

What Impact do the Accessibility Features of Colour and Contrast, Text-to-speech, and Magnification in ePublications Have on Undergraduate Students' Ability to Retain Information?

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Abstract

The purpose of this research study was to discover if ePublications with the accessibility features of contrast, text-to-speech, and magnification benefited undergraduate students in the retention of information from required readings. Participants of this research study consisted of twenty Ryerson University undergraduate students from all four years of study.

To conduct this research, two documents were created that were to be read by participants of the study. The first ePublication testing document was a PDF without accessibility features, whereas the second ePublication document was in the format of an .iBook. The second document incorporated the three accessibility features under examination throughout this study: colour and contrast, text-to-speech, and magnification. Each document that was read had a corresponding ten-question multiple choice test administered through Google Forms. All participants were given four options for each question. Both assessments required the participant to answer all ten questions to the best of their abilities based on their reading comprehension, to test their information retention on either document. The third assessment of this research was an opinion questionnaire formatted as a Google Form, which participants were asked to answer after the completion of the previous two tests.

All data, both from the testing documents and the opinion form, were analyzed using Microsoft Excel, 2018 version. It was recorded that the average score on the multiple-choice test was 82% after students read the accessible document. In

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contrast, the average of the multiple-choice test was 59.5% after the students read the non-accessible document. The T-Test results demonstrated that the probability of the non-accessible and accessible reading and testing results was 0.00139, equivalent to 0.14%. As a result, accessibility features in ePublications should be implemented within the documents students receive as a required course reading.

Introduction

The study was conducted in association with Ryerson University as part of the curriculum for the Graphic Communications Management undergraduate program. The study took place between February and April of 2020 in Toronto, Ontario. Although there is an abundance of studies that aim to understand how accessibility features in ePublication documents benefit those with disabilities, there is an overall lack of research conducted to understand the effect of accessible documents on those without a known disability. The purpose of this study was to identify if accessible documents are proven to aid undergraduate students, which would in turn persuade publishers to implement these features into their publications. The study contributed to the debate about accessibility and whether it should be made more readily available in electronic publications through the evaluation of accessibility features within ePublications for undergraduate university students.

The main issues this study addressed were those in regards to how accessibility features were not presented in the ePublications that Ontario University undergraduate students were required to read for their studies. University professors provided students with online readings in the format of PDF documents that did not offer accessibility features.

The purpose of this research study was to discover if ePublications with the accessibility features of contrast, text-to-speech, and magnification benefited undergraduate students in their retention of information from the required readings. This research highlighted and critically analyzed the importance of the aforementioned accessibility features in relation to why they should be made available to all undergraduate students.

Research Question

What impact do the accessibility features of colour and contrast, text-to-speech, and magnification in ePublications have on undergraduate students' ability to retain information?

Methodology

Through the use of the primary research testing, the study determined the importance of colour and contrast, text-to-speech, and magnification within ePublications. To

answer the research question, two research tests were conducted that determined the accuracy of information retained by the study participants. The participants were presented with two ePublications and asked to answer a questionnaire that tested what they had read. Participants of this research study consisted of twenty Ryerson University undergraduate students from all four years of study. For the research test, one of the ePublication testing documents was a PDF without accessibility features, while the other document was in the format of an .iBook that incorporated the three accessibility features under examination: colour and contrast, text-to-speech, and magnification. The test that the participants were asked to fill out after reading consisted of a ten-question multiple-choice Google Form.

After participants were tested, they were asked to fill out a short survey with questions pertaining to which ePublication they felt most aided them in retaining the information. A second primary research method of a survey was presented to participants as a Google Form that enhanced the testing of research documents to determine if the proposed accessibility features were necessary for information retention. In the comparison of the test results and survey results, it was found that the two research methods presented the effects of how students believed the accessibility features had in fact benefited them in retaining information, rather than how the features assisted them.

Results

It was recorded that after students read the accessible document, the average score on the multiple-choice test was 82%. After students read the non-accessible document, the average of the multiple-choice test was 59.5%. As a result, students that read documents with the accessibility features of text-to-speech, colour and contrast, and magnification, scored an average of 22.5% higher on the test than when using the non-accessible document. After the results from the opinion survey were reviewed, it was found that students enjoyed reading the accessible document more than the non-accessible document. In fact, 90% of students stated that if their required course readings were presented with the accessibility features, as they were in the second testing document, they would be more likely to complete their readings.

The T-Test exemplified that the probability of the two situations, the non-accessible and accessible reading and testing results, was 0.00139, which can be interpreted as 0.14%. Therefore, there was a significant difference in the data collected in association with the non-accessible and

accessible documents after the analysis of their respective tests. This information supported the theory that accessible documents did not just help those with disabilities, but also assisted the broader public in general; in this case, undergraduate students.

Literature Review

Student Perceptions on Future Components of Electronic Textbook Design

Authors Kimberly Anne Sheen and Yan Luximon (2017) addressed the question of which accessibility components students thought were necessary for future electronic textbooks based on their academic reading requirements. Sheen and Luximon (2017) further researched this question through the discussion of whether electronic textbooks should move away from the one-size-fits-all approach that has dominated the industry. One of the key concepts demonstrated was that changes in the user interface affected one's reading experience and performance, which was proven through research. For this reason, accessibility features should be taken into account in the design process of electronic textbooks (Sheen & Luximon, 2017). Furthermore, Sheen and Luximon (2017) stated that the majority of textbook publishers continued to produce simple digital representations of existing texts. Textbook publishers should take full advantage of the transition from print to digital documents to accommodate students with their ability to read electronic documents in order to excel within the learning environment.

The study took an innovative approach to answer the research question through the use of a questionnaire. The ten-item questionnaire was the main method for analyzing student perceptions on seventeen possible components of future electronic textbooks; this included which features they found beneficial, a ranking of the individual features' importance, and whether they would make use of the proposed components. The questionnaire was sent by email to the entire population of an English-Language university in Hong Kong. Of the 705 students who responded, 79.4% of questionnaires were deemed valid, and an analysis was conducted on 560 valid questionnaires (Sheen & Luximon, 2017). Sheen and Luximon stated that the accessible components generally reported to be desired by the participants of this study varied from one respondent to the next. The students did not have an established method to engage with the material. For this reason, many support methods may be employed to assist them. It was observed that students believed that future electronic textbooks should have included text, highlighting tools, bookmarks, multimedia, translation tools, dictionaries, and encyclopedias to enable the successful use of electronic textbooks. It was also found that many demographic categories had significant associations with student perception of which components should be included in their textbooks. The most significant category that required specific design is academic discipline.

An advantage of the questionnaire research methodology was that it was short, concise, ignored the use of open-ended questions, and left room for students to leave comments. This was an advantage because students may not have wanted to participate in a long study, as they might not have been available throughout the whole duration. For this reason, the researchers considered this possibility and

altered their study to benefit their research population. As the questionnaire was sent by email, the researchers were able to reach a diverse student population that included undergraduate, graduate, and doctoral students (Sheen & Luximon, 2017). However, the email questionnaire method may have also been a disadvantage to the researchers as they did not know if the respondents were truthful in their answers. Another disadvantage of the research method was that out of the 30,000 students, only 705 responded. As a result, the study was not able to generalize the findings to the entire student body.

Evaluating E-Book Platforms: Lessons From The E-Book Accessibility Audit

The issue that McNaught, MacMullen, Smith, and Dobson (2018) addressed was how it was often difficult to find information from the publisher on accessibility in e-books. A key concept of the article indicated that accessibility in e-books was no longer just a luxury, but was in fact a necessity. They continued to state that the change in higher education in England where higher education institutions (HEI's) could no longer make do with inaccessible resources; purchasing accessible content was no longer an aspirational goal, but a legal necessity (McNaught et al., 2018). Another perception the authors defined was that in modern workflows, it was not difficult to provide accessible content, and it also could have new marketing opportunities.

This research used the established framework of a crowdsourced research project designed by library and accessibility specialists, called E-book Accessibility Audit Project Group, to draw attention to the opportunities in accessibility. This method of a crowdsourced e-book audit of 44 e-book platforms was taken on by 33 UK universities, and they used an audit questionnaire during 2016 (McNaught et al., 2018). It was concluded that since accessibility varied between format types, guiding students to the best formats, EPUB and HTML, led them to benefit from improved accessibility. The surveyed data strongly suggested that participating library teams had a higher degree of empathy for disabled users, more confidence in advising them, and more determination to get better accessibility information from suppliers (McNaught et al., 2018). It can be noted that this made the library teams powerful advocates for accessible products, or as the authors stated, the “secret solutions,” referring to accessibility features in e-books (McNaught et al., 2018).

An important conclusion of this research was that the platform dramatically affected the accessibility of a publisher's content and made it significantly more important for publishers to work with suitable vendors to circulate their publications. A strength of the study was that the researchers had a large scale of 78 testers, which allowed them to audit 280 e-books across a wide range of platforms (McNaught et al., 2018). However, a downside to crowdsourcing was sample choices and tester reliability.

E-Book Reading Hinders Aspects of Long-Text Comprehension for Adults with Dyslexia

The main problems that the authors investigated in long-text reading were (a) the different aspects of reading comprehension skills among university students with dyslexia and (b) the impact of e-book reading on reading comprehension in this population (Cavalli et al., 2019). A key concept that the author identified was how reading e-books was accompanied by a reduction of manual activities that created less tactile or kinesthetic feedback. The decrease sometimes gave the effect of feeling lost in their navigation of digital text, which affected the capacity of readers to memorize the chronology of the story or their ability to understand the context of the text fully.

The researchers proceeded with an innovative method of testing thirty university students who identified as adults with dyslexia and matched them with thirty skilled readers. Both groups read the same text presented from a printed book and e-book, using the platform Amazon Kindle. The reading

comprehension questions, which were asked and answered verbally, were all open-ended and based around literal and inferential processes, location of events within a story, and reconstruction of the plot (Cavalli et al., 2019). Results showed that with printed books, the adults with dyslexia performed similarly to the skilled readers. However, the results of the e-book comprehension test suggested that the adults with dyslexia were outperformed by skilled readers. This signified that reading from an e-book hindered only some aspects of reading comprehension for adults with dyslexia. During the inferential comprehension tasks, the dyslexic readers performed similarly to the control readers on both reading print and e-book formats. The study demonstrated that when adults with dyslexia read a printed book, they performed as well or even better than non-impaired readers in reading comprehension (Cavalli et al., 2019). The authors concluded that digital reading might not always be advantageous to people with dyslexia. They also discussed that in contrast to their results, digital devices provided readers with useful tools that were not used in their research experiment. These tools greatly benefit people with disabilities, including having a navigation bar so that readers can go straight to a section the researcher asks about.

Does Use of Text-to-Speech and Related Read-Aloud Tools Improve Reading Comprehension for Students with Reading Disabilities? A Meta-Analysis

Authors Wood, Moxley, Tighe, and Wagner (2018) addressed the question of how effective text-to-speech was at improving reading comprehension for students with disabilities in their research paper. A key theory presented was that when material was presented verbally, in addition to presenting it in a print form, it removed the need to decode reading material and had the potential to help students with reading

disabilities in their comprehension of written texts. The article also reviewed the concept that research on text-to-speech technologies to support comprehension had been characterized by contradictory results. For example, some studies reported an improved reading while other studies did not (Wood et al., 2018).

The authors conducted a meta-analysis on the effects of text-to-speech technology and related read-aloud tools on reading comprehension for students with reading difficulties (Wood et al., 2018). The research used established frameworks, and the work they assessed had to meet the following four criteria: (1) reading comprehension must be measured at sentence, paragraph, or passage level, and (2) only studies in which the effect size could be calculated for students with dyslexia, reading disabilities, or learning disabilities were included. Furthermore, students could have more than one disability, but had to have a reading disability. The third (3) criterion was that all studies must have included a condition with oral presentation of the reading material, including one of the following: (a) human recorded audio, human readers, or (b) a variety of technology like synthesized text-to-speech or reading pens. The fourth (4) criterion was that the studies must be reported in English (Wood et al., 2018). The results of the average effect size of the use of text-to-speech on measures of reading comprehension section of the meta-analysis revealed that the effects of text-to-speech and related read-aloud tools indicated that verbal presentation of text for students with disabilities helped their reading comprehension test scores. The results suggested that text-to-speech technologies may have assisted students with reading comprehension. However, more studies are needed to further explore the effectiveness of moderating variables of text-to-speech and read-aloud tools for improving reading comprehension.

A limitation of the authors' research was that they used a relatively small sample size of studies, as the sample size only consisted of twenty-two studies. Another limitation was that the sampled studies were diverse and tested at different intensities instead of a narrow and focused sample, such as a cohort of post-secondary students.

The Academic E-Book Ecosystem Reinvigorated: A Perspective From the USA

Watkinson's article addressed the proactive philanthropic support of infrastructure development in new forms of long-form digital publishing that went "beyond the eBook" (2018). The key themes that this article addressed were: (a) an emphasis on shared values throughout development, (b) a focus on building an ecosystem of interoperable platforms and tools, and (c) engagement with the challenges faced by new-form digital publications, which included preservation, discovery, and accessibility (Watkinson, 2018). Watkinson (2018) stated that new platforms found that designing for accessibility was a challenge, especially when fulfilling legal responsibilities. He further explained this by affirming that publishers of enhanced eBooks understood that designing platforms and content with accessibility in mind also catalyzes good digital design (Watkinson, 2018). A concern was raised

about the amount of additional labour required for accessibility in multimedia publications, and the challenge it imposed on authors and publishers. For example, audio and video files require extra labour to caption or transcribe. Another example was that the images needed alternative text, and if a model or graph was not able to be transcribed, there was a further requirement of an explanation as to why the medium might not have been fully accessible.

An Overview of Content Accessibility Issues Experienced by Educational Publishers

Frederick Bowes' (2018) research emphasized the educational publishing segment and the impact on students with disabilities from the rapid shift of an analogue society to the digital world. The key theme was how the traditional analogue model rapidly transformed into a digital environment that provided educational content via new technologies, which allowed the delivery of configurable personal learning experiences, and how these experiences are analyzed (Bowes, 2018). Bowes (2018) mentioned that in the new multifaceted digital learning paradigm, students with disabilities could have only been successful if all parts of the new learning experience were fully accessible to them. Market pressure was also mentioned towards the publisher with references to how most institutions were awakened to the reality that they must have paid attention to the accessibility of their digital course offerings with regards to legalities under the ADA (Americans with Disabilities Act). The author further expanded on his analysis by stating that text-based content, enhancements, linked content, and contributed/uploaded content are the four categories that should have been addressed by the publisher, from the perspective that all content in a learning experience needs to be accessible to ensure that students with disabilities encountering these elements can benefit effectively (Bowes, 2018).

Bowes (2018) discovered that the four most consequential accessibility problems that plagued the accommodations model created an opportunity to successfully convert materials from print to digital and add accessible features. These problems were: (a) the quality of source content and resources available to execute the conversion, (b) costly component of converting, and (c) security of content being pirated (Bowes, 2018). The article concludes that publishers need to ensure that their text/words, platforms, and learning experiences conform with all appropriate standards and ultimately measure up to the broader requirement – that students with disabilities must receive all the educational benefits provided by the technology in an equally effective and equally integrated manner.

Accessibility features in e-publications was a significantly more important topic that many professionals attributed to the progression of education. Kimberly Anne Sheen and Yan Luximon's (2017) research dived into the student perspective aspect of this topic and reported which accessibility features students believed to

be essential to their learning. The results of their research study were compared to the authors and researchers Wood, Moxley, Tighe, and Wagner (2018), whose study answered the question of the effectiveness of text-to-speech in improving reading comprehension for students with disabilities. The students in Sheen and Luximon's (2017) research enjoyed the use of text-to-speech features and indicated that this tool was highly supportive to students in the study. The students in the following study, who had disabilities, also found that the text-to-speech accessibility feature assisted them while reading. The two aforementioned studies demonstrated that offering this accessibility feature, even if they chose not to use it, helped students, regardless of whether they had a disability. The thesis further contributed to the discussion on the effectiveness of text-to-speech through its ability to aid students to retain information and their insight on the use of accessible features.

The topic of how digital publications and print publications differed in effectiveness for those with disabilities was another sub-topic in the broader scope of accessibility of e-publications. Cavalli, Colé, Brèthes, Lefevre, Lascombe, and Velay's (2019) research about e-books hindering characteristics of long-text comprehension for adults with dyslexia, investigated the different aspects of reading comprehension skills among university students with dyslexia and the impact of e-book reading on reading comprehension. The thesis extended the aforementioned research study by using short-text reading samples, which were tested for information retention instead of comprehension. The results of this study indicated that digital reading for students with dyslexia was not as effective in reading comprehension as when it was in the format of print documents. For the purpose of the thesis project, students did not have to specify if they had a reading or learning disability. Instead of solely focusing on one disability, the thesis project opened up the debate on how accessibility features in e-publications supported students despite their disabilities. In contrast, Bowes (2018) research signified the educational publishing segment and how the transition from an analogue to a digital world impacted students with disabilities. This research related to that of Cavalli, Colé, Brèthes, Lefevre, Lascombe, and Velay's (2019) in the sense that the comparison made was between print and digital publications. The comparison brought to light the topic of which was more suitable for educational purposes and how students adjusted to the change into digital publications.

Research regarding how accessibility features in e-publications affected readers was important not only to those reading, but to those who produced these publications. Watkinson's (2018) findings demonstrated how crucial it was for publishers of enhanced e-books to understand designing platforms in combination with good digital design. The e-publication needed to be accessible; it also needed to serve the purpose of being read on screen, which was formatted much differently than in print mediums. This research provided the perception of the publisher's responsibility within the implementation of accessibility features. Concerning Watkinson's (2018) work, McNaught, MacMullen, Smith, and Dobson (2018) also took the subject of

the publisher in the accessibility of e-publications topic in relation to how it was often difficult to find information from the publisher on accessibility in e-books. They pointed out a key vision that accessibility in e-books was a necessity and was no longer just an asset. In comparison to Watkinson's (2018) paper, it was debated that publishers should have been required to implement accessibility features into their e-publications as it was an essential component to the document. Throughout the thesis project, the researcher contributed to this debate about how accessibility should have been made more readily available from publishers of electronic publications through the evaluation of accessibility features within ePublications for undergraduate university students.

Methodology

Perspective

The method in which the researcher conducted the study took the form of two testing documents and one opinion survey. First, participants were asked to read one PDF document that was not accessible, and then answer a ten-question multiple choice test to record their information retention. Then, participants were asked to read the second document, in the format of an iBook, which included the magnification of text, colour and contrast, and text-to-speech. Participants were provided with these accessibility features in the second document, but it was left to their discretion if they wanted to use them as it was not a requirement. After reading the second document, a second ten-question multiple choice test was to be filled out by participants. Once participants of the study completed both tests, they were then asked to fill out an opinion questionnaire that focused on how the participant felt towards both documents. For example, if they thought one document helped them retain more information than the other, or if they used the accessibility features and if these features were helpful or distracting.

Research Design

To enable students to sign up for in-person research appointments, the researcher created a Google Document sign-up sheet with research openings within the timeframe of two weeks, between February 23rd to March 1st, 2020. Each research appointment was limited to thirty minutes, as students were more willing to give their time if it was limited and not extensive. The Google Document was shared on the Graphic Communications Management Facebook page, and participants required a Ryerson University email to sign up for the study. The appointments were held at the Ryerson Library or the Ryerson Student Learning Centre (SLC). This ensured that all appointments were accessible for students to attend between classes. For both locations, quiet study rooms were booked to provide students with an undistruptive environment.

Research Questions

1. What impact do the accessibility features of colour and contrast, text-to-speech, and magnification in ePublications have on undergraduate students' ability to retain information?
2. If required readings for undergraduate university students were provided from professors in the form of accessible e-publications, would students be more motivated to read these documents?
3. Does having the ability to change the colour of text and background help students while reading in different light settings (i.e. library, dimmed study area, well-lit classroom, etc.)

Hypothesis

Students will realize the difference between the two documents and prefer the accessible document as opposed to the standard document. The accessible e-publication will aid the students to retain more information than the non-accessible document.

Subjects, Participants, and Sample

The participants of the study were Ryerson University Undergraduate students from all four years of study in the Graphic Communications Management program. The researcher did not collect the demographics of age, gender, or year of study due to the ethical requirements of the Ryerson

Ethics Board. However, the study ensured that all participants were enrolled at Ryerson University for their undergraduate studies. Although age data was not collected, it can be estimated that the average age of participants was 20.7 years old according to Ryerson University's 2018-2019 statistics of the Graphic Communications Management student enrollment data (University Planning Office, 2019).

The research study sample consisted of twenty students that were tested over two weeks, or fourteen days. This student sample size was established due to the time constraint of the research period and the allotted time given to each student to complete this research test. It was required for students to use a single laptop provided by the researcher to complete the research test. This ensured that all participants had access to the iBooks application and prevented students from viewing the test documents throughout their completion of the multiple-choice questions. As a result, only one student completed the research test at a time. For this reason, it was mandatory to meet with students at their chosen time slot in order for them to be tested using the researcher's selected laptop.

Instruments and Measures of Data Collection

The first testing document was presented in the form of a three-page PDF. The content of the document consisted of the article *Halifax* by L.D. McCann, cited from The Canadian Encyclopedia (McCann, 2019). This PDF was first created and formatted in Adobe Illustrator CC 2018 and then exported as a PDF to be viewed by students. The format of this document consisted of two-columns of text, captioned photographs, and text set in the standard serif typeface of Times New Roman.

The second testing document was presented in the form of a reflowable document that used the Apple application iBooks. The content of the document was the article *Winnipeg* by Alan F.J. Artibise, cited from The Canadian Encyclopedia (Artibise, 2019). This accessible iBook was constructed in Adobe Illustrator CC 2018 and incorporated the features of text magnification, contrast of text and background colour, and text-to-speech capabilities. The format of this document included captioned photos and the sans-serif font of Arial. Participants were able to change the magnification and leading of this text to their set preference. The four colour and contrast options for the text were black text on a white background, black text on a pastel-yellow background, white text on a dark grey background, and white text on a black background. The text-to-speech ability was not created using a synthesized reader due to time constraints of this research. However, participants had the option to use the text-to-speech feature on Apple iBooks if they preferred the document to be read to them.

Each document that was read had a corresponding ten-question multiple choice test. This short test took the form of a Google Form, where participants were given four options per question. Both assessments required the participant to fill out the ten questions to the best of their abilities based on the article to test their information retention on either document. Each question resulted in one correct answer, and participants were able to review their scores after the entire research test was completed.

The third assessment of this research was an opinion questionnaire as a Google Form, that participants were asked to fill out after they completed the two previous tests. The form included fourteen multiple-choice questions where participants were asked how they felt towards both documents, if they thought one aided them to retain more information than the other, if they used the accessibility features, and if these features were helpful or distracting. Underneath each question was an “other” option, which the participants were able to select and input their own answer if they wanted to provide an explanation. The form also included a comment section if the participant had additional details about the research study they would like to share.

Methods of Analysis

All data, both from the testing documents and the opinion form, were analyzed using Microsoft Excel 2018. The researcher created tables using Excel to format the data collected from both the testing documents and the opinion survey. To compare the results, the researcher used Microsoft Word 2018 to generate four graphs for the collected raw data using the information inputted in the Excel tables. The visual graphs depicted in Figures 1 to 3 provided a visual representation of the research study. For this reason, one does not have to make assumptions about the data collected. A T-Test was also prepared on Microsoft Excel in order to analyze the test data (see Table 1).

Validity and Reliability

The researcher chose the demographic of undergraduate university students as the research sample because they have been consistently required to read documents for their academic courses. For this reason, the researcher decided to test the student demographic to discover if the accessibility features in e-publications would have made a difference in how they felt about their readings and if they would be more inclined to read if they were provided with accessible documents instead of PDFs.

The research was conducted in-person and was supervised as the participant took the research test. It was suitable to use an in-person method of research to ensure that students did not look at the reading documents, or consult with others as they took the tests. Furthermore, supervision guaranteed honesty and reliability from participants' test scores.

In-person testing provided the limitation of a small sample size due to time restraints and flexibility with the participants' schedules. There were 44,400 undergraduate students enrolled at Ryerson University (University Planning Office, 2019). By comparing that to the sample size of the research that included twenty fourth-year undergraduate students in the Graphic Communications Management program, it posed as a drawback in the representation of the student population. However, in-person research ensured greater accuracy than a larger sample size for an online survey.

Results and Discussion

Document Test Results Comparison

The results of the research study found that after students read the accessible document, the average score on the multiple-choice test was 82%. However, the average of the multiple-choice test was 59.5% after students read the non-accessible document (see Figure 1). The results validated that when students read

the accessible document, with features of text-to-speech, colour and contrast, and magnification, they scored an average of 22.5% higher on the test than when using the non-accessible document. With the data shown in Figure 1, it was evident that the accessibility features included in the reading document enabled students to perform better on the test. The results further indicated that the three accessibility features of this research study aided students in terms of information retention more than the non-accessible document. As a result, accessibility in e-publications and various accessibility features in digital readings should be implemented within the documents that students receive as required course readings. This is because of the evidence that it helps them to retain more information than when they are just reading a non-accessible PDF, as demonstrated through this research test.

This paper will examine the main features of image processing in web-to-print systems. We will especially focus on what distinguishes this technology from desktop publishing systems, the likely points of difficulty, and how the Customer’s Canvas development team responds with solutions that were judged worthy of a 2020 InterTech Technology Award from Printing Industries of America.

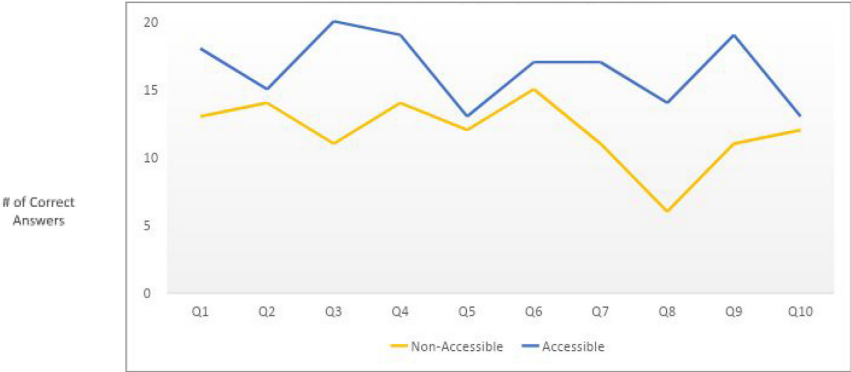


Figure 1. Document 1 and 2 Test Comparison

Opinion Survey Results

Figure 2 presents that students preferred the accessible document over the non-accessible document, for they thought they had better readability, enjoyed reading more, and thought it helped them retain more information. The readability section of the opinion survey indicated that students felt that magnification and the ability to change the colour of text and background helped to format the document to their preference. This was due to a variance in reading levels among participants. For this reason, the ability to change the document to the user’s preference gave participants the freedom to alter the document in accordance with their reading capabilities. The PDF document was not able to be altered, which resulted in twelve participants stating that they had difficulties reading the two-column document because they had to scroll up at the end of a page to start the next column, which made it difficult to keep track of the sentence. The accessible document allowed text to reflow if the

participant changed the size of the font. The same twelve participants were then able to flip from page to page without losing their spot.

Overall, students enjoyed reading the accessible document more than the non-accessible document. Figure 2 showed that out of the twenty participants, only one participant stated that they enjoyed the PDF document that was non-accessible (0.05%). Two participants indicated that they did not enjoy one document over the other (0.1%). This left seventeen participants who stated that they enjoyed reading the accessible document more than the non-accessible document (0.85%). These results displayed that undergraduate university students enjoyed reading documents with accessibility features over the PDF document without accessibility features.

In comparison to Figure 3, 90% of students stated that if their required course readings were presented with the accessibility features as they were in the second testing document, they would be more likely to complete their readings. Participants made comments that they enjoyed the ability to change the background and text colour, which could potentially be used at night when reading in darkness. One participant in particular stated that having the reading documents set to “night mode”, where the background is a soft yellow, helped them to read at night as opposed to the regular PDF that was formatted with black text on a white background.

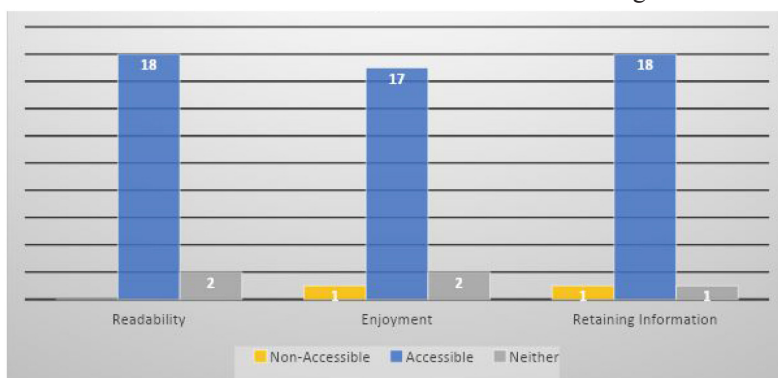


Figure 2. Opinion Survey: Document 1 and 2 Comparison

During the research study, there were six students who stated that they enjoyed reading the accessible document because they were able to change the text size and have the paragraphs reflowed. Using the PDF document, the students stated that instead of having the accessible document features to increase text size and to keep the document static, they had to scroll into the document to increase the text size. This made it harder for these six students to flow through the document consistently because they were not able to read the entire paragraph on the screen and kept having to scroll up and down the page. Participants were given the opportunity to make comments about the study and the accessibility features chosen. As a result, six students pointed out that although they did not have a visual impairment, it was their preference to have the text enlarged. For this reason, the accessible document

with the ability to increase the magnification of text without losing the overall format aided students to read in alignment with their needs.

Another section of the opinion survey that was completed by participants of the research test was about if they believed the accessible document helped them to retain more information than the non-accessible document. Eighteen students, or 90% of the participants, felt that the accessible document aided them in retaining more information than the non-accessible document. This statistical finding signified that students believed the accessible document better supported them in remembering information from the reading in contrast to the non-accessible document. The result of this section of the opinion survey correlated to the actual performance of the information retention of participants on the test that is shown in Figure 1.

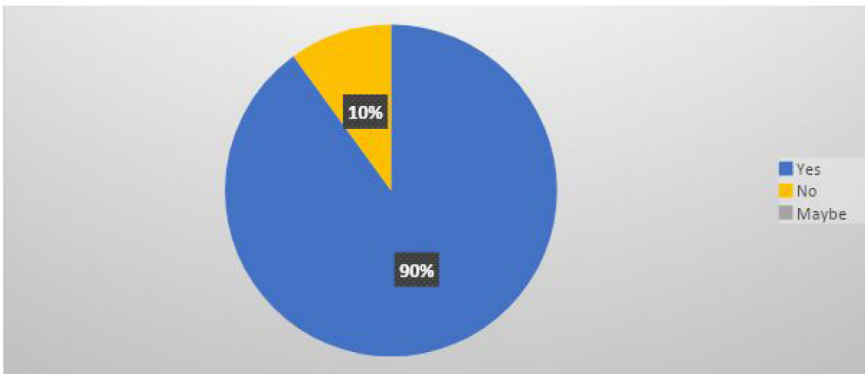


Figure 3. Would You Rather be More Inclined to Complete Readings if the Information was Presented as Accessible?

T-Test Results

A T-test was performed using the data collected from the research in Microsoft Excel (see Figure 3). Using this research study test, the T-test illustrated that the probability of the two situations, that of the non-accessible and accessible reading and testing results, were the same as 0.00139, which can be interpreted as 0.14%. The difference was accepted if the probability was less than 0.05 or 5% (Kenton, 2020). In the case of the data that had been collected comparing the results of the two documents, the T-test demonstrated that there was a significant difference in the data collected in association with the non-accessible and accessible documents after the analysis of their respective tests. This further proved that when students read the accessible documents, they performed better on the multiple-choice test.

Test on Non-Accessible and Accessible Document Comparison			
Question	Non-Accessible	Accessible	
1	13	18	
2	14	15	
3	11	20	
4	14	18	
5	13	14	
6	15	16	
7	12	16	
8	6	14	
9	10	18	
10	11	14	
Average	11.9	16.3	
T-Test		0.001398633	

Table 1. T-Test results created using Microsoft Excel

Discussion

Through the results of this study, it can be further discussed how the information supported the theory that accessible documents did not just help those with disabilities, but also assisted the public in general. Since these results proved that accessible documents had a positive effect on the information retention of undergraduate students, the topic of how easy it was to have accessible documents made available by e-book or e-publication publishers arose. Robert Gordon, Manager of Audio Publishing and Distribution at the Canadian National Institute for the Blind (CNIB Lab), stated that when files have been written, whether in Microsoft Word or another software, the process to turn these non-accessible PDFs into e-publications that have accessibility features was very minimal (Gordon, 2020). Whether it was the addition of the ability for users to change the colour of the text and background, alter the magnification of text, or enhance the document so it can be listened to instead of read, it was just an extra step within the publishing workflow to generate accessibility features into these documents. Gordon (2020) further built upon this statement through his expression that these features were simple to create by running a Microsoft Word document through a speech generator in order to create synthesized text-to-speech.

In correlation to the research findings and results, students not only performed better on the test after reading the accessible document, but they also enjoyed and felt that these features aided them in retaining information. Participants also stated that they would be more inclined to complete course readings if they were presented in an accessible format. Gordon’s (2020) statements about the implementation process of accessibility features promoted the notion that these documents should be formatted with accessibility features when published to be readable for all users.

To extend the idea that documents should be made accessible to everyone, Gordon (2020) gave the example of the electronic toothbrush. He explained that the electronic toothbrush was first designed to aid veterans who had been in World War II and needed assistance when brushing their teeth to support the circular motion of the brush (Gordon, 2020). It was found that not only did the electronic tooth aid those with a disability, but also the general public in achieving better usability. This example can connect with the implementation of accessibility features within e-publications. Not only do these features support those with disabilities, but the research study's findings demonstrate that it also helps general undergraduate students. Although these accessibility features were not initially designed for the average user and were made specifically for those with disabilities, we can interpret the findings to further Gordon's (2020) theory that accessibility features in e-publications extend from their intended user, and contribute benefits to the retention of information for the general public.

Furthering the concept that documents should be built accessible for everyone to use, the "curbcut" effect, a theory identified by Jutta Treviranus, describes that when accessibility is implemented within daily objects, it benefits the general public simultaneously, not only those who the features were intended for:

... frequently when these accessibility functions are made available to the general public it becomes clear that they benefit everyone... This is referred to as the 'digital curbcut.' Curbcuts were put into sidewalks to enable wheelchairs to get on and off sidewalks, yet they benefit people pushing strollers, shopping carts, or riding skateboards (2014).

The statement by Treviranus extends this research study's main argument, and Gordon's (2020) theory, that when accessibility features are implemented, it benefits the public in general.

Another application of these accessibility features throughout e-publications is that they are portable. Gordon (2020) explained that the features within this study are able to be viewed on any electronic devices, such as laptops, smartphones, and tablets. A benefit of having these features readily available and portable means that the participants of the study were able to interact with these accessibility features outside of the classroom. As Ryerson University is located in Downtown Toronto, where this study took place, it is known as a "commuter school" where many students commute to school because of the high cost of living downtown (Ryerson University Planning Office, 2019). If students wanted to complete required course readings on their way to or from school during their commute, the accessibility features within this study aid students. For example, the text-to-speech option can be used with headphones to eliminate background noise. The ability to change the colour of text and background can be adjusted to the lighting of the atmosphere around the reader, and magnification can be used to reflow text in order to support the viewer's text preference (Gordon,

2020). As a result, e-publication accessibility features used outside of the tested information retention can be used to support students in learning outside of the classroom.

Conclusion

Using the data collected and analyzed from this study, the effects and benefits that the accessibility features tested have on those for whom the features were built for and students who did not identify as having a disability were evident. Future development of this theme can take form in similar research studies using different accessibility features than the three tests employed in this study. The results of future studies can be juxtaposed to the conclusions of this study to indicate which accessibility features best support the general public in information retention.

The limitations of this research study included time restraints, which resulted in using a small sample size as there were only two weeks for participants able to sign up for a testing appointment. As the results of this research study suggest that the tested accessibility features benefit those of the general public, a more in-depth and wide-spread test with a greater sample size can further ensure validity and an accurate representation of the research population. Furthermore, a longer time period to recruit participants would result in a greater number of student participants, which in correlation, would increase the accuracy of results yielded from the study.

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Appendix



Appendix A: The accessible document that participants read, showing the option of using the accessibility drop-down menu, which allows for users to change the colour contrast of background and text, size of text, and text-to-speech.



Appendix B: The non-accessible PDF that participants read for this research study.