arrival of the iPhone in 2008 new possibilities started to arrive where we could write applications for the iPhone. But, for the longest time I never saw much value in writing an iPhone application which just replicated the tasks you could perform on the web site. The iPhone had a great web browser and you could just use it to access our site. At the time very few people were even using their phones to access the internet.

As time passed I finally conceived of an idea which might just make an iPhone application make sense. It revolved around the challenges I had when reading recorded books and jotting down notes about key parts of the recording, which I wanted to reference later. This is where the initial idea for SpokenText Reader came from. With my return to school SpokenText Reader started to become a reality not just an idea.

### **Initial design and prototype of SpokenText Reader**

Starting out using an expert design approach a prototype and a list of key tasks was developed using agile methodologies and iterated over time. I used this application in varying forms during my Master's course work. Also, during the creation of my thesis to aid me in studying and reading printed material.

Even though the design was initially conceived by me I have a lifetime of knowledge of the disabled and have used myself a visually impaired and learning disabled student as the first tester and evaluator. This could have provided some issues around positionality, potential biases, ethical issues and personal vulnerability, which I reflect on in the following sections of this thesis. Overall I think it has led to a solution which is geared towards its target audience in a way and with an understanding of their needs that would be very hard for a non-disabled person to have achieved.

My expert knowledge of User Centered Design and User Experience gained from my 20 plus years working in business, analysis, design and development of software systems also played a major role in how this application was conceived of and came to fruition.

## **My approach to design**

As a disabled person I have been modifying, tweaking and constructing solutions to fix issues with other people's designs or to create my own solutions to problems I have faced for my whole life, which I feel, has helped to influence and define in some way my design approach and design style.

My sense of interaction and visual design is best categorized as minimalist. My design style also favors function over fashion. In addition, I am passionate that the work I do is first and for most usable not just visually appealing. And desire to have the projects I work on make the world a better place if possible.

Of all the aspects of design, I have struggled with visual design the most. Until I found and read *The Elements Of Graphic Design* (White, 2002) this book really helped me to understand visual design, visual design language and provided me with a means to explain its value to others.

The selection of features within software I design, are influenced by the idea that everything must provide value and be there for a reason. Each feature must not cause people to have to think. All features and experiences should be fluid and aid in creating a sense of flow for the user. Steve Krug, in his book *Don't Make Me Think* (Krug, 2006) describes well how all properly designed interactions should not make you think and thus not break your sense of flow.

I favor simple, clean visual and interaction design. This is probably for many reasons. From reading Stephen Krug's books and from the writing of Don Norman specifically his books, *The Design of Everyday Things* (Norman, 2002) and *The Design of Future Things* (Norman, 2007) both informed my interaction design sensibilities. These two books describe well the core design principles which are relevant to all types of design not just the design of software and they have influenced the work I have done on all design projects I have worked on since reading them.

Simplicity (Maeda, 2006) is such a core concept to me because I think it is also critical to creating an interface which will be easy to use by disabled people. Every element you add to an interaction is just one more element that everyone using the product must spend time trying to figure out, remember its function, its location within the software product, how it relates to other features and store this all in memory for later recall. It is my belief that, the simpler an interface is, the more consistent it is, the easier it is to remember and use by visually impaired people.

Another key reason, I think, I favor simple design and have this design style as my default style only came to me after years of reflection, and relates to my habit of remembering all interfaces I have to interact with on a daily basis. It is quicker than looking closely at them each time I want to use a piece of software or product. This constant analysis of interfaces has helped me to learn the true nature and value of simplicity, usability, user experience and visual design.

## **Target Audience**

Visually impaired, but the larger print disabled community (learning disabled, ESL students, illiterate) might benefit from the approaches discussed for converting printed text to speech and the application developed to study the resulting recordings.

This solution might, have a larger reach and could be useful for non-disabled students as has been observed with SpokenText.net which is used by many non-disabled people.

## **Before taking my masters**

Since the initial creation of SpokenText and the whole time I was an undergraduate student I struggled with the best way to convert printed text to digital text.

In 2006 I discovered a process where I would buy a book; have the spine cut off it and then I would run the book through a double sided scanner, once scanned I would OCR the book and save the result, a PDF file and upload it to SpokenText.net for conversion to audio. With this process each page of the printed book mapped to a page of the digital book and when recorded I could use the page numbers recorded along with the books text to get a general sense of where in the book I was. This worked well for me.

## **Issues with existing SpokenText.net conversion process**

Like all systems, SpokenText has its own issues some of which might be fixable over time while others are inherent to the technology.

One of the main issues is with how SpokenText.net conversion process handles tables of data. Where possible it linearizes the information and then reads it. Depending on how the source document was formatted and how complicated the table of data was it can either produce somewhat acceptable results or lead to confusing outcomes where it can be hard to relate a table cells data back to the row heading or column heading which related to it. After many years of thought on this issue I think it is just one of the limitations of this system and if someone needs to have ad hock navigation ability with data in a table structure they should use a full blown screen reader or other access technology to work with this type of information. No technology can be the one size fits all for every problem. Many designers, programmers and business people fail to see this and in turn end up producing overly complex software, which their users struggle to use. I have intentionally followed the advice provided by Fried in Getting Real (Fried 2010) and have fought the urge to add features to SpokenText over time unless it was clear that they would not make the experience more complex but add to it in a meaningful way. This idea of not adding features unless they drive value for users was the reason, why until I could conceive of a benefit, I did not design and develop a mobile version of

SpokenText. It was only the idea that it would be very useful to have a note taking system integrated with the ability to listen to recordings all in the same place, custom designed for the needs of people studying with audio using mobile devices that I thought SpokenText Reader was truly worth doing. And not just going to create extra complexity without providing true value which made the extra complexity worth it.

### **Reading more than average**

I think many people find reading books time consuming and tiresome. So they do less of it and only do it for pleasure or limit the amount they read based on the time they have to spend dedicated to looking at printed text which for many busy people could be very limited in any given day.

Personally, I have found since I have access to SpokenText.net and my processes for converting printed books into speech when and if needed. I typically read a lot of books and it appears that I read more books on average than other people I know who are in a similar age group and have similar employment and education levels. It is not uncommon for me to read 10 to 20 books in a year. Which from talking to others in my age group, similar employment and education level is a much higher number of books than they would typically read in a year.

This is probably due to the fact that I can read books while walking around, exercising and standing in the bus, which if you try to read the printed text only you just can't do as easily. I also do not need to carry around a large collection of heavy books or an eReading device as all of my reading is done from the SpokenText Reader application on my iPhone, which as like most people I always have on me.

From my time working on and using SpokenText I really believe that listening to books is much easier than reading them for all people, not just the vision impaired or print disabled population in general but I still need to research this idea more.