2018

# Applying Inclusive Principles in Web Design to Enhance Accessibility for Disabled Users

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CHAPTER 24

# Applying Inclusive Principles in Web Design to Enhance Accessibility for Disabled Users

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## Section 1: Overview

This chapter presents how librarians can better apply the core values of our profession to the use of technology in digital and web services in order to promote broad public access to library services. If broad public access is understood to mean effective and meaningful access for everyone in the community a library serves, we believe it must be achieved through an inclusive approach that recognizes the full diversity of individuals in that community and embraces the argument that information is a fundamental human right necessary for equal opportunity and full participation in society.

Our approach to inclusive employment of technology addresses not only technological competencies but also diversity and cultural competencies. Both are defined as American Library Association (ALA) core competencies in the ALA Policy Manual;[1] the latter is addressed in section B.3. Diversity, and the former in B.4.6. Electronic Environment. In the following, we will describe those competencies most closely related to digital and web services.

ALA Policy Manual Section B.3 identifies Diversity as a foundational principle and an important professional value that ensures equal access to information for all members of society. It states that

> The American Library Association (ALA) promotes equal access to information for all persons and recognizes the ongoing need to increase awareness of and responsiveness to the diversity of the communities we serve. ALA recognizes the critical need for access to library and information resources, services, and technologies by all people.[2]

Diversity is recognized as an essential requirement for cultural competency: B.3.5 Goals for Inclusive and Culturally Competent Library and Information Services defines "Cultural competence [as] critical to the equitable provision of library and information services."[3] The following two statements under the section should particularly apply to web services:

> Care must be taken to acquire and provide materials that meet the educational, informational, and recreational needs of diverse communities.
>
> Efforts to identify and eliminate cultural, economic, literacy-related, linguistic, physical, technological, or perceptional barriers

> that limit access to library and information resources must be prioritized and ongoing.[4]

Professional devotion to diversity and equal access is also reflected in a number of major American Library Association documents, including the Library Bill of Rights, which declares that the library serves "all members of the community,"[5] and the Intellectual Freedom Statement, "Libraries, an American Value."[6] Equal access has also been emphasized as one of the foundational principles of intellectual freedom and a strong democracy.[7]

Now that digital formats are the de facto standard for information exchange, equitable access to websites is a prerequisite for inclusion, with library websites serving as an important access point to online resources for those who are disadvantaged in terms of information. The ALA Policy Manual, Section B.4. Equity and Access, states that the equity principle continues in the Electronic Environment (B.4.6), and directs libraries to go beyond the goal of equal access by pursuing equity in digital and web services.[8] With that goal in mind, the ALA Policy Manual Section B.4.6.2 recommends that "[d]igital content must be provided in various and alternative ways to meet the unique needs and circumstances of all people" and that "equitable access to digital library materials is ensured through maximum accessibility, ubiquity, sustainability, and barrier-free access."[9]

## Technology and equitable services

Technology has the potential to promote equal access to library resources by bringing library services to a greater number of people in a wider variety of formats. The inherent flexibility of digital materials can support individualization if it is leveraged to give users access to a wider choice of formats so they can seek out those that best meet their needs. The current trend toward modularization of website contents may also make digital resources accessible for certain groups who experience barriers, such as screen reader users or people with certain cognitive disabilities.

Technology's success in ensuring equal access, however, depends on it being truly usable. If some groups of users are systematically excluded from using a resource because the technology is not usable for them, then the technology is actually a hindrance to accessibility. For example, some website designs still use exclusive combinations of mechanisms that favor a sighted and hearing user who has full upper body use. A common example would be a site that hosts captionless videos, employs menus that are difficult to access without a touch screen or mouse, and responds to form entry errors with pop-up messaging (which can be tricky

for screen readers to detect). Obviously, limiting a site's functionality with this combination of mechanisms makes navigation and interaction difficult, if not impossible, for those not fitting the description above.

Social exclusion is another negative outcome caused by a relatively poor user experience for disabled users. Many social media and collaborative tools, for example, reward quick response times, effectively excluding users with disabilities who have a systematically poor user experience, regardless of whether the platform is technically accessible. It is crucial for libraries to ensure that the technology used to provide library resources neither limits access to information nor contributes to social isolation.

A potential source of difficulty in implementing inclusive online environments in large organizations such as libraries is that the growing complexity of technology increasingly results in components being assembled from pre-written packages, such as code libraries or commercial software. While this can be an advantage for developers, it poses a challenge to equitable access if the component software is not fully accessible and usable for disabled users. In many cases, library websites are partly or completely sourced by commercial vendors of catalog and database software, and the amount of control that librarians have over website features may vary a great deal. To promote meaningful accessibility, it is critical that the needs of diverse users are prioritized in the vetting process for new software, in discussions with vendors, and in the selection of code components for technology projects.

## Section 2: Web Accessibility

We will focus specifically on library website accessibility and barrier-free access and how they can be achieved through the use of inclusive design principles, with special attention given to disabled user groups. We interpret web accessibility barriers to be the absence of inclusive principles in a website's design, and we address accessibility as a diversity issue. Applying inclusiveness principles to the design of technology services enhances libraries' ability to make digital information resources accessible and available to all individuals.

### Technical standards—important, but only one aspect of accessibility

In general, accessible web design seeks to meet the needs of people with disabilities coming from diverse backgrounds and possessing a wide range of abilities. The WAI (Web Accessibility Initiative) of the World Wide Web Consortium (W3C) is the leading organization establishing standards and requirements for accessible

web development, including the Web Content Accessibility Guidelines (WCAG). Many resources provide recommendations and best practices for accessible web design using WCAG as a basis.[10]

The first iteration of WCAG in 1999 centered on specific code-level directives intended to ensure technical accessibility and interoperability with websites and adaptive technologies;[11] however, the rapid rate of change in these technologies made it difficult to keep the standard up to date. A good example is the guideline stating that all content must be accessible via keyboard, which is not clearly applicable to mobile devices with virtual keyboards or no keyboard at all.[12] In response to this problem, version 2.0 (2008) represented an effort to make the guidelines more outcome-based and less technology-dependent.[13] Though the WCAG 2.0 is broad in scope and can potentially result in a comprehensive analysis of a site's accessibility, this lack of specificity results in ambiguity for developers using them as a baseline to create accessible websites.[14]

The WCAG working group has announced plans that WCAG 3.0 may be released within a few years and is "expected to be a more substantial restructuring of web accessibility guidance."[15] In the meantime, updates like WCAG 2.1 (a working draft at the time of this writing) indicate that the guidelines for accessibility need to be revised frequently to keep up with the rapid pace of changing technology.

The challenge in using WCAG 2.0 to design websites lies in the lack of recommendations for applying the standards and the absence of frameworks for integrating them at various stages of website planning and development. Perhaps because of this, a frequent approach to web accessibility is to have developers "adjust the code" to comply with the technical aspects of the guidelines as best as possible after a site has been designed. This typically results in a product that is technically accessible but not usable for people with disabilities because their actual needs have not been considered in the design of the site.[16] As of yet, however, there are no comprehensive guidelines designed to assist web developers to approach website accessibility holistically as a design problem, rather than as a technical compliance issue.

## Accessibility testing tools

The W3C defines web accessibility evaluation tools as "software programs or online services that help determine if a website meets accessibility guidelines."[17] These tools conveniently allow web developers to evaluate the conformity of a website to accessibility guidelines with minimal effort; however, such tools cannot verify the accessibility of websites or guarantee their true functionality for disabled users.[18] Research has shown that over half of the accessibility problems

encountered by disabled web users during a usability test were not addressed by either WCAG 1.0 or 2.0 in an audit by automated testing tools. In addition, there was little to no correspondence between the priority levels of the WCAG criteria and the actual severity of problems faced by real web users with disabilities.[19] The results indicate that automatic evaluation tools may detect fewer than half of the barriers that real users with disabilities most likely face, and that compliance with the highest-priority WCAG criteria does not guarantee that even the most severe accessibility problems will be eliminated. This is further evidence that compliance with technical accessibility guidelines does not guarantee meaningful information access for people with disabilities.

## Usability, beyond accessibility, and universal design

Universal design is a principle that prioritizes equality by "designing all products… to be usable by all people to the greatest extent possible."[20] In the context of websites, universal design aims to provide a barrier-free environment that allows all users to navigate and access information by means of a user-centered information architecture. Information architecture is a design process and outcome resulting in the structural design of an information space that facilitates the usability and "findability" (retrievability) of information.[21] By providing the proper combination of organization, labeling, searching, and navigation schemes, information architecture enables designers to create an information space that adheres to the principles of universal design.

Universal design should not be confused with a "one-size-fits-all" approach. When an interface is designed to meet the needs of a specific user group, it may limit accessibility for other users. For example, integrating images and graphics as a text supplement is a common priority when designing websites to meet the needs of people with certain cognitive and learning disabilities,[22] but an ideal website for users with visual impairments prioritizes text-based and audio information over visual content. Following the idea of "flexibility of approach, delivery, and application" that allows universal design to be accessible to diverse audiences,[23] information architecture must emphasize the varying abilities and constraints of individuals in a diverse user population, rather than seek a uniform solution that prioritizes some users at the expense of others.[24] To this end, we have developed a concept for an inclusive information architecture that employs multiple layers of interfaces to meet the unique needs of different user groups through alternative information architectures, while at the same time allowing all users to access the same underlying website, services, and content (See Section 4).

## Section 3: Case Study with visually impaired people–accessibility of Library Websites

### Description of the study and the findings[25]

As a test case for identifying an underserved group's needs in order to extend information access based on the principles of inclusion, we investigated the accessibility of three library websites, one public and two academic, for persons with visual impairments. We use this investigation as an illustration of one possible approach to identifying unaddressed diversity issues of an information-disadvantaged population that contribute to inaccessible library websites,[26] and for developing a possible remedy that incorporates inclusive principles into information architecture design,[27] which is specifically illustrated in Section 4 as applied for visually impaired users.

### Library website use for people with visual impairments

Visually-impaired patrons using assistive technologies encounter many challenges in accessing library websites and digital library materials such as e-books, audio books, databases, and digitized collections. In fact, visual impairment is the most challenging barrier among various physical disabilities to accessing and interacting with digital materials, and a significant portion of library digital collections are not readable with a screen reader. The primary cause is the lack of a transcript or otherwise digitally readable text associated with digitized materials.[28] Such findings suggest that a policy mandate may be needed to make library accessibility a higher priority.

In the test case study, a usability-accessibility test was conducted with six blind participants who were asked to navigate three different library websites and two non-library websites,[29] while the researchers observed their navigation patterns through thinkaloud protocols. Participants used their own laptops and screen readers. Their level of experience with screen reader technology ranged between fifteen and thirty-three years.

### Findings: 1. Overview of accessibility and web use

Our test results were consistent with other studies' findings that most library websites are not truly accessible.[30] In fact, even with frequent intervention by the researchers, no single participant was able to complete all of the library website tasks successfully. Normally, usability criteria ask the question of how easily participants

are able to complete a task or how many tasks are completed easily. Yet our study revealed that visually impaired users are not able to navigate or explore typical library websites independently. The question for our study therefore became how many tasks the participants were able to complete with some intervention. A task scenario that required finding an item from a library catalog was completed by only one participant without intervention, taking seven minutes. Another task that required finding a subject resource was completed only once without intervention, taking five minutes. Finally, a task that involved signing up for a workshop was extremely difficult for all but two participants. Overall, the library websites were more difficult for participants to navigate than the non-library websites, even with assistance. For example, even with effort, very few participants had success finding the library catalog search interface on their own.

### *Strategies used for web browsing*

The observations from the study suggested that screen reader users have multiple strategies for making sense of a new site. Two general patterns of exploration were observed among the participants. A pattern seen more frequently in the older participants involved exploring hierarchical headings to get a sense of content structure when exploring a new page. The other strategy, seen more commonly in the younger participants, relied on links lists (a list of page links summarized by the screen reader) to obtain a broad overview of the content. One possible explanation is that the older users had acclimated to screen readers in a predominantly textual environment, before the emergence of the web, while the younger users would have had their first exposure within an environment of hyperlinks and non-textual content. Another possibility is that the older screen reader users have, over time and through trial and error, developed more systematic strategies for approaching websites.

A second observation was that regardless of age or preferred screen reader brand, all participants regularly sought specific information through the use of word prediction. The browsing methods of all six test participants frequently involved some sort of word search, either in the links list or the full text of a page, using the screen readers' word find feature to look for an occurrence of some desired word that the user expected to find on the page. They all used one or both of the word prediction strategies regularly while completing the tasks.

These observations cannot be generalized to the larger population of screen reader users without further research using a larger number of participants. However, considering that many of the barriers uncovered in the study were caused by websites poorly suited to screen-reader-specific browsing strategies (see below section, "Findings 2: Specific barriers"), it would seem that designers of library

websites need to better accommodate search and browse techniques specific to this user group in their websites if they are to be truly accessible.

### *Use of library websites*

Our interviews with participants revealed that they did not use library websites frequently compared to other types of websites, despite their desire and need to access and use information on the web, which was consistent with other study findings.[31] Most participants used the internet regularly for purposes such as email communication, social networking on sites such as Facebook and Twitter, shopping, job searches, music, and reading. Many also indicated that they preferred to use familiar sites when possible to avoid the frustration of learning how to get around on a new site.

Most of the study participants did not seem particularly comfortable exploring library websites, although the participants who are current students did demonstrate some familiarity with the typical features of an academic library website. None of the participants listed any libraries among the sites they use on a regular basis.

While this does not mean there is a difference in their library use relative to the general population, it does suggest that there is room for improvement when it comes to outreach to this population. Groups who face disproportionate barriers to information also benefit disproportionately from library services, and reaching them is crucial if libraries are to fulfill their mission to support equitable access to information.

## Findings: 2. Specific barriers

### *2.1. Difficulty of using the catalog*

Overall, the library websites tested in the study were extremely difficult for participants to navigate and use without assistance. Without an adequate understanding of the library site structures or without a sense of the value of library resources to them, many participants expressed that they would not have the motivation to commit on their own to the steep learning curve they typically expect as screen reader users on unfamiliar websites. This poses considerable inequity in meeting the needs of this particular user group and calls for attention to the conceptual implications of the problem for the broader library and information science field.

Without high-level accessibility, i.e. usability, users may be discouraged from using unfamiliar or complex websites that they might otherwise find useful. This is

especially true for library sites, whose complexity and tendency to include a high volume of information on each page is difficult for screen reader users to manage due to the linear transmission of text into audio format, which limits the user's ability to easily skim or browse. Special high-level considerations, including information architecture design, are critical if a website is to facilitate browsing or skimming by non-visual users. However, the typical approach to web accessibility, which relies on technical accessibility guidelines and online evaluation tools, is unable to address high-level design considerations such as information architecture.

## Locating catalog

All six participants in the study encountered moderate to severe obstacles when it came to access and use of the library catalog. In fact, simply finding the catalog on a library website was surprisingly difficult for the test participants and resulted in non-completion of a number of tasks. This problem was primarily the result of the navigation issues discussed in a later section.

Library sites often provide multiple entry points for searching items; for example, "databases," "journals," "nonfiction," and "new collections." This is not inherently bad design, but it may confuse screen reader users because they do not have the benefit of visual cues and are more attuned to semantics. Simply finding a library catalog was not an easy task for the study participants due to multiple points to access scattered among other busy contents. When participants tried to read pages containing a large amount of text or diverse types of information, they were often unable to make sense of the pages' context, especially if the information was not coded in a hierarchical structure that allowed them to get an overview of the page or skip to the desired content, or if the pages relied too heavily on visual cues for navigational context.

## Using the catalog: Searching and browsing results

The participants who were able to locate a catalog generally found it difficult to use. Some of the catalog tasks required participants to filter search results by certain criteria, such as the desired format of the library materials. However, the checkboxes or other form-based filtering options commonly found on online catalogs are not always coded for usability—or even minimal accessibility—with a screen reader. In addition, it was observed that search options can be structured in a way that is not intuitive to screen reader users. In one of the catalogs tested, a search button was positioned before a number of advanced filter options both visually and in the code sequence (as it would be read by a screen reader) (see Figure 24.1). Though the researchers, who were sighted, could easily perceive them, it did not occur to the

test participants to scroll or tab beyond the search button for more options because their expectation was that it would be placed at the end of the form.

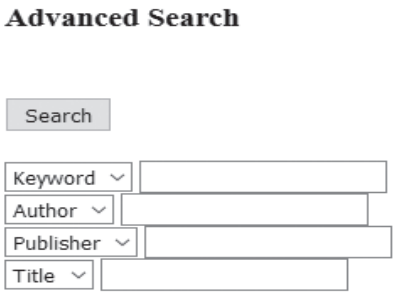



**Figure 24.1.**
In this interface, a sighted person can perceive that the filters go with the button, but a screen reader user would not know that there is more content after the button and therefore might not find the filters.

The formatting of search results was also problematic for study participants. In one of the catalogs, the titles on the results list were not formatted as headings or links, which would have allowed for much easier skimming because screen reader users can tab between them. This forced participants to listen to every word of the bibliographic entry for each result before moving to the next. Those users whose desired item came up higher on the list were able to complete the task but not without frustration. Those whose search terms were broader were unable to complete the task, as it was not feasible to scan through more than a few results with no way of skipping quickly from one item to the next on the list.

## Catalog suggestions

Many of the tweaks that make library catalogs more usable for screen reader users are quite simple. For example, participants commented favorably when "skip to results" links were placed at the top of catalog search pages, above the navigation menus and filtering options, because it allowed them to jump directly to the results with one keystroke without excessive tabbing through every navigational element of the page. Scanning the search results list also became more efficient when titles were formatted either as links or headings, so that screen reader users could use a shortcut key to tab between them. Such formatting is increasingly standard for online library catalogs, but the fact that this was not always the case demonstrates that in the current environment of rapid technological change, libraries need to be more proactive about uncovering and remedying such web design barriers through the use of inclusive design principles.

Finally, in terms of the search interface, we recommend that dynamic design elements (addressed in section 2.3 below) and any form fields employed to deliver the benefits of advanced search and faceted browsing should be rigorously tested for accessibility and intuitiveness by screen reader users to ensure they are not effectively shut out of the catalog.

### *2.2. Navigation problems*

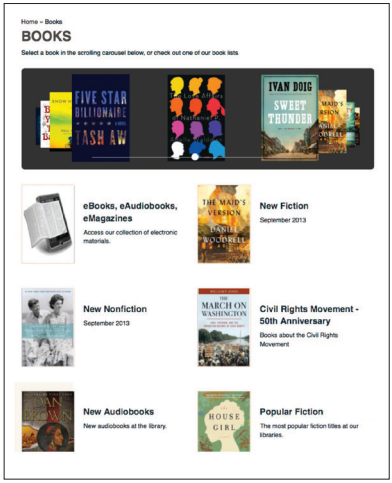
The most common barrier to task completion on the library websites was difficulty with navigation. This problem was most often the result of participants' confusion about the websites' information architecture rather than technical barriers. Participants were often unable to locate themselves within a site's structure (i.e., determining which page they were on or which process they were involved in). In some cases, basic orienting information was not properly available. Examples included the fact that a "home" button was not shown on the catalog page, which caused users to rely on back buttons or to try editing the page URL, or the fact that the full name of a university was not available as text in the website page headers (only the acronym was used in the alt image text) while it was visible to sighted users via a subtitle on the logo image.

Navigation problems generally fell into two categories: difficulty navigating pages containing large volumes of linearized text without the advantage of visual cues, and semantic and structural barriers such as misleading link labels and a lack of proper heading structure. It was also observed that the semantic and structural barriers compounded the linearization issue by making it difficult for screen reader users to group content in other non-visual ways.

#### Linearization issues

Linearization, the method used by text-to-speech technology, refers to the representation of website content in the exact sequence it appears in the source code (see Figure 24.2 for a visual interpretation).

Linearization often seemed to result in cognitive overload for the study participants; without the advantage of visual cues, they were required to "read" far more irrelevant text than a sighted user typically would in order to find the information they were looking for. In addition, the information often lacked any predictable flow, since the sequence of HTML code rarely corresponds with its visual representation, and even when it does, the visual structure may not be apparent without visual cues. The poorly sequenced catalog search filter interface mentioned above in Figure 24.1 is one example of this problem.

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Graphic eBooks, eAudiobooks, emagazines Heading level three Link eBooks, eAudiobooks, eMagazines Access our collection of electronic materials. Graphic The Maid's Version Heading level three Link New Fiction September two thousand thirteen Graphic These Few Precious Days Heading level three Link New Nonfiction September two thousand thirteen Graphic The March on Washington Heading level three Link Civil Rights Movement dash fifty th Anniversary Books about the Civil Rights Movement Graphic new audiobooks Heading level three Link New Audiobooks New audiobooks at the library. Graphic popular fiction
Heading level three Link Popular Fiction The most popular fiction titles at our libraries....

B

**Figure 24.2**

## Semantic issues

Poor link labeling, which includes non-intuitive anchor text, a lack of context in the surrounding text, and the omission of descriptive attributes in the HTML code, caused navigation problems across all of the sites tested. When link text was not descriptive enough to indicate whether that link was useful (e.g., "read more" or "click here"), participants tabbing through links to find relevant content were consistently taken on extended detours, or "rabbit holes," as one participant put it. These detours were time-consuming and difficult to recover from, as was the case for two participants who tried to navigate within a site but ended up on external sites without realizing the error for some time. Misleading text also caused detours; for example, one participant looking for e-books followed the link "Find eBooks" but instead ended up listening to a lib guide on available databases that might contain some e-books. On another library site, participants consistently confused a menu item labeled "Books" (that linked to a page highlighting specific titles) for the catalog, a mistake any user might make, but without access to visual cues, it hindered participants' task progress significantly because they did not detect a false lead.

In some cases, the problem was more a lack of description in the sentences surrounding the hyperlink anchor text rather than the anchor text itself. The test participants repeatedly noted that links or headings relying on visual groupings for context, such as "Main Site | Kids | Teens," made no sense to them. In addition, participants had difficulty discerning the purpose of links labeled with isolated

characters, such as a series of differently sized letters ("AAA"), which are supposed to indicate the option to resize text, or the numerical links at the bottom of an image carousel, which are meant to allow users to browse manually through the images.

The recommended best practice is for link text to be clear enough that the target page is evident even if the text is read apart from the context of the page; for example, "ask a librarian" is more obviously understood out of context than "click here." It is also important to avoid misleading link text, such as the "Books" link in the tested public library site, which might have been better named "New Arrivals," since the existing text implied to participants that it linked to an interface where they could search for books.

### Headings/hierarchical structure

A major barrier to navigation for some participants was the lack of hierarchical page structure on the tested sites. Two of the participants relied extensively on hierarchical heading lists to navigate the websites, much like navigating a book with a table of contents. However, when the test sites lacked a proper hierarchical heading structure, as was the case with one site in which all headings were set to level 2, navigation by headings was virtually impossible, thereby frustrating the participants who preferred heading navigation and providing fewer options for the remaining users.

Though semantic issues can lead to navigation errors for all users, it was observed that the test participants expended a great deal of time and energy reorienting themselves because they could not access visual cues, and the resulting information overload seemed to be an indirect cause of task failure. Therefore, semantic issues and cognitive fatigue resulting from the use of a text-centric technology to interpret a visually-oriented presentation appear to be high-level barriers that should be addressed at the web design stage if a functionally accessible site is to be achieved.

A hierarchical heading structure is a good way to help screen reader users navigate the high volume of information on a library website. In a typical website, headings appear in larger or smaller font sizes to indicate to sighted readers whether they are main headings or subheadings. These headings can be an essential navigation aid for screen reader users, but only if the headings are coded in the underlying HTML according to their semantic level (e.g., <h1>, <h2,> etc.), not just styled with different font sizes in CSS formatting code, which is not perceived by screen readers.

## *2.3. Dynamic design elements*

The final major accessibility challenge for the participants was poor interoperability between screen reader applications and dynamic web elements. We use the term

"dynamic" to mean any web element that shows or hides content based on a user's action, typically mouse hovering and clicks. The dynamic elements that our study participants encountered were combo boxes, drop-down menus (also called menu bars or dropdowns), and tab panels (tabbed containers within a webpage that allow users to view different content options while remaining on the same page).

## Combo boxes

Certain dynamic elements seemed to function well for the participants. Specifically, several commented favorably on combo boxes (see Figure 24.3), which function similarly to drop-down menus and are used to select options for search criteria or other form fields but are accessed more easily by screen readers because they are identified as a distinct element rather than a link, and because their screen readers offered a shortcut key to jump quickly to the next combo box.

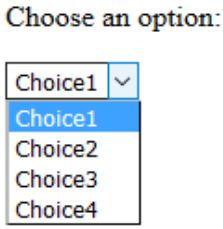


**Figure 24.3**

There was only one case of a problematic combo box. Normal combo boxes allow keyboard users to arrow up or down through the list of options and then activate an "Enter" or "Go" button to select the desired option, but this particular combo box automatically selected the first option the participants landed on (the equivalent of clicking on the option with a mouse), linking them to a new page. In order to proceed further down the list, the participant had to hit the "Back" button from the new page and then arrow down again, which once more selected the next option automatically, making it impossible to effectively navigate the list of options.

## Drop-down menus

Drop-down menus, which differ from combo boxes only in that a drop-down menu is accessed not by a click, but by hovering the mouse cursor over its root (see Figure 24.4), were frequently challenging for participants. This was because screen readers cannot easily simulate the act of hovering the cursor and often interpret

the top level of a drop-down menu as a link, even if it does not actually link to a separate page. When a participant would select such an item from their list of links on a page, it caused confusion since they were under the impression that they had gone to a new page when, in fact, they had not. Without knowing to set their screen readers to simulate a mouse-over, the participants could not get the drop-down menu to appear and thus could not access the real links they needed to complete the tasks.

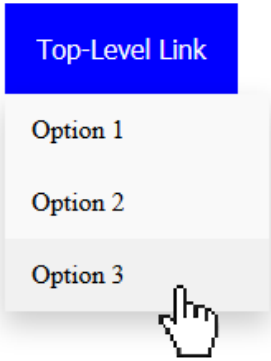


**Figure 24.4.**
The top level of a drop-down menu appears to screen readers as a link, even though its only purpose is to trigger the rest of the options during a mouseover.

## Tab panels

A similar problem occurred on sites containing scripting for a tab panel whose links dynamically changed the content within a single page rather than linking to a new page (see Figure 24.5). All of the participants who encountered tab panels (four out of the six) became very confused after clicking on the links and not hearing the expected screen reader prompt announcing a URL change. These participants commented that they had no idea whether the links worked, and when they tried navigating the new page content, it seemed as though they were on the same page they had been on previously. In these cases, the facilitators needed to explain that only a small portion of the page had changed.

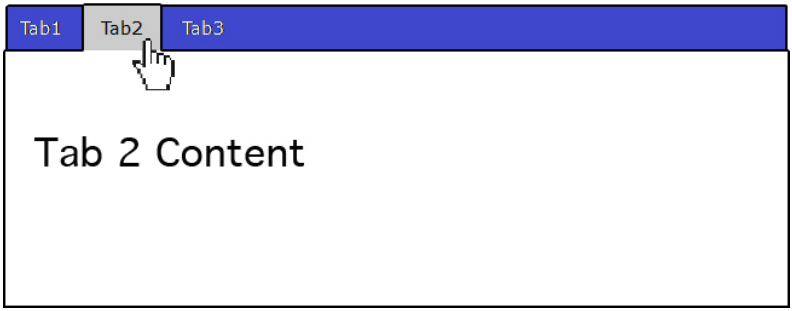


**Figure 24.5.**
In a tab panel, the tabs and the portion of the page around the panel stay constant. Clicking one of the tabs only changes the content underneath the tabs within the panel; the page URL does not change.

### Dynamic elements suggestions

For sighted users, dynamic features such as drop-down menus, tab panels, and accordions streamline navigation by reducing the number of pages that must be visited and the amount of information that must be viewed at once. For screen reader users, however, navigating these features can be confusing. WAI-ARIA (Accessible Rich Internet Applications) is a set of coding guidelines that will improve interoperability between dynamic web elements and assistive technologies without affecting the browser behavior for nondisabled users.[32] In order to make tab panels more accessible, for example, WAI-ARIA recommends using the roles "tabpanel," "tab," and "tablist" on the page's HTML.[33] Compliance with WAI-ARIA Authoring Practices 1.0 ensures that the tab panel navigation will behave the way screen reader users expect.

Compliant code is also necessary when implementing combo boxes, which are perfectly accessible to screen reader users when coded properly. The combo box scripting itself should never take the user to a new page. A better practice, recommended by WebAIM, is to have a separate "Submit" button so that users can arrow freely through the options and then hit "Submit" when they are ready.[34]

## Findings: 3. Comparison to an automated testing tool

In addition to the usability testing with the six participants, we analyzed the technical accessibility of the test websites with a tool called AChecker.[35] AChecker and other automated accessibility testing tools examine the code behind a web page and flag potential accessibility issues as errors. The tools are designed to catch problems that can be detected at the code level, like images without alternative descriptive text or font colors that do not contrast enough with the background color.

Our testing with AChecker and our comparison of its results to the accessibility issues found by the study participants indicate that most of the barriers found by the automated tool did not cause noticeable problems for participants in their own use of the sites. Conversely, most of the barriers identified from usability testing with the participants were not related to any of the items on AChecker's list of known errors. In fact, there seems to be little to no correspondence between AChecker's analysis of accessibility barriers and the participants' own experiences with the sites. Contrary to the expectation that the sites with the most coding errors would be the most inaccessible for participants, this was not the case. The two academic library sites had very few accessibility errors flagged by AChecker but they had fairly low task completion rates. Such a small sample of websites cannot be treated as conclusive evidence, but this result agrees with the findings of

Rømen and Svanæs, who determined that the errors typically found by automated tools do not predict problems that are encountered most by disabled users.[36]

One possible explanation is that the test participants have developed strategies for dealing with typical errors that have serviceable workarounds, such as using adjacent text to predict the relevance of an image that does not have accessible alt text, using the back button to return to the home page when navigation menus are inaccessible, or using word prediction when inaccessible link text or page structure hinders navigation to something they are looking for. Another is that the barriers enumerated by AChecker and other automated tools highlight very specific technical problems and not the high-level usability issues that tend to be encountered before the user digs very deeply into the site. This seemed to be the case for participants in the study since usability issues often prevented them from using library websites as intended, and it is likely they did not have a chance to encounter many of the technical errors listed by AChecker due to the interference of higher-level barriers. For that reason, this finding, if correct, does not negate the importance of accessible coding.

## Section 4: Inclusive Information Architecture for Web Design

The fact that technical compliance with accessibility standards did not reduce usability barriers for study participants seems to confirm the proposition that for mutually shared usability problems, people using screen readers experience barriers of significantly higher severity than people who are able to browse visually, and that usability must be adopted as a success criterion if web accessibility standards are to be effective in meeting the information needs of real people.[37]

Our study results therefore suggest that screen reader users are effectively excluded as a target audience for library services in the sense that their needs are not adequately considered in the design of those services. We interpret this inaccessibility of library websites to be a fundamental diversity issue; in other words, users with visual impairments are not included in the working definition of "users" in website design requirements.

Given this interpretation, we will focus on providing a high-level recommendation for library web design. The fundamental issue of equal accessibility is a diversity issue, not just a technical one. The principle of inclusive information architecture should be incorporated as a conceptual framework to guide website design from the very beginning of the process in addition to conventional accessibility testing, which is usually done only after the site is completed. The inclusive information architecture considers the individual contexts of diverse groups by expanding the

notion of universal design to include multiple modes of presenting the same content in order to meaningfully support the unique needs of different users.

The inclusive information architecture suggested is multi-layered, with each layer employing a user-centered design to cater to different user groups with different disabilities or other unique contexts of use, who would ideally be included in the development process. As an example, we focus specifically on the design of one layer, which is based on the understanding gained through our study of the nature of visually impaired users' information processing through screen readers. In the following, we describe how the proposed inclusive information architecture will be screen-reader-friendly and will reduce the accessibility barriers found in our study by applying four guiding principles below.

1. Screen readers assume that information is presented linearly.
2. Screen reader users process information aurally.
3. In aural processing, cognition is limited by the amount of information.
4. Screen reader users have the same information needs as any other users.

**1. Screen readers assume that information is presented linearly: Support linearization of information with hierarchical structure**

The inclusive information architecture proposed in this discussion assumes that users with visual impairments are the main target audience in order to prioritize and address their specific needs, information-seeking strategies, and interests. This group relies on screen readers and uses the keyboard exclusively instead of the typical mouse-keyboard combination preferred by sighted users. Screen reader users do not have a critical advantage that sighted users have: the ability to glance across the entire page at once and know which area contains the desired information. Therefore, screen-reader-friendly information architecture should enhance usability for the linear presentation of information so that users can navigate websites according to their own unique strategies for browsing, searching, and locating information when linearized. It should be based on text-oriented content, with a well-embedded hierarchical structure, and should not rely on visual cues.

Effective linearization of information is fully enhanced by a clear hierarchical navigation system and a careful re-organization of content that highlights available resources that are especially useful to screen reader users. With linear content presentation, it is essential to provide top-level navigation so that users can effectively skip to the information they want and bypass unnecessary sections. The hierarchical structure should allow the content to be logically divided into broad categories first and then further divided into subcategories as needed.

The architecture that supports linearization can be viewed as analogous to the idea of responsive web design; for example, mobile sites are an effort to rearrange

the desktop site's information in a way that is compatible with small, narrow screens. In responsive web design, the small screen size means that the most effective architecture for user experiences allows a fluid layout that turns multi-columns into single-column layouts, among other adaptations. Incidentally, users with visual impairments often seem to rely on the mobile versions of websites when available because mobile sites tend to be more accessible in general.[38] This is most likely because the single-column design common in mobile sites forces web developers to linearize the site's content into a logical order and provide a clear set of navigational headings that can be understood without extra text or visual cues. It should be noted, however, that some study participants expressed disappointment with the need to rely on mobile sites because they often lack features or content found on the full versions of websites.

**2. Screen reader users process information aurally**: **Information is only available through text reading; prioritize information content that can be read as text-only and is suitable for aural processing rather than visual**

With effort, hierarchical navigation can and should be implemented reasonably well, even within a visually oriented website; however, a screen-reader-friendly information architecture would differ in prioritizing and calling attention to information and resources that are actually available and accessible via screen readers. The catalog, for example, should allow for searches of collections that would be of interest to visually impaired users by virtue of being in a readable and accessible format, such as audio books, e-books, Braille books, and other machine-readable contents. Given that one of the most important features of a library website is catalog searching, the search interface should be augmented with filters that help users find these types of items quickly and easily.

In our study, library catalogs presented numerous obstacles to screen reader users and simply locating the search interface for materials was a struggle. Searching was also difficult for many participants because search interfaces, particularly filtering options, were not vetted for perceivability or usability in a linearized environment, and catalog searches brought up a long list of results that could be difficult for the participants to scan. Search results should be presented in a way that is manageable for browsing with a screen reader; for example, titles should be formatted as links or headings to facilitate skipping from title to title. The presentation of catalog search results is one of the areas where improved navigational hierarchy is needed for screen reader users to bypass unwanted items and to go directly to the desired one.

A brief tutorial explaining a catalog's basic and advanced search tools would also be a useful feature, as many of these tools on the test websites proved difficult for the study participants to use. Though difficulty with search interfaces can be

attributed to a lack of familiarity with library catalog searching that affects all types of users, certain difficulties, such as poor linearization and difficulty perceiving or accessing search options in faceted or advanced search forms, are specific to screen reader users. Some websites create tutorials specifically tailored to this group of users that are invisible to anyone not accessing the site via screen reader.

For screen-reader-friendly information architecture, it is also important to provide a meaningful description to screen readers for the missing context that visual cues and context provide. When library websites in our study contained links requiring visual placement or contextual cues to be fully understood, their text-only presentation confused the participants. We observed that such confusion often resulted in detours from which the participant could not reroute because the appropriateness of a link could not be evaluated on the destination page without the benefit of visual context.

Another consideration to be taken into account is that users with visual impairments generally get no benefit from taking time to listen to summaries of decorative elements or background images that do not contribute to the substance of the information on the page. Therefore, we suggest separating decorative images from content images, providing meaningful alternative text for content images and blank alternative text ("") for decorative images, which is recommended by the WCAG.

Links browsing for screen reader users is most effective when the guidelines for accessible link labeling are followed. Many screen reader users rely heavily on links lists for navigation, which means that they do not have the context of the rest of the paragraph to help them make sense of a link's text. For that reason, it is important to make sure that the link text is descriptive enough to be understood out of context without being overly wordy. Links browsing is also facilitated when redundant links are removed, as these make the browsing experience less efficient.

**3. In aural processing, cognition is limited by the amount of information; help reduce cognitive overload to improve information processing**

An accessibility barrier found numerous times in our study was the presence of too much information. Many library websites appear to use the homepage to appeal to every possible user and use of its web resources, and study participants often complained that library sites were "too busy," especially homepages, indicating that there was too much information to process efficiently. Many of the issues stemming from this problem can be resolved not only by a hierarchical structure for top-down navigation but also by eliminating redundant points of access to the same content. Multiple access points can be useful for visual browsing but almost always seem to hinder screen reader users. This practice results in an unmanageable volume of text for the screen reader users to parse and creates the

additional barrier of lengthy links lists, which places a large burden on short-term memory. We suggest minimizing the amount of redundant content to reduce the cognitive load on users.

By cutting out repetitive content and paring down the volume of information on the homepage, screen-reader-friendly architecture may also limit potential accessibility barriers generated by dynamic web elements, such as tab panels, accordions, and drop-down menus, that are used to add real estate to a crowded web page. When contents are streamlined and excess information is reduced, then there will be less overall need for dynamic elements. While careful testing and coding with the WAI-ARIA standard can make most dynamic elements work reasonably well with screen readers,[39] these features in general do not provide added benefit to non-sighted users and, in some cases, may be a barrier to those using older assistive technology even when coded accessibly.

Cognitive load can also be reduced by reorganizing information so that the content is linearized in a logical sequence. Even if a page is hierarchical, we observed that it does not necessarily linearize logically, which can limit the screen reader users' ability to find what they need. An example of this is the search filter interface described above in Figure 24.1, where the search button came before the filter options, so the participants stopped reading upon reaching the search button because they thought they had come to the end. An improved design would place the search button after the last filter when linearized, so that the user would read the filtering options before reaching the button. It should also be noted that tailoring the layout and contents of the page to reduce cognitive load in some ways parallels practices in web design meant to enhance usability for multicultural audiences and to allow targeting of shared content to particular local groups.[40]

**4. Screen reader users have the same information needs as any other type of users; create an additional but not separate architecture**

It is important to note that the proposed architecture is not intended to be a separate website, but should be additionally available at a user's request. It is usually the case that when a website maintains a completely separate "accessible" version that version is not updated as frequently as the standard one, with a resulting disparity in information access between disabled and nondisabled users.[41] In our proposed architecture, a screen reader user would have the option to select a link and go to the screen reader version if desired but could also stay on the main page as well. Screen-reader-accessible architecture can be added as a "Skip to" link in the HTML at the top of the main site's navigation, and the link can be styled to be hidden from sighted users' view while still being available to screen readers. Similarly, "Skip to" links can be employed in other major navigational aids. For example, a "Skip to Results" link can be added to the catalog searches, thus saving time and making search interfaces more usable.

Adding inclusive information architecture for screen readers would allow the existing visually oriented information architecture to fully leverage current trends in the visual and dynamic features that help sighted users optimally organize information. Such techniques can actually enhance communication and support for users with disabilities such as dyslexia or other cognitive disabilities.[42] By creating an inclusive information architecture for screen reader users, developers would be able to address the needs of multiple disability groups: one architecture would provide visuals to assist users with learning disabilities and cognitive impairments, and the other architecture would provide screen reader users with the linear, focused, text-based content that best meets their needs. The information architecture for linearized content should not be considered as an add-on but as a built-in part of the initial website design populated with the same content as visually oriented architecture, so that screen reader users can interact with it in the same way as sighted users.

Not all libraries have mobile or responsive websites, but when available, an augmented mobile site may be a good starting point for a screen-reader-friendly architecture because it is already linearized in a meaningful way. Quite a few other features of mobile-specific architecture are also optimal for screen reader users, such as the fact that mobile sites have fewer redundant repetitions of links and content than desktop sites, and the fact that the content relies on hierarchical navigation and linear order rather than on visual context to make sense.

## Conclusion

Our study found that library websites were not regularly used by participants, and that the most common accessibility barriers were design issues that caused a large number of usability problems for screen reader users. These included (1) difficulty in finding the library catalog, (2) difficulty in efficiently navigating through a high volume of linearized information, and (3) difficulty in making sense of current non-textual web design elements, such as dynamic and highly visual contents. This chapter provides both a conceptual principle for inclusive information architecture and a practical design solution to make library websites more usable and accessible for screen reader users by employing inclusive principles of universal design. These recommendations could be applied to the design of library services to meet the needs of any underserved group. The library and information science profession has always been committed to equal information access for all, and for libraries to remain relevant, they must work to be useful, useable, and welcoming to an increasingly diverse population. Ensuring that information on library websites is equally accessible to all users is an important part of achieving that goal, but it is only possible by designing library services inclusively from the ground up.

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