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Devon Waugh. Site Unseen: Website Accessibility Testing for Academic Libraries with Visually-Impaired Users. A Master's Paper for the M.S. in I.S degree. April, 2019. 67 pages. Advisor: Sarah Arnold

Research was conducted to evaluate the accessibility at the University of North Carolina at Chapel Hill by having users with visual impairments answer questions about the use of the library website and use of assistive technologies in a questionnaire and following-up with a usability test. The usability test involved having participants complete tasks that were guided by a sample research question. Throughout the test, they navigated a database access page, a subject guide, and two databases to find research articles that related to the question. The resulting data indicated users preferred the organized layout of the database access page, but overall participants were frustrated with navigating the interfaces of databases, which varied in their design and delivery of accessible PDFs. Making changes to the database access page's code and structure also ensured that the page was accessible prior to confirming with participants in the testing environment.

Headings:

Academic Libraries.

Accessible Web sites for people with disabilities.

Libraries and people with visual disabilities.

Web Site ------ Design.

Usability Testing.

Questionnaire.

SITE UNSEEN: WEBSITE ACCESSIBILITY TESTING FOR ACADEMIC LIBRARIES WITH VISUALLY-IMPAIRED USERS

by
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A Master's paper submitted to the faculty
of the School of Information and Library Science
of the University of North Carolina at Chapel Hill
in partial fulfillment of the requirements
for the degree of Master of Science in
Information Science.

Chapel Hill, North Carolina

April 2019

Approved by

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Sarah Arnold

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Acknowledgments

I feel particularly grateful to dive deeply into a topic that unintentionally changed my life in high school and set the course for my first foray into academic research. I was introduced to accessibility issues by Sister Mary Ann Tantalo when learning how to navigate a JAWS screen reader with a dial-up connection was no easy feat. I cannot begin to thank her for teaching me what it means to be of service to others.

I'd also like to thank my students at Northern Vance High School for sharing their life stories and teaching me about what is means to make a classroom inclusive. Navigating the daily struggles with technology and accessibility proved that the little changes can make a huge difference. You all showed me what it means to be a leader.

Sarah Arnold has truly gone the extra mile for me as an advisor, and I cannot begin to thank her enough for her dedication to this project and willingness to collaborate on a shared passion for accessibility. I am immensely appreciative of your support and mentorship.

And lastly, to all my friends and family. You have stuck with me through this whole journey of graduate school and I am forever grateful for your love and company.

Introduction

Advances in technology have made it possible for many libraries' online services to flourish and cover a broader base of users. The simple tools used by libraries to expand their online presence could come at the cost of alienating a growing population of users who have visual impairments, which will continue to rise as the population ages. Visual impairments can vary from a temporary condition to low vision to lifelong blindness. Traditionally, blind patrons received services and materials from a designated state library but many people with visual impairments do not qualify for this service (Lewis, 2013). As mobile devices build more accessibility features into their operating systems, the visually-impaired population relies on more advancements in their access to digital information (Lewis, 2013). However, digital services from libraries do not always offer consistently accessible formats to make their information available to all users (Mulliken, 2018).

Web accessibility needs to follow two main standards for compliance: the Web Content Accessibility Guidelines (WCAG) 2.1 success criteria and Section 508 of the Rehabilitation Act of 1973 (Mulliken, 2018) (Jaeger, 2006). WCAG 2.0 guidelines can be used as a resource for building an accessible website but they are not a heuristic for determining whether a website is exhaustively accessible (Rømen & Svanæs, 2011). Section 508 of the Rehabilitation Act emphasizes that the content of a web page must be made accessible in formats for all viewers (Jaeger, 2006). The WCAG guidelines

recommend that website creators add alternative text to media so assistive technology can read the text and give context for what the image is to visually-impaired users. Assistive technology typically comes in the form of a screen reader that reads the content of a web page sequentially. If websites do not incorporate accessible features outlined in these guidelines, screen readers cannot read the content (Lazar & Jaeger, 2011). Each webpage should also use heading tags that are coded in HTML, so a screen reader can determine the order that content should be read (Mulliken, 2018). In Rømen & Svanæs' (2011) study, users with disabilities tested websites and faced considerable accessibility challenges. However, more than half of these websites met WCAG 2.0 guidelines (Rømen & Svanæs, 2011). In web pages with considerable content, screen readers read the entire page in order so websites need a feature for this population to navigate away from irrelevant content (Mulliken, 2018). Meeting these guidelines does not replace the experiences of actual users attempting to meet their information needs on a website or search engine.

Instead, user studies with visually-impaired participants complement WCAG compliance measures and give the field of usability more concrete evidence that accessibility benefits all users. In particular, this user study is focused on an academic library website due to the changing nature of scholarly research on campuses (Al-Qallaf & Ridha, 2018) (Dermody & Majekodunmi, 2011). Students, faculty and staff members are required to participate and learn online more than ever before. Additionally, navigating an academic library website requires sifting through thousands of e-journals, databases, e-books and other resources to meet research needs (Dermody &

Majekodunmi, 2011). It has become increasingly crucial to understand how users with disabilities meet this expectation as well.

Components of the University of North Carolina at Chapel Hill's University Libraries website will be evaluated to determine whether they present challenges for this population. The UNC Libraries website is a hub for students, faculty and staff to find research articles. The main search bar allows users to search through most of the library's database and journal subscriptions as well as the catalog. Below the search bar, the Research Tools menu organizes six methods for finding research: the library catalog, the E-Research by Discipline page, Articles+, Google Scholar, WorldCat, E-Journals and the Triangle Research Libraries Network (TRLN). Unlike the search bar, the E-Research by Discipline page is a list of all the main, potential fields of research at UNC. Each research field is arranged into four categories: General & Reference, Humanities & Social Sciences, Health Sciences and Science & Technology. It offers a high-level view of the fields in each discipline and links to each field's sub-page, which can vary from Dramatic Arts to Toxicology.

The right sidebar of the page allows users to find the most frequently used databases, search for DOIs and view an alphabetical list of subscribed databases. This page directs users to discipline-specific databases and sources of scholarly research and employs a complex information architecture to do so. In usability testing, the representative user group typically does not include users with visual impairments, which leads websites to ignore the requirements of meeting this population's needs. Conducting a study with this population allows the library's website to gather feedback and evaluate

whether its primary service meets all users' information needs. The questions to then be answered are:

1. How usable is the UNC Libraries website's navigation page to databases for visually impaired users?
2. How does this page's structure impact the amount of time this population spends finding research on a particular subject?

Literature Review

Information Seeking Behavior of Visually Impaired Users

Learning how specific user groups search for information online helps us develop a broader picture of the various needs that an interface must fulfill. Several models of information behavior have essentially become a shared vocabulary for describing users (Bates, 1989) (Kulthau, 1991). The process typically starts out with forming their queries with a combination of keywords and reforming them depending on the results received from an interface (Marchionini, 1995) (Marchionini & White, 2007). After this initial search, users evaluate results and use these judgments to reform their query until their information need is satisfied (Bystrom & Jarvelin, 1995) (Kulthau, 1991). For visually impaired users, their information needs are the same as their sighted peers, but the ways they seek out this information involve developing strategies to speed up or remove steps in this search process (Power et al., 2013) (Hunsucker, 2013) (Sahib et al., 2012).

Navigating the layout of a website is the primary challenge that visually impaired users face online (Power et al., 2013). Sighted users rely on visual cues to orient themselves as they would in a physical space. In contrast, visually impaired users employ assistive technology to read HTML headings and focus on sections of a page to become familiar with the virtual space of a website (Power et al., 2013). It also incorporates keyboard shortcuts so users can speed up their searches (Power et al., 2013). Subsequently, the information behaviors of query development and reformulation happen at a faster rate for visually impaired users. Power et. al's (2013) study of blind, low vision

and dyslexic users found that the blind and low vision users determined the overall structure of a webpage through headings. Often, visually impaired users re-read sections of a page to determine how key headings and sections structured the page's content. While sighted users scan a page, this population uses boundaries and headings to read a web page section by section (Power et al., 2013)

Anchoring was another common technique found in Power et al.'s study (2013) as well as Hunsucker's (2013) study of 13 blind users who carried out self-directed search tasks. Visually-impaired users anchor themselves on a web page by narrowing their gaze to a particular section (Hunsucker, 2013) (Power et al., 2013). Avoidance was another word used to describe this behavior because users avoided looking at a side of the page or stopped their query once they reached a satisfactory result (Hunsucker, 2013) (Xie et al., 2015). Low-vision users employed this strategy because they needed to magnify a section of a page to read its content (Power et al., 2013). Users in Hunsucker's (2013) study often anchored themselves vertically from top to bottom because horizontal reading was not as compatible with the screen magnifier. This technique indicates that this population gets an overall feel of a web page in short bursts and needs clear boundaries to orient themselves (Power et al., 2013). Trying to conduct a satisfactory search in one step means that visually impaired users devote a considerable cognitive load to website navigation. When evaluating their results, Xie et al.'s study (2015) found users struggled to assess the quality and relevance of the information efficiently. Navigating a website shifts the burden of understanding onto the user, especially for those who cannot see the content well or all at once.

The search process for visually-impaired users is also impeded by the amount of time and cognition it takes to operate assistive technology. Consequently, their queries are much more focused and lengthy compared to sighted users (Marchionini & White, 2007) (Hunsucker, 2013) (Power et al., 2013) (Sahib et al., 2012). In Hunsucker's study (2013), users began their searches with precise search terms and did not reform their queries. Once they reached their results, only 13 percent of users went beyond the first page. Using assistive technology helps visually impaired users read articles once they have located them. However, the actual process of navigating to a database and finding an article can be far more complicated.

Throughout the search process, studies have found that this population took extensive notes and bookmarked pages to avoid refinding the information later (Sahib et al., 2012) (Hunsucker, 2013) (Mulliken, 2018). However, this behavior can take users away from the results page and interrupt their search process many times in a single session. Sahib et al's (2015) study provided two features to counteract this issue: a record of the user's search and a note-taking app within the interface. The record of the user's search functioned similar to breadcrumbs on websites (Nielsen, 2007). Identifying and integrating information behaviors more seamlessly into the search process could help visually-impaired users reform queries more efficiently over time.

When reforming queries, some visually-impaired users cannot take advantage of spelling suggestions in an interface because they require sight and are not compatible with screen readers (Sahib et al., 2015). Subsequently, well-formed queries can be rendered useless by one spelling error (Sahib et al., 2012) (Sahib et al., 2015) (Leporini et al., 2004). In Leporini et al. (2008)'s study, a modified Google interface was developed

for 12 blind users in which non-speech sounds signaled when a search yielded no results. Users found this queue helpful for evaluating results quickly. Tab navigation and shortcuts were also incorporated to make the interface compatible with assistive technology (Leporini et al., 2008). This concept was then revised in the prototype of a search interface developed in Sahib et al.'s (2015) study. Visually impaired users received these queues when search terms were spelled incorrectly so these mistakes did not interfere with the search process (Sahib et al., 2015). Because this population spends limited time evaluating search results, modifications to an interface can help them satisfy their information need efficiently without having to read extraneous information (Sahib et al., 2015) (Power et al., 2013) (Hunsucker, 2013). Small adjustments to an interface and the inclusion of auditory features can have a major impact on usability for visually impaired users. Ultimately, this impact can and should only be evaluated by testing with the users themselves.

User Studies of Visually-Impaired Population

Usability testing with this population requires creating and explaining tasks to users in a way that reflects their information seeking behavior and use of online information. Instead of exploring an interface, evaluating the usability of a website for this population depends on having users complete tasks. Visually impaired users often have a specific information need that lead them to search online (Craven & Nietzio, 2007). Sahib et al. (2015) created multi-session search tasks to examine the experience of re-finding information in the modified interface. Because visually impaired users take notes and use bookmarks throughout their search (Hunsucker, 2013) (Power et al., 2013), the interface had a built-in word processor and breadcrumbs to assist users with tracking

searches. Participants were then able to reform queries between their first and second searches, which is an information behavior common to sighted users. Building a new interface helped Sahib et al. (2015) explore what features facilitate their existing search process. Creating meaningful tasks allows participants to feel a connection to the test and invite more qualitative description about how these searches relate to their information seeking strategies. However, effective task analysis cannot happen without feedback from users themselves. Usability testing of this population can vary in their structure and protocols because they are not attempting to cover the most representative user group.

Along with the tasks, studies also found that it was critical to think about how the think-aloud protocol can hinder usability tests (Chandreshekar et al., 2006) (Stefano et al., 2010) (Strain et al., 2007) (Babu & Xie, 2017). Chandreshekar et al. (2006) prompted participants to think aloud every 15 seconds. The four blind participants in the study continued searching instead of answering the prompt, while two low-vision users answered each time. In response, studies have proposed several adapted protocols to allow users to share feedback in a more naturalistic way (Sahib et al., 2015) (Xie et al., 2014) (Stefano et al., 2010). Stefano et al. (2010) developed a protocol called Partial Concurrent Think Aloud in which discussion follows each search task but remains focused on the task. Keeping the responses focused on tasks during the user study allowed users to give feedback on current issues with the interface and remember their thoughts (Stefano et al., 2010). Ultimately, each decision in a user study of this population needs to consider existing methods of usability studies and modify them as it makes sense. Making the protocols and tasks of a usability test inclusive does not diminish the results gathered or their impact for gathering descriptive user feedback.

Another consideration for this population is how to incorporate assistive technology into a usability test in a way that suits participants. Studies that incorporate screen readers attempt to differentiate between advanced and novice users (Sahib et al., 2015) (Calvo et al., 2014) (Leporini et al., 2008). Interviews and surveys prior to a usability study established a baseline of participants' proficiency with screen readers in Sahib et al's (2015) study and allowed them to determine whether this technology suited the study's purpose and tasks. For complex search tasks, assistive technology can help support this population's completion of them and offer a guideline for navigating the interface (Sahib et al., 2015). The screen reader enhances the user's experience in so far as it can read the screen efficiently and be used easily by the participant. Evaluating usability for this population also needs to include actual users because they can offer immediate feedback and draw from their own experiences navigating online information. Having one sighted researcher operate a screen reader and evaluate an interface independently cannot sufficiently document the user experience of this population (Xie et al., 2014).

Better understanding of designing interfaces for all users can come from testing with participants with visual impairments. WCAG and Section 508 compliance are not sufficient; people have more needs for using an interface than headings and alternative text for images. There are automated accessibility tools such as WebAIM's WAVE that check whether a website's content and code comply with WCAG guidelines. However, this tool can only test for twenty-five to twenty-nine percent of all WCAG guidelines (Groves, 2012). Another consideration for users with low vision is that any items in color need to have a significant contrast to be read. Additionally, screen-magnification

software can sometimes alter the contrast of colors as well as fonts. Giving captions to all graphics, allowing users to change color options and not specifying exact font sizes or layouts can assist this population with using a website. The visually impaired population needs ways to re-find information quickly, take notes within an interface and have another way to correct spelling errors besides visual cues (Sahib et al., 2015) (Stefano et al., 2010) (Chandreshekar et al., 2005). For all interfaces, the visually impaired population expects the same efficiency, ease of use and learnability when navigating websites and mobile applications that is afforded to their sighted peers. Making websites accessible does not imply sacrificing design considerations or making websites only in text-form. Instead, it means that the website is incorporating features that lend more organization and forethought to its pages.

Accessibility of Academic Library Websites

Because academic libraries offer thousands of databases, journals and other forms of digital content, web accessibility has emerged as an issue for them to address on their respective campuses. Their services are also accountable to a broad, protean base of users who have come to expect research to be online and readily available (Al-Qallaf & Ridha, 2018). Given these shifting responsibilities, the academic library has moved away from its original role of storing and managing massive collections of print materials. Instead, it is a major hub for digital information on campus that serves students, faculty, staff members, hospital employees, and citizens of the state, in the case of public universities like UNC-Chapel Hill. Each academic library uses its website as a platform for managing access to subscribed materials and self-produced content to support users (Al-Qallaf & Ridha, 2018). In this process, academic libraries have turned their reliance on database

vendors and the private-sector publishers into a point of advocacy. With support from their parent institutions, academic libraries have begun to support open access publishers and the open textbook movement to shift the burden of cost off of their collection development budget and their users as well (Al-Qallaf & Ridha, 2018) (Dermody & Majekodunmi, 2011).

All higher education institutions must make public-facing materials accessible under Section 508 of the Rehabilitation Act of 1973 (Leonard, 2018). As recently as 2013, Comeaux and Schmetzke evaluated 56 academic library websites and found 40 percent of these websites complied with WCAG guidelines based on tests completed between 2002 and 2012 (Comeaux & Schmetzke, 2013). In early 2017, the baseline compliance for academic library websites was updated to meet AA compliance for WCAG guidelines, which required academic libraries to remediate their online presence rapidly. Leonard (2018) detailed Seton Hall University's process of remediation due to a federal complaint in May 2017. Seton Hall University (SHU) Libraries had to reach out to each vendor to identify accessibility issues, conduct accessibility training for employees who create public-facing content, and make a plan for future content (Leonard, 2018). Even without a lawsuit hanging over the university, academic libraries across the world have sprung into action to make their current and future content accessible (Mulliken, 2018) (Laufer Nir & Rimmerman, 2018) (Leonard, 2018) (Ismailova & Inal, 2017). In reference to SHU Libraries, Leonard acknowledges, "a single library can do a great deal, but not everything" (Leonard, 2018). Ultimately, vendors remain impervious to any legal pressure, while the license holders of databases bear the burden of making content accessible (Leonard, 2018). In Power and Lebeau's

(2009) study of thirty-three academic library websites and six database vendors, one database vendor was found to be compliant with Section 508. Maintaining WCAG or Section 508 compliance does not guarantee that the content is usable for people with disabilities (Leonard, 2018) (Comeaux & Schmetzke, 2013) (Lazar & Jaeger, 2011) (Yoon et al. 2016). Better understanding of making library websites usable can come from the direct experiences of college students who have visual impairments.

In a user study of twelve visually impaired students, Dermody & Majekoudunmi (2011) found that forty-one percent could find an article on the topic assigned to them. After locating an article, the interlibrary loan system and inaccessible PDFs posed a significant barrier for users. Most PDFs were image-based so they did not have optical character recognition and were not tagged for use by screen readers (Dermody & Majekodunmi, 2011). Fifty-five percent of users could find readable, full-text articles to satisfy the search tasks (Dermody & Majekodunmi, 2011). Inaccessible PDFs require users to convert the PDF into an accessible format, which can typically be done through an online PDF conversion service (Oswal, 2014) (Mulliken, 2018). The system of online databases can vary for each academic library website and no two PDFs behave alike (Oswal, 2014). Despite these online constraints, this population is still expected to access and learn from scholarly research, but developing this skill poses more logistical challenges to them than their sighted peers.

The amount of links required to reach and use a database can place a significant cognitive load on visually impaired users and overwhelm their search because they are not able to find and evaluate results as quickly as sighted users. (Dermody & Majekodunmi, 2011). This navigation issue is also rooted in the complex information

architecture that links the library website to databases. Because academic library websites act as a portal to their subscribed databases, users have to start on the library's website to gain access to the database and then navigate through at least two or three pages to reach the search interface (Oswal, 2014). Once users reach the results page, they find it difficult to focus the amount of results and must keep track of the number of links because there is no breadcrumbs feature (Mulliken, 2018) (Dermody & Majekodunmi, 2011). This confusing path and cluttered layout of results makes searches longer and leads users to satisfy their search with one page of results (Mulliken, 2018) (Dermody & Majekodunmi, 2011) (Hunsucker, 2013).

In other cases, academic library users will seek out assistance from librarians to help navigate their searches. One participant in Mulliken's study (2018) of eighteen visually impaired academic library patrons noted, "There's so many different tabs and ways of using it, it feels like a maze to me, I don't understand quite how to navigate through it" (Mulliken, 2018). This complex information architecture adds more time to their searches compared to their sighted peers: "I could spend maybe 8 hours doing something that would probably take a sighted student maybe half or even a third of the time" (Mulliken, 2018). Librarians can be a valuable resource because they understand how the information architecture of the website is set up and can "filter through the data a lot quicker" (Mulliken, 2018). However, constant support from librarians can impact this population's ability to search independently for reliable and relevant sources. Selecting and finding articles is the necessary first step for building self-efficacy online (Dermody & Majekodunmi, 2011).

When visually impaired users run into problems with a database, few help pages have an accessible format, such as plain-text, that helps them remedy their issue quickly. In a survey of thirty-three library websites, three of them had text-only options for the database interface (Power et al., 2013). Visually impaired users would benefit from this format for help pages because the interface's clutter can be what led them to seek help. Pop-ups and visual cues can offer correctly-spelled search terms and lead users to help documentation in a search interface (Sahib et al., 2014) (Oswal, 2014). However, these features cannot assist this user group with resolving issues. Studies also found there is no way to respond efficiently to an issue with a screen reader on these platforms (Oswal, 2014) (Sahib et al., 2014). Therefore, these system responses are useless for a population that needs them often. The lengthy process of troubleshooting in a database grows even longer when screen readers have to read through each prompt sequentially and cannot skip to relevant help documentation.

Evaluating these complex interfaces has led studies to notice three primary design solutions. In databases, many mouse clicks are required to perform certain actions, but visually impaired users use keystrokes to navigate websites with screen readers (Gooda Sahib et al., 2014) (Oswal, 2014) (Dermody & Majekodunmi, 2011). Tabs for skipping content and incorporating keystrokes into the website's navigation would guide this population to results more efficiently (Mulliken, 2018) (Becker & Yanotta, 2013). The inclusion of text-only navigation menus, help documentation, and site maps allows users to determine the navigation of the website in a way that coincides with their mental models of the website and their assistive technology (Dermody & Majekodunmi, 2011) (Becker & Yanotta, 2013) (Al-Qallaf & Ridha, 2018) (Deltor & Lewis, 2006) (Mulliken,

2018) (Yoon et al., 2013). Al-Qallaf & Ridha's (2018) survey of academic library websites found one fifth of them did not include a site map. Al-Qallaf & Ridha (2018) also found 59 percent of surveyed websites contained excessive or irrelevant graphics (Al-Qallaf & Ridha, 2018). Even more so than their sighted peers, clutter impacts how visually impaired users navigate through a webpage and adds more time to their search (Oswal, 2014). Effective design of an academic library website has to strike the delicate balance between avoiding information overload and giving users satisfactory search results.

Long-term solutions for accessibility depend on making their design inclusive at the interface level, rather than fixing issues as they arise from litigation (Leonard, 2018) (Oswal, 2014). Libraries also need to offer targeted instruction on web accessibility to their employees and university departments, given the legal responsibilities placed on higher education institutions (Mulliken, 2018) (Byerly et al., 2007) (Dermody & Majekodunmi, 2011) (Power & Lebeau, 2009). Iterative usability tests on library websites and databases can provide concrete feedback for any future re-designs of the website's interface (Al-Qallaf & Ridha, 2018) (Byerly et al., 2007). It is also doubly important that people with disabilities are incorporated in this testing process because actual users can give feedback on issues they experience with accessibility and usability. All of these efforts will be minimal unless there is greater collaboration between database vendors and academic libraries (Power & Lebeau, 2009). Improving the online research experiences for this population allows libraries to improve the experience for all users. Building accessibility into library websites will provide users with more intentionally designed and organized search interfaces, thoughtfully used graphics, and a more

learnable search experience overall. Improving the experiences of marginalized populations may upend the notion of a traditional user group.

Methodology

Overview

The study conducted a survey to recruit participants and gather feedback on experiences with the UNC Libraries website. The usability test then used these responses to develop a representative research question that guided participants between the UNC Libraries website and subscribed databases. After each task, participants self-reported the task's ease of use and rated it on a scale from 1 to 5. Once the test ended, the principal investigator followed up with participants in a brief interview to discuss the experience and search behaviors for finding scholarly research online.

E-Research by Discipline

The literature emphasized that visually impaired users can provide concrete feedback when asked to complete a set of tasks rather than explore an interface. This approach will give users time to offer feedback after each task and use several components of the E-Research by Discipline page. Its interface arranges research fields by discipline in a list of links arranged into four categories: general reference, humanities and social sciences, health sciences, and science and technology

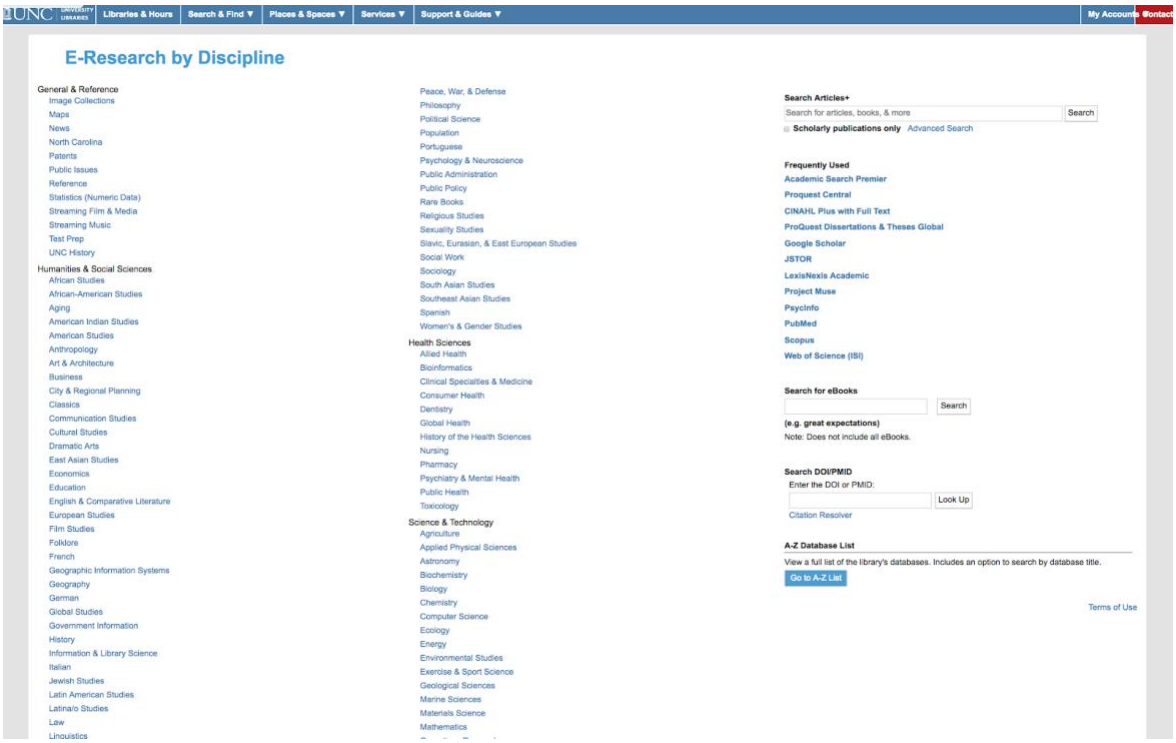

Figure 1. Screenshot of the E-Research by Discipline page as of November 2018.

When users click on a field such as Environmental Studies, each link offers a set of subject-specific databases, LibGuides and the contact information for a subject librarian covering that field of study. Once users click on the name of a database in that sub-page, they leave the main library website and are directed to the database's search interface.

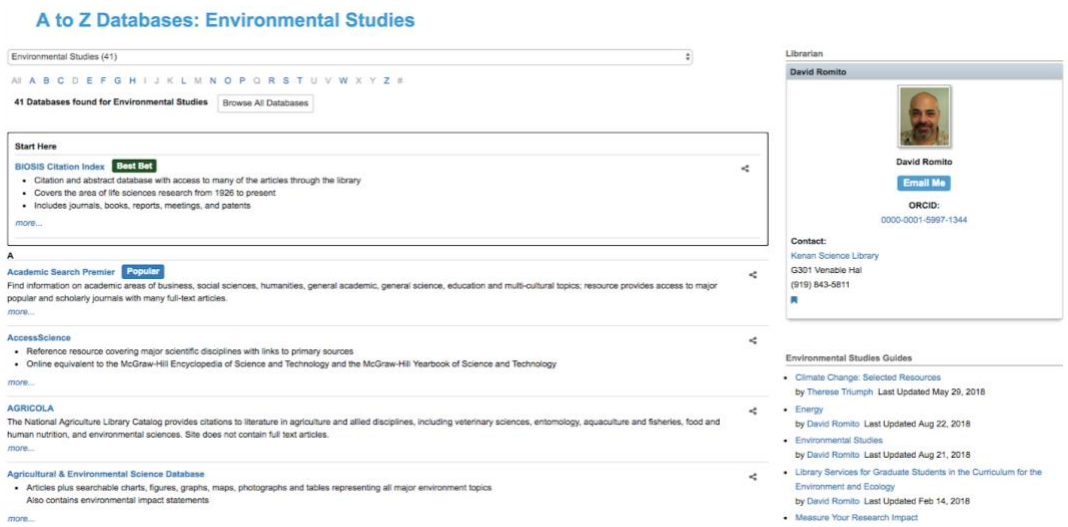

Figure 2. Screenshot of sub-page for Environmental Studies as of November 2018.

The E-Research by Discipline page acts as a portal because users can click on a subject page, navigate to a database and subsequently, leave the main library website. However, users may need to navigate back to the website if their database search did not return relevant results. The purpose of this tool is to allow users to focus their search on a particular sub-field and find library resources and databases geared toward it.

The goals of this study were to understand the search habits of visually impaired users and evaluate how usable the E-Research by Discipline page is for this population. In using a screen reader, the study also measured the compatibility of this technology with each page opened in the user study. A secondary goal of this study was to determine how usable the PDF copies of articles are for this population and recommendations for making them comply with assistive technology.

User Population

The user population consists of any students, faculty and staff members on campus who have visual impairments. The study used convenience sampling by distributing an initial pre-study survey through several campus listservs and the listserv

from Accessible Resources and Services (ARS). ARS also distributed the survey in their newsletter. Based on past experience with Maze Day, an event for K-12 visually impaired students and community members, the study also used snowball sampling to identify potential participants. The purpose of conducting a user study with this specific population is to evaluate the accessibility of the E-Research by Discipline page, which serves as a hub for several types of digital resources. The literature has reinforced that web accessibility not only involves compliance with WCAG guidelines and Section 508, but also testing whether a website is usable for individuals with visual impairments (Dermody & Majekodunmi, 2011).

Questionnaire

Many studies of the visually impaired population used surveys as their initial tool for recruitment (Mulliken, 2018) (Dermody & Majekodunmi, 2011) (Strain et al., 2007) (Sahib et al., 2012). A questionnaire was created using Qualtrics through UNC's online tools. The questionnaire used survey logic so that if a participant records their affiliation as a staff member, they will not be asked questions about using research articles for class assignments. If a participant recorded that they do not have a visual impairment, then a follow-up question will not be asked about whether they use any form of assistive technology. The initial questionnaire served three purposes:

- Be a record of search habits related to the usage of the library website
- Establish a baseline of proficiency with assistive technology
- Recruit participants for the follow-up usability study

The questionnaire itself is organized into four sections: demographics, library use, information behavior, and interest in participating in a follow-up user study. While the

first and last sections supported the second purpose of the survey, the library use and information behavior questions informed the tasks developed for the usability study. The questions used multiple-choice options and a Likert scale. All questions were pilot-tested prior to delivering the survey to listservs and contacts on campus. Ultimately, the survey builds a foundation for the usability study, allowing the study to evaluate the user experiences of this population with respect to the library website.

Usability Test

User studies with the visually impaired population have tested out the think aloud protocol with fairly mixed results (Chandrashekar et al., 2006) (Strain et al., 2007) (Sahib et al., 2014). Instead, Chandrashekar et al.'s study suggested adding in more inclusive ways of gathering user feedback. A considerable amount of audio competes for attention when a screen reader is involved in a user study. After each task, the participant was asked two brief interview questions to prompt them to share their thoughts about the task. Participants shared their opinions on the task and how usable they considered the interface for each task. Additional probing questions were incorporated depending on the participant's initial response and the task itself. While this strategy can interrupt the flow of task completion (Strain et al., 2007), the cognitive overload is not as significant.

This study used Techsmith's Camtasia screen and audio recording to record participants' actions and audio via screen capture, which allowed the study to gather data on task completion and the system's compatibility with assistive technology. Because of the significant amount of audio, the user study was completed by one user at a time in a specified location on campus. The principal investigator observed participants, offered support when prompted and asked interview questions after each task and at the end of

the study. The note-taker took notes with an observation guide to record the participants' completion of search tasks and observe their responses and behaviors.

Because of the complex arrangement of this search tool, the study included a set of user tasks that will satisfy a specific information need and require users to navigate to subject-specific databases and back to the E-Research by Discipline page. A screen reader was used and the study was audio-recorded to determine how compatible and usable assistive technology is with the existing layout of the page. Users were asked to find articles and download PDF copies of the articles to evaluate the process of downloading an article and determining its compatibility with a screen reader. The usability test evaluated each participant's task completion to compare participants' experiences with the tasks. An observation guide recorded the following key actions during each task: the participant's use of navigation features, such as skipping to HTML-tagged headings, the compatibility of the website with assistive technology and how accessible the download PDFs are. After each task, users shared their feedback so their thoughts did not compete with the sound of the screen reader and they can continue to navigate through the task. In addition, a post-study questionnaire and brief interview recorded participants' perceived success with search tasks, recommendations for the library website, and satisfaction with the overall search experience.

The post-study questionnaire used the System Usability Scale, which incorporates participant feedback to quantify if a system is usable or not. It is considered "the most widely used standardized questionnaire for the assessment of perceived usability" (Lewis, 2018). Participants answered the SUS questions on a scale from 1 being Strongly Disagree to 5 being Strongly Agree. Each response is then calculated to aggregate to an

overall usability score. Given the test's user population, the principal investigator read aloud the SUS questions and the notetaker will record participants' responses. While this questionnaire offered a reliable and consistent measure, it can only evaluate perceived usability at most (Lewis, 2018). Rather, the post-study interviews offered more insights on participants' attitudes and satisfaction with the overall search experience. Several of the interview questions are adapted from Saqr's dissertation on the online behaviors of visually impaired users (Saqr, 2016) because the study also wanted to gather feedback on the participants' existing patterns of research behavior along with their recommendations for the interface. Qualitative measures contributed to understanding the ways that visually-impaired users already interact with the library website. Their responses gave subjective insight into problems they have experienced while interacting with the website. A post-study questionnaire and interview also allowed the principal investigator to review key actions from the test with the participant and gave a more nuanced record of participants' experiences.

Data Analysis

Several critical sources of data were gathered to evaluate the experiences of visually-impaired users with the E-Research by Discipline page and by extension, a massive collection of subscribed databases. Given that the initial questionnaire was a tool for recruiting participants in the usability test, survey responses were analyzed for the following criteria: affiliation with the university, diagnosis of a visual impairment, experiences with the UNC Libraries website, proficiency with assistive technology and interest in participating in a follow-up study. This scope ensured participants will only be contacted if they express interest in participating in the follow-up study. Survey results

were analyzed visually but conducting statistical analysis was not considered necessary since the user population is small and the study is not generalizable. Once the survey was conducted via Qualtrics, the principal investigator contacted interested participants from the user population and created tasks that fit their existing research needs.

The usability test gathered data on task completion, observations and participants' responses to the System Usability Scale and interview questions to create a more nuanced portrait of their experiences with the UNC Libraries website. Task completion data offered a direct assessment of the usability of the UNC Libraries website's information architecture related to finding research articles. Observations consisted of any instances of participants' emotions, frustrations, experiences, and opinions of the system. An existing coding scheme from a usability study of health information systems was used as a reference and adapted as needed by the principal investigator (Kushniruk & Patel, 2004). This coding scheme was chosen for its identification of 11 broad themes for describing usability issues but will not be exhaustively used given the exploratory nature of this study.

Results

Pre-test Questionnaire

The questionnaire was originally meant to capture participants' experiences with UNC Libraries' online resources as well as their patterns of information behavior when searching for scholarly research. While the questionnaire was open for 48 days, 20 respondents began the questionnaire with 15 completing it - a response rate of 75%. However, the questionnaire ended up being a tool for recruiting participants for the follow-up usability test and preparing the testing environment with the necessary assistive technology. It also ended up being a single way to gather participants' contact information. To ensure that the survey was accessible, the principal investigator used the Qualtrics check for accessibility tool and made a note on the first question that the questionnaire would deviate from its numbered order due to survey logic.

One of the unforeseen challenges of the survey was the question asking if participants had a visual impairment was too broad. In two cases, participants had visual impairments that were minor and only required glasses to support their vision while others required assistive technology. In retrospect, the question could have offered more clarification that the visual impairment must hinder their ability to access information on computers or mobile devices. While visual impairments can vary in their severity, the purpose of the study is to evaluate a population that faces barriers to accessing information online.

Overview for Usability Test

For the usability test, participants were asked about what assistive technology was necessary for them to complete the test. Participant A used a browser extension for high contrast. Participant B used screen magnification and the NVDA screen reader. Participant C used his own iPad with VoiceOver, citing a lack of comfort with the NVDA screen reader. Each participant made these adjustments and preferences for assistive technology known before the test began. While this decision made it challenging to establish a baseline of performance, expecting them to make do with the current technology of the usability lab was counterproductive at best and ableist at worst.

To gauge prior knowledge, participants were asked questions about their familiarity with the E-Research by Discipline page as well as their experience with the library website. Then, they were given a research question: What is the impact of pesticides on honey bees? The principal investigator developed tasks guided by this question because users who are visually impaired do not explore interfaces. They often use computers and mobile devices to look up realized questions and conduct known-item searching. The tasks also reflect the assignments that are typical for a first-year student at UNC - mirroring the expectations of the college research curriculum.

With the research question, they were asked to complete three tasks on the library website based on how they would find resources to answer this question. The preselected research question controlled the results and gave investigators outcomes that could be compared across participants. After each task, participants were asked to share their general thoughts and rate the task on a scale from 1 being very easy to 5 being very difficult. While each of the three tasks had an ideal path that revealed what investigators

wanted to learn about the library's databases and integration with the website, participants were asked to behave as they normally would. If participants veered from this path, they were asked to return to the site and complete the task within the guidelines.

After first viewing the E-Research by Discipline page, all three participants noted the organization of headings for disciplines and alphabetical listing of academic subjects. Participant A commented on a preference for a single column list of links,

> "I tend to like things to all be in one list instead of all the way across. I like the headings and subheadings. Since I don't have that wide a field of view, I can miss things across the screen."

Participant C found that it could be useful, "if you didn't know how to get to your discipline" or have experience with research on a new subject or class. As more faculty members and graduate students are expected to conduct interdisciplinary research, the library expects this page can be a conduit between academics that invite them to become familiar with related disciplines and collaborate across disciplines as well.

Task 1 - Searching in a General Database

Participants then searched for articles in Academic Search Premier - an Ebsco database - under the list of Frequently Used databases and opened a chosen article in a PDF viewer. Participant A clicked on the first result and could not find a PDF of the article. He went back to the results page, selected the second result and found the link for 'PDF Full Text' on the results page. While Participant A rated the task as a 3, he made the following comment:

> "I tend to like things to all be in one list instead of all the way across. I like the headings and subheadings. Since I don't have that wide a field of view, I can miss things across the screen."

Participant B opened up a new window in the browser to type out the keywords for his search terms in Google and make sure they were spelled correctly. Google was

able to correct “pesticides hunnybies” to “pesticides honey bees.” While Participant B said he normally looks at all the results on the first page to see what he wants, he clicked on the ‘PDF Full Text link’ for the second result on the page. Before reading the article, Participant B had to find the NVDA default key on the keyboard, which differed from his screen reader setup at home. Once the screen reader began reading the PDF, he started to use keystrokes to read the article headings. Participant B considered this task very easy and found that it would have been even easier on his computer at home by stating, “I’m more used to it, and I have the keys on my keyboard mapped to particular things.”

Participant C did not fully complete the first task after he found a PDF, but was not certain about its relevance to the research question. Before the task, he explained that he had “never used [Academic Search Premier] before.” He explored the fields of the search bar, but was not sure how to spell pesticide, even though suggested spellings helped him spell it correctly. On his own device, he had to navigate through all of the search boxes at the top of the page to find the list of search results. He said, “Oh there’s the one,” chose the first result, and navigated to the ‘View PDF - Full Text’ link. He struggled to have VoiceOver read the content of the article from start to finish, instead of starting on the second page. If Participant C wanted to keep it, he normally would click on the ‘Share’ option and email the result to himself. He ranked the task as a 2 and commented that he normally searches for known-items in the library rather than browsing in the beginning stages of researching a topic.

Task 2 - Navigating an A-Z Database List Subject Page

After the initial search, the principal investigator asked participants to navigate back to the E-Research by Discipline page and find the Environmental Studies subject

page. On the guide, participants had to find a recommended database to perform the final task. The interface for each subject area involves a section for databases that are labeled 'Best Bet.' The reason for this task is to determine whether the description of databases was meaningful and could help participants narrow a search to a particular discipline or subject.

Participant A was not sure what 'Best Bet' meant but considered it "on the right track." However, he struggled to figure out where to click. The principal investigator assisted Participant A by reading the title of the page and then the Start Here section. He attempted to click on 'Start Here' assuming it was a button. The principal investigator then stepped in again to show that clicking on the title of the database allows the user to navigate to that database. Participant A described the second task as "hard" and found the links and descriptions made it unclear what actions were possible in the database.

Participant B originally missed the Environmental Science subject page on his first scan of the page. He then asked what browser he was on and used the Ctrl+F keyboard stroke to find the page. After skimming the page to find Start Here, he immediately said "I would think this is recommended since it said Start Here" and then called the first choice the most reliable. Participant B found the task to be very easy, but wished all the headings for subject guides were in one single list down the page stating that, "I do wish all those headings were down in one row so I wouldn't have to go back and forth across the screen."

Participant C navigated back to the library homepage to get to the E-Research by Discipline page and made the comment that he "usually opens in a new tab, but this time it opened in the same tab." He then found the Environmental Studies page by navigating

by headings. Once he reached the subject page, he was unsure what qualified the three databases to be 'Best Bet.'

> "They have the few at the top that are supposedly best bets, not that I know how they determine what goes there and in the alphabetic."

He also considered the headings organized by discipline are helpful but would not know how to find them unless he scrolled through the lists of databases, which would take a considerable amount of time. He rated the task as a 1 - very easy - only because he had scrolled through the Science section before the tasks and heard the screen reader say Environmental Studies. While Participants A and B chose the Agricultural & Environmental Science - a ProQuest database, the first result on the subject guide, Participant C chose the Environment Complete - an Ebsco database.

Task 3 : Search in Subject-Specific Database

In the final task, participants were asked to find articles in a subject-specific database from Environmental Studies that related to the original research question. Once Participant A reached the search results for "pesticides and honeybees," he was unsure whether the results were the same as the first search. He settled on the article - Biomonitoring with Honeybees of Heavy Metals and Pesticides in Nature Reserves of the Marche Region - the third result on the page. While Participant A saw the PDF download button on the top-right corner of the article detail page, he kept losing his cursor and struggling to recover its place on the page. After the task, Participant A found the search to be more challenging on this interface:

> "Once I was able to find stuff, it became a lot easier. I think they're there. I just wasn't seeing them. I guess it was just kinda hard. I didn't know where to click."

Participant B used the same search terms from his first search that he had copied and pasted from Google. Before selecting a result, he hovered over the first result title and explored some of the options for sharing the article. Participant B then began to compare the first and second search results and noticed the database tagged results based on their type of publication, such as trade journal or scholarly article. After hearing NVDA read the article, "Current knowledge of detoxifying… in honey bees", he paused for a moment and said "Okay, I've got it." On the PDF viewer of the article, the screen reader started reading article information on the page but not the actual article. He then asked, "The text is there so why would it not read it? What would be different about this one?"

Participant B tried to use the select all keystroke (ctrl+A) so he could copy and paste the article into another place to read it. The principal investigator then suggested downloading it. After some discussion, Participant B discovered that the PDF is in a frame in the browser so the screen reader is reading the article information that is outside of the frame. The article was not accessible within the frame so he downloaded the article and opened the PDF in Adobe Acrobat so the screen reader could read it aloud. After discovering the setup issue, Participant B considered the task a 2 - easy - but difficult because of the way the computer was set up. While the search results offered description of resource type, the use of a frame for the PDF involved some extra troubleshooting.

Participant C did not complete the task after finding no PDF versions of relevant articles in the database he chose. After entering "honey bees" and "impact of pesticides" in one search bar, no results were found in the database. He searched again by placing the search terms in separate search boxes to incorporate Boolean logic and added "Honey

Bees" to second search box. The search rendered no results. He commented, "Okay that's strange," cleared the search boxes, and placed "Honey bees" in the first search box and "impact of pesticides" in the second search box. This search yielded results but the first result was the same article he chose in the first task. Participant C navigated to the second result but found that it was 'Detail only available.' On the results page, he cited that the search "would be much easier to navigate if this were a table" rather than having to go link by link to find results. After finding another article that was 'Detail only available,' he asked, "Of course, why would they actually have the article?' At the 11th result on the page, Participant C realized he could tab through the article titles because they were headings. Once he reached the second page of results, he said,

> "I'm starting to think this is a bad database. If you weren't asking me to do it this way, I would go to one search and have it show only full text. Maybe this database can do that but I don't know."

One search, called Articles+ Catalog at UNC-Chapel Hill, is a combined search on the homepage that gathers resources from most of the library's subscriptions and catalog records. It uses the Summon and Endeca discovery services. Participant C stopped looking through the search results after reaching the 20th out of 35 possible results concluding that he would not have luck with finding full text versions given the previous results. The principal investigator mentioned that the database had a full-text option and shared the Find@UNC button that can be used to locate full-text versions of articles across UNC Libraries' available subscriptions. Participant C used the Find@UNC option, but UNC did not have the article available through that option. After going back to the search results, he selected *A Common Pesticide Decrease in Foraging Success in Honey Bees*, but could not find a PDF on the page, he asked, "Okay, why are you not in UNC holdings? I don't want abstract references and notes." The principal investigator

attempted to assist Participant C with finding the PDF option but only found a 'Download PowerPoint' option. Participant C tried navigating through the article's references for one minute, but then gave up and scrolled to the top of the page. After struggling to find a PDF of a relevant article, Participant C said the task did not work "not for accessibility reasons but because the one database I selected didn't have articles." He also commented that searching by individual databases adds more time to his search.

> "Okay do I want to waste the time looking for this? Instead you start with 'Does UNC have this somewhere?' and that's one of the big reasons I don't do the database by database thing."

Participant C was unsure of how to rank the task because he was unable to complete it. He said it was "maybe a 3" but said "If this was just me, I'd go back to the one search because you get stuff like this where the database is just citations - unless I see one article I need and can request it through [Interlibrary Loan]." However, he rarely requests articles through Interlibrary Loan because he finds that time-consuming as well.

System Usability Scale

Participants varied greatly in their self-reported experiences with the E-Research by Discipline page and corresponding resources. A system is considered to provide an above-average user experience if participants report a score higher than 68. On the System Usability Scale, Participant A reported 77.5, Participant B reported 95, and Participant C reported 55. The average score was 75.8, which was still higher than the baseline for an optimal user experience. These scores indicate broad variation in user experience, despite the test being focused on a specific population. Participants A and C, who are not experienced users of screen readers, reported a lower usability of the system compared to Participant B, a power user of search methods and NVDA. Compatibility

with a variety of assistive technologies can alleviate the challenges with navigation experienced by this population.

Users struggled with the language of the System Usability Scale. Participants B and C asked what the scale meant by “well-integrated” with the following item: “I found the various functions in the E-Research by Discipline page were well integrated.” The principal investigator explained that well-integrated meant the navigation between the E-Research by Discipline page and the library’s e-resources. In response, Participant B said “I think the tools are good for accomplishing the task that you set.” Participant C also commented that "I guess 3 and that's not having anything useful to say." For the statement, “I would imagine that most people would learn to use the E-Research by Discipline page,” Participant C shared his perspective on the navigation:

> “The E-Research by Discipline page itself is fine, the tricky thing is the databases with significant variations. Finding a database part is all very nice, then the issue is 'Now what?' that's not the E-Research by Discipline's fault, but whoever created the database."

Post-Test Interview

After the usability test, the principal investigator debriefed the tasks with participants and asked a series of questions related to their preferences and experience using the library website, E-Research by Discipline page, and databases. The traditional think-aloud protocol was adjusted so that the principal investigator’s questions did not interfere with the audio of participants’ assistive technology. Instead, the post-test interview asked more in-depth questions about information behavior and an opportunity to debrief the tasks. The interviews were transcribed and coded with a scheme; however, the codes did not seem to provide any more useful information than the responses themselves, especially because there were three participants. Additionally, the responses

pointed to actionable results that can be taken to improve the interfaces on the library website as well as database vendors. When asked about what they needed most from the library website, participants all cited spelling correction and the incorporation of PDF buttons for downloading articles instead of providing links to the PDF. Participants also found that the E-Research by Discipline page was well organized and easy to navigate. Participant A stated:

> ""Honestly it's one of the better pages I've seen on a website, it's pretty easy to get around. The titles help me, it's like reading a menu, I struggle with reading menus but this is easy to read. Alphabetical order is good too. And then of course the search bar, that's really helpful. Oh, and the frequently used is really good, I don't have to search for something I'm not going to use a lot, that's probably my favorite part now that I think about it."

Participant B also appreciated "how disciplines are organized into headings and subheadings so you have a good sense of whether it will be in the row you're looking at" and considered the Frequently Used section useful. Prior to testing, a screen reader would have had to read through the entire list of disciplines and subdisciplines to find this section. One critique of the Frequently Used page was that there was no information provided to distinguish one popular database from the other, which Participant B found limiting:

> "I was surprised that there wasn't a short description of what some of the main things do. If I'm just getting started, I might not know the difference between some of the different general databases that are in that frequently used ones. It might be better to have a short description there instead of having to click through and click back if I wanted to look at what those things are."

Offering description through hover text or a structured menu could provide more explanation of what databases offer and reduce the learning curve of using databases for first-time users. However, hover text can also get cut off when screen magnification is

turned on, which creates a tradeoff between improving the experience and accommodating a critical form of assistive technology.

While participants appreciated the E-Research by Discipline page's structure, the navigation between the library website and databases left more to be desired. Participants found the pages required to find and download an article frustrating, particularly when the databases yielded few relevant results. It was challenging for Participant A to determine when he was clicking into an article and stated that "When I click, I'm not really sure what I'm looking at." Participant C commented on this experience,

> "The page itself was fine. It's annoying to have a database that consists mostly of things that aren't even articles. I'm honestly not sure what the point of that is. I know that a lot of the databases are like that where they just have citations. I mean I guess if that's all you had in the library, you could look at the abstracts and find them. If the library actually has the full text, then that's just a waste of time."

Participant A also cited that he tries to limit his clicking as much as possible so navigating databases provides the additional challenge of determining where to click in the first place. He often tries to limit his search to the first page of results but would prefer if the databases offered larger buttons for the next page of results.

> "I mean I go through whatever is easiest to read. I'll go through the pages if I have to. That's another thing. Finding the page numbers. The page numbers are hard to see and clicking the next page button but I do it."

The navigation of the pages could be improved with clear indications of what actions are possible. Users need to know where to find the next page of search results, how to download the article, and whether the database even has the article in the first place. These basic actions are not clear when databases use links to differentiate between content and do not offer hover states to signal where actions are possible on the page.

Earlier in the test, Participant B said that he appreciated the single-search on the library homepage because it made the action clear. However, the subject-specific database, Agricultural & Environmental Science Database, had a single search bar that surprised him. Participant B stated,

> "I was a little bit surprised that it didn't have the additional fields and you know the Boolean search stuff all out there. It was just the single search bar that I saw. I'm sure there were advanced query options. I'm not sure which one I liked better. I think it can be a pain when these things are hidden."

He then went on to describe that this trend was common in other websites he has seen.

> "I'm not a fan of this make everything look as clean as possible and bury all of the features away. It's a lot more clicking and confusing to try to figure out where the heck they put it but I understand it's a tradeoff. The more crap you have on the screen all at once, the harder it is to figure out what you're supposed to do. I think both had a reasonable balance it wasn't excessive in either direction."

On the surface, single-search bars on databases and hiding the option for advanced features mirrors the interface of search engines like Google. However, databases do not function like search engines. They depend on more clearly defined information needs and structured combinations of keywords or controlled language. Therefore, this seemingly simplified interface change can pose more problems for users who have low vision, especially when they are familiar with multiple fields for searching.

When asked about whether they would use the E-Research by Discipline page again, Participants A and B stated they would. Participant B found it useful for subject-specific research: "Especially if I need to search for something more academic and narrow. It might not be my first stop but it might be my second step." In contrast, Participant C found that it would only be helpful for discovering articles. In his own discipline, he said he planned to check the list of resources again to see if there was anything useful. He had enough content knowledge to know which databases were useful

to him and considered researching articles in a completely different discipline uncommon for his field. He offered a scenario of being asked to conduct interdisciplinary research: "Unless there's a situation where it's like 'you need to study this new field now!,' I don't think so." The E-Research by Discipline page provides access to all of UNC Libraries' databases and guides users into new disciplines with contextual description. While it provides this access, users are left to navigate the actual databases on their own with no means of returning to the library website without the back button.

Discussion

Before the principal investigator tested the page with participants, changes were made to ensure it complied with WCAG guidelines and removed resources that were not necessary to the page's purpose. These improvements indicated that that there is no substitute for good HTML design. The hierarchy of headings from <h1> to <h2> to <h3> created structure, so that screen readers can jump to disciplines and the frequently used section quickly. Without these headings, a screen reader would read the Frequently Used column last after reading all the disciplines and subdisciplines, making it a less than ideal resource. Structuring the columns of disciplines with <section> tags also made the page semantically meaningful for the assistive technology used by our participants. The <section> tag is not a generic container element like a . Rather, the screen reader announces "Region" when it reads a <section> tag, which allows users to distinguish between sections of the page. This affordance aligns with the existing method of "anchoring" that users from this population exhibit. Removing the tab-index also made the page keyboard accessible, which was critical for Participant B - an experienced screen reader user. Identifying and resolving these issues demonstrated how HTML5 elements allow anyone who publishes information online to make their content usable and accessible. Testing with users also challenged us to identify improvements beyond this baseline.

Another factor in the test was how different interfaces communicate what actions are possible to take. While most of resources relied on a combination of links, these links

did not always provide a hover state that could signal to a user with low vision that they could click on the link. The most common pain points appeared when users had to determine what resources the subject page recommended, how to access an article, and whether the PDF of the article was available. In all three situations, links with no hover states made these actions unclear.

Buttons and links with hover states are simple affordances that require no extraneous skill development and could be carried out across any database. Forcing users who are visually impaired to guess whether an action is possible adds to the existing time barrier they face online. All three participants cited that the current aesthetics of web design that emphasize visually engaging imagery, flat buttons, and hide a website's functionality behind layers of navigation that make interactions less obvious. This trend could also be attributed to the increase in content management systems.

The UNC Libraries website is made through WordPress and LibGuides - two popular content management systems. While this arrangement has made it easy for library staff to create content without knowledge of HTML or CSS, the UNC Libraries User Experience and Assessment department has trained content creators to add headings, alternative text, and other HTML features to comply with accessibility guidelines. The Content Strategy Librarian has also led projects to internally make changes to many areas of the website. HTML5 elements like headings, semantic labels, and alternate text are essential guideposts for assistive technology users. In making content creation possible without an extensive knowledge of web development, academic library websites have been able to create content without accessibility in mind in the past. Content management systems save time and effort; however, a working knowledge of HTML5 and WCAG guidelines

should be an expectation for anyone tasked with content creation. In the long run, this knowledge saves libraries the time and effort of having to deal with potential legal ramifications or complaints.

While the test attempted to capture a common search strategy, interactions with participants proved that they preferred known-item searching. It revealed how usability tests are meant to be an artifice for information behavior. They cannot fully indicate how users will behave on their own terms. Participant B customized his keystrokes for his screen reader at home so he had to not only navigate the website but also determine the default keyboard setup for NVDA. Participant C used his own device altogether because he was not confident in using a different computer and screen reader set up. As much as the principal investigator could prepare through the survey and email correspondence with participants, conducting a usability test can indicate gaps between what is expected of users and their actual behaviors.

However, testing gave the principal investigator the opportunity to gather qualitative description and see where participants struggled to navigate between resources. Within this specialized population, it is difficult to generalize their experiences. While Petrie et al. (2006) justified that remote testing with users who are visually impaired could evaluate performance, they also argued that in-person testing invites more opportunities for qualitative description. This finding proved to be true for this test. The tasks were an entry point to broader challenges with accessible website navigation and search interfaces. Spelling support not only helps users on search engines, but could also dramatically improve the setbacks of failed searches on databases. Buttons not only assist users with purchasing items online, but could also help users know exactly

where to download PDFs on a database. Making interfaces accessible also depends on providing consistency across websites and third party vendors. Having three different visual representations for downloading materials adds even more of a burden to users who are expected to conform to online interfaces that were not made with their needs in mind. When the tasks did not map onto participants' lived experiences, asking probing questions, investigating their contexts of use, and adapting to their needs offered more accurate insights.

Users from this population take a metacognitive approach when searching because they are making choices, creating workarounds, and using assistive technology to perform the search altogether. Recruiting these participants into any usability test allows their perspective to be incorporated into design and navigation. In this test, participants passionately shared their experiences and made connections to past experiences with library websites. Personal connections do not hinder usability testing. Even when the tasks felt artificial, they brought up actual needs and past use cases during the test. An interface change was made with a major e-book vendor because of this phenomenon. It is also important to note that this passion can dissipate if the same participants from specialized populations are called into usability testing again and again.

Based on the literature, academic libraries often default to discount usability methods and allow users to self-select for their participation. Reaching out beyond the users who already visit the library on a regular basis allowed the principal investigator to see where there is room to improve. Instead of assuming that all users interact with our content in the same way, in-person testing allowed us to see how our services could better fit the participants' information needs and be more inviting to their existing search behavior.

Testing with users with disabilities not only highlighted pain points that were common with sighted users but also identified specific challenges that could improve the experiences with finding scholarly research. Remediating inaccessible PDFs requires far more knowledge and time than redesigning web content to be accessible. Therefore, libraries can and should make improvements to their PDF workflows and urge third party vendors to do the same. PDFs may be the standard for document delivery but inaccessible ones should not be the norm. Even though Participant B has completed advanced Google search trainings and customized his screen reader, an inaccessible PDF presented a barrier for him that took time to identify and work around. When presented with this barrier, it was particularly interesting to see that he blamed himself instead of the database. Testing with a variety of users with disabilities detects challenges that are impossible to uncover otherwise. Additionally, these test results can facilitate changes that support other populations like senior citizens, whose vision and hearing can change as they age. Understanding these experiences allows libraries to go beyond a baseline and ensure their online services are convenient and pleasurable for everyone to use.

Limitations of the Study

Conducting a usability study can offer rich description and pinpoint challenges with an interface. However, this method had its drawbacks. Users could self-select and only participate if they are available. Also, there may be a variety of experiences with the website. For example, some users may be experts at navigating the website and have done so for many years. Others may be brand-new to using it and struggle to understand the interface. Doing a usability study of an existing interface may not give as much detail about its usability but rather, offer description of users' information behaviors. In this case, users may cling to what they do know about the site, rather than attempting to try out an unfamiliar task.

Another factor that may have biased the data was that recruitment for the study depended on users having a visual impairment, which means the study's participants were not chosen randomly. However, the UNC Libraries website had not been tested in this way for accessibility. This decision was made to focus on an exploratory approach to usability testing (Sahib et al., 2016). Finding interested participants in a specialized population proved to be more challenging than the principal investigator originally thought. Even though campus partners, like the Office of Accessibility Resources and Services, were happy to distribute the survey to their existing channels of contacts, people from specialized populations often get asked to participate in testing on a college campus. Therefore, it is important to consider whether you are asking too much

of the same few participants and whether these findings demonstrate actionable changes to the interface.

In the questionnaire, it became clear that there were broad and varying definitions of what constituted a visual impairment. Future testing needs to clarify that users' impairments affect how they use computers and mobile devices. When users rely on assistive technology to find information everyday, it changes their relationship to the interfaces they interact with. In many cases, this information is not only fulfilling a need but allows them to complete tasks that able-bodied users might take for granted.

Even within the testing environment, participants demonstrated differing levels of need and experience with assistive technology. These factors biased the data because we allowed participants to use assistive technology that they knew and were comfortable with outside of testing. It made more sense to adjust the testing environment in the moment than expect everyone to use a screen reader. Therefore, it is important to allow for flexibility and accommodate participants than expect them to conform to inaccessible technology.

Testing on a university campus also highlighted the challenge of creating tasks that mirrored common information behaviors. All our participants had differing levels of experience with research. What constitutes research looks different depending on the discipline or field of study. Depending on participants' affiliation within the university, they may have more specialized knowledge of a subject area that does not require as much keyword-based searching in databases. Input from various disciplines and affiliations invited more context for different use cases, but also made it challenging to

generalize that all participants could or should interact with the library website in the same way.

Conclusion

The purposes of this study were to evaluate the usability of the E-Research by Discipline page for users who are visually impaired and whether the page's navigation to databases impacted their completion of search tasks. This study discovered the participants preferred the heading structure of the page and the alphabetical arrangement of subfields, comparing it to reading a menu. Participants liked how the page organized the Frequently Used databases, which gave them the opportunity to choose their own path and circumvent this longer list of subjects as needed. On the databases, participants found the experience was usable except for the unclear links and inaccessible PDFs. Within a group of three participants, there were cases in which participants varied in their completion of tasks.

Some changes can be made to include links with clear hover states and improvements to the design of the Best Bets section on subject pages. Participants generally liked the E-Research by Discipline page, but met barriers with finding articles in databases because there were differing levels of navigation and inclusion of links or buttons for PDF download. These challenges pointed to further conversations between academic libraries and their third-party vendors. Most subscriptions involve a VPAT, or Voluntary Product Accessibility Template, where vendors document how they conform to accessibility guidelines. However, these documents can and should be dynamic agreements between vendors and libraries that aim to improve accessibility. The process of making something accessible never fully ends. As library websites incorporate more

services and functionality, accessibility must go hand and hand with these additions and the interface design.

Further testing with this population could involve how well the library supports known-item searching for this population based on behaviors identified in post-test interview. Recruiting users with disabilities beyond this population could also identify more hard-to-detect barriers that benefit all users' experience on the library website and with subscribed resources. Usability in academic libraries does not begin and end with the website. Instead, the navigation between vendor provided resources and the library website needs to be evaluated and improved with feedback from users. Additionally, users with disabilities bring an enthusiasm to usability testing, giving them the potential to identify changes that not only serve their needs, but also improve all users' experience with the library website. Their passion for improving search interfaces and unique needs make them a critical voice in usability, particularly as libraries migrate more of their services online.

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Appendix A: Questionnaire

The purpose of this research is to record the experiences of students, faculty, and staff who are blind or have low vision with navigating library resources online. This survey will gather broader background information on online, research habits.

Due to the use of survey logic, question numbers may not follow sequentially as you proceed through the survey.

For the first four questions, please rate your experience with doing research online on the UNC Libraries website or elsewhere.

1. I am confident that I can research a topic online.
    a. Strongly Agree
    b. Agree
    c. Neutral
    d. Disagree
    e. Strongly Disagree
2. I am confident that I can search for articles in a database.
    a. Strongly Agree
    b. Agree
    c. Neutral
    d. Disagree
    e. Strongly Disagree
3. I am confident that I can find a PDF of a research article.
    a. Strongly Agree
    b. Agree
    c. Neutral
    d. Disagree
    e. Strongly Disagree
4. I am confident that I can download a PDF of a research article.
    a. Strongly Agree
    b. Agree
    c. Neutral
    d. Disagree
    e. Strongly Disagree
5. I am confident that I can read a PDF of a research article.
    a. Strongly Agree
    b. Agree
    c. Neutral
    d. Disagre

    e. Strongly Disagree
6. What is the first place you go to begin researching?
    a. Google
    b. Wikipedia
    c. Articles+
    d. E-Research by Discipline
    e. Other (please explain)
7. What is your preferred interface for searching for information online?
    a. Search bar
    b. Drop-down options for keywords, titles and authors
    c. Other (please explain)
8. Have you attended a library instruction session during your time at UNC?
    a. Yes
    b. No
    c. I'm not sure
9. Have you used the UNC Libraries website to find a research article?
    a. Yes
    b. No
    c. I'm not sure
10. Have you downloaded a PDF of a research article from the UNC Libraries website?
    a. Yes
    b. No
11. Approximately, how many times in the last month have you used the library's website to find research articles?
    a. 0-1
    b. 2-4
    c. 5-6
    d. 7-9
    e. 10 or more
12. Have you used the E-Research by Discipline page on the library website to find research articles?
    a. Yes
    b. No
    c. I'm not sure
13. Approximately, how many times in the last month have you used the E-Research by Discipline page to find research articles?
    a. 0-1
    b. 2-4
    c. 5-6
    d. 7-9
    e. 10 or more
14. What best describes your affiliation with UNC?
    a. Undergraduate student
    b. Graduate student

   c. Faculty Member
   d. Adjunct Faculty
   e. Hospital Staff Member
   f. Post-doc
   g. Retiree
   h. Staff
   i. Not affiliated with University
   j. Other

15. Are you a UNC Libraries employee?
   a. Yes
   b. No
16. What is your major or intended major? You may list more than one.

17. What is your department/unit affiliation?

18. Have you been diagnosed with a visual impairment?
   a. Yes
   b. No

19. Please describe the nature of your visual impairment(s).

20. Do you currently use any form of technology to read information on a computer? Please check all that apply.

   a. Virtual Assistant (Cortana)
   b. VoiceOver for Mac
   c. Screen Magnification
   d. Screen Reader
   e. PDF conversion
   f. Other (please describe)

21. Do you currently use any form of technology to read information on a smartphone? Please check all that apply.
   a. Virtual Assistant (Siri or Alexa)
   b. VoiceOver for iOS
   c. Mobile App
   d. Screen Magnification
   e. Braille Display
   f. Barcode Reader
   g. Other (please describe)

22. Is there a time that you wanted to use a website that wasn't accessible?
   a. Yes (please describe)
   b. No

23. Would you be willing to participate in a follow-up study of the library website?

a. Yes
b. No

24. You will be randomly selected to participate in a usability test of the library's E-Research by Discipline page. This would make you eligible for a $20 Amazon gift card for your time. The one requirement is that you must be available for testing between January 15th and February 22nd. Participation in this study is completely voluntary and all data will remain confidential. Are you available to visit UNC-Chapel Hill's campus for one hour between January 15th and February 22nd?
    a. Yes
    b. No

25. Please provide your name and contact information.

Appendix B: Usability Test Observation Guide

During testing session:

1. Start the audio recording
2. Record partial or full task completion
3. Record the actions of the participant (sighs, fists raised in triumph, etc.)
4. Take notes on any memorable phrases or insights offered by the participant after each task
5. Record any problems the participant encounters with navigating the interface (errors or other unexpected behaviors)
6. Recorded participant's responses to any scripted or unscripted questions asked by the moderator
7. Record answers to the ASQ questions asked between tasks
8. Record any time the moderator gives help to the participant or answers a question about the system

Pre-test Questions

1. Do you have any questions before we begin?

Take a minute to explore and then I'll ask your initial thoughts.

I'd like you to use the screen reader to read sections of this page aloud. Then, tell me what you think it is, what stands out to you, and what would you use or click first. You don't need to click on anything in particular, just tell me what you would click.

2. What are your initial thoughts on the E-Research by Discipline page?

3. Do you have any questions before we begin?

Task A: Find article on honey bees/pesticides in Academic Search Premier and download PDF of article

You have a research project and need to find a highly-cited article about the impact of pesticides on honey bees. You choose to search in the Academic Search Premier database to start your search. How would you search for that from the E-Research by Discipline page?

Please let me know what you've found by saying "I've found an article" and reading the title of the article.

- Task completion: full/partial

General notes include:
- Participant actions (sighs, fists raised in triumph, etc.):
- Memorable phrases/insights after each task
- Problems participant encounters (errors or other unexpected behaviors)
- Did moderator help participant or answer questions about system?

Post-Task Questions
What are your general thoughts on this task?
On a scale of 1 to 5 (1 being very easy and 5 being very difficult), rank the task.

Task B: Best Bet database in Environmental Studies

- Task completion: full/partial

General notes include:
- Participant actions (sighs, fists raised in triumph, etc.):
- Memorable phrases/insights after each task
- Problems participant encounters (errors or other unexpected behaviors)
- Did moderator help participant or answer questions about system?

Post-Task Questions
What are your general thoughts on this task?
On a scale of 1 to 5 (1 being very easy and 5 being very difficult), rank the task.

Task C: Find article on honey bees/pesticides in the Environmental Studies Database and download PDF of article

Now that you've found an article, you want to find more articles about honey bees. Now that you've found one article, you're interested in searching for articles in a subject-specific database that you found on the Environmental Studies page. How would you find a Best Bet database on that page?

Please let me know what you've found by saying I've found a Best Bet Database and reading the title of the database.

- Task completion: full/partial

General notes include:
- Participant actions (sighs, fists raised in triumph, etc.):
- Memorable phrases/insights after each task

- Problems participant encounters (errors or other unexpected behaviors)
- Did moderator help participant or answer questions about system?

Post-Task Questions

What are your general thoughts on this task?

On a scale of 1 to 5 (1 being very easy and 5 being very difficult), rank the task.

Appendix C: Post-Test Questionnaire and Interview Questions

System Usability Scale

Please circle the number that best matches your thoughts on the following statement.

	STRONGLY DISAGREE				STRONGLY AGREE
1. I think that I would like to use the E-Research by Discipline page frequently	1	2	3	4	5
2. I found the E-Research by Discipline page unnecessarily complex	1	2	3	4	5
3. I thought the E-Research by Discipline page was easy to use	1	2	3	4	5
4. I think that I would need the support of a technical person to be able to use the E-Research by Discipline page	1	2	3	4	5
5. I found the various functions in the E-Research by Discipline page were well integrated	1	2	3	4	5
6. I thought there was too much inconsistency in the E-Research by Discipline page	1	2	3	4	5
7. I would imagine that most people would learn to use the E-Research by Discipline page very quickly	1	2	3	4	5
8. I found the E-Research by Discipline page very cumbersome to use	1	2	3	4	5
9. I felt very confident using the E-Research by Discipline page	1	2	3	4	5

10. I needed to learn a lot of things before I could get going with the E-Research by Discipline page	1	2	3	4	5

Interview Questions

1. In your own research, what do you use most often on the UNC library website?
2. What's most important to you in using the UNC library website?
3. What would you change about the layout of the E-Research by Discipline page to better help you complete searches?
4. What do you like about the E-Research by Discipline page?
5. What do you find frustrating about the E-Research by Discipline page?
6. On the library website, what surprised you about it?
7. On Academic Search Premier, what surprised you about it?
8. On the Environmental Studies Database, what surprised you about it?
9. Would you ever use the E-Research by Discipline page again? Would you ever search for articles in a database again?
10. Would you make any changes to the E-Research by Discipline page? If so, what would you change?