Website Design and Usability Assessment Implications from a Usability Study with Visually Impaired Users

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Abstract. Outdoor recreation websites present complex design considerations because of their wide range of potential users and the variety of their needs. Usability testing allows users to interact with websites and give feedback on its usability. Knowledge acquired during the usability testing process can be used to improve the information architecture of the website and its content. This study included usability tests with both visually-impaired and sighted participants visiting the Natural Resources Management Gateway, a complex information-rich website. The study identified best practices for designing and testing websites that effectively and efficiently meet the needs of visually-impaired and sighted website users. In addition to design recommendations, the study also looked at the impact of visual impairments on usability test duration, determining a rule of thumb for allocating time for usability testing of websites.

Keywords: Usability, visually impaired users, disability, public website, outdoor recreation website, usability testing duration.

1 Introduction

Large public websites, such as those for outdoor recreation (e.g., the NRM Gateway), present complex design considerations due to the large amount of information they contain and their wide range of potential users. The need to provide sites that are accessible to individuals with disabilities has grown as the range of disability-friendly activities has increased (including recreation). According to a Harris Interactive/Open Doors Organization market study, more than 21 million American adults with disabilities (69% of American adults) spend more than $13.6 billion a year on travel-related services. Persons with disabilities travel at least once every two years (approximately 63 million trips), and 51% of them use the Internet to plan their travel [1]. These numbers show the high rate of Internet use for people with disabilities, especially with respect to travel. Travel and leisure websites must support the needs of a diverse audience to address this significant market.

Usability refers to how easily a specific task can be accomplished with a specific tool. The International Organization for Standardization (ISO) defines usability as the

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"extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use" [2]. Effectiveness is defined as "accuracy and completeness with which users achieve specified goals," efficiency is defined as "resources expended in relation to the accuracy and completeness with which users achieve goals," and satisfaction as "freedom from discomfort, and positive attitudes towards the use of the product." While other conceptualizations of usability have been proposed ([3], [4], [5]), the ISO definition is the most widely accepted and is used by Michigan State University Usability/ Accessibility Research and Consulting (UARC) in evaluating website usability. The value of conducting baseline usability testing is to identify usability issues within a site using a systematic, performance-based approach.

Including usability research in the website design process can save time and costs associated with development, maintenance, training, support, documentation, and litigation. It may also increase sales, traffic, revenue, user satisfaction, market share, productivity, and trust ([6], [7]). The return on investment for usability efforts is high:

- Cost-benefit ratios can exceed 1:100 [8]
- Traffic and sales commonly increase by over 100% [9]
- User satisfaction can increase by as much as 40% [10]
- Training and supervisory time can decrease by 30-35% [11]
- Productivity can be increased by 70% [12]
- Employee turnover can be reduced by 20% [8]

The earlier usability is included in the production process, the greater the benefits and savings. It is estimated that for every $1 spent fixing usability problems in the initial design of a system, $10 needs to be spent once it is in development, and $100 once it has been released [13].

1.1 Usability for Persons with Disabilities

Ensuring that websites are usable for persons with disabilities will greatly expand their potential audience. Worldwide, 650 million people or about 10 percent of the world's population are living with some kind of disability [14]. In 2008, the overall percentage of people with a disability for all ages in the US was 12.1 percent (36 million), 6.9 million of whom (2.3%) were blind or visually impaired. Disabilities affect many more people than is generally realized [15].

According to the 2008 Disability Status Report for U.S. [15], a significant number of persons with disabilities are employed and have substantial incomes, albeit at lower levels than persons without disabilities. For example, the overall employment rate of working-age people with disabilities in the U.S. was 39.5 percent, with the second highest employment rate for people with a "visual disability," 43.4 percent. Median earnings of people with disabilities (full time/full year) in the U.S. was $35,600, compared to $40,700 for people without disabilities (full time/full year) [15]. Moreover, as the general population ages, the number of persons experiencing a disability will grow, further increasing the number of persons with disabilities.

The Internet is also a significant and positive resource for persons with disabilities. It has the potential to increase the independence and social connectedness of persons with visual impairments, since it removes the barrier of physical proximity for

shopping and communicating. Bradely and Poppen [16] found that Internet access improved how individuals with disabilities evaluate their level and quality of communication with others. Moreover, Internet use enhanced their sense of independence and self-determination [17]. More recently, Smedema and McKenzie [18] found that there was significant positive association between Internet use and overall sense of well-being.

Depending on the availability of assistive technology and the type of disability, however, websites may be more or less accessible. To be fully accessible, websites must include special instances of HTML code that enable adaptive technologies to provide additional context or flexibility [19]. For example, proper coding enables individuals who are blind and use screen readers, such as JAWS, and people who have low vision who use screen magnifiers, such as ZoomText, to navigate through a site, understand its content, and operate its features. Without accessibility-oriented coding, using a website may be impossible for persons with disabilities. Inaccessible websites remain a problem, with up to 90 percent of F100 corporate website home pages found to have at least one accessibility issue [20], and over 70 percent of the 50 states and the District of Columbia home pages do not meet accessibility standards [21].

This combination of interest in recreation, disposal income, personal benefit from using the Internet and continued website inaccessibility for persons with disabilities, led the Corps of Engineers to initiate an accessibility review of their Corps Lake Gateway page, which we conducted in early 2008. We in turn structured our research so that we could determine which aspects of their website would be more difficult for persons with visual impairments to use, and identified research-based design recommendations based on the findings.

1.2 Impact of Visual Impairments on the Duration of Usability Tests

In addition to design recommendations, we looked at what must be taken into account when conducting usability tests with persons with disabilities. Based on our prior experience, conducting tests requires a modified approach. One of the key differences is the amount of time that participants take to complete tasks, which in turn impacts the maximum time per task, the number of tasks per session, and the overall length of the session. One common rule of thumb, based on anecdotal evidence, is that blind individuals take 3-4 times longer to complete a task than sighted individuals without impairments. It has been observed that persons with low vision require additional time as well. No specific references in the literature exist to support these guidelines, and in order to create a clear rule to be of use to practitioners, we looked for differences between groups in our study of the Corps Lakes Gateway.

2 Case Study Background

To gain a better understanding of how different types of users interact with an information-intensive website and identify best design practices, researchers at Usability/Accessibility Research and Consulting at Michigan State University have been performing a series of user experience evaluations on the Corps Lakes Gateway website for the past three years. The current usability evaluation on the Corps Lakes

Gateway website within the Natural Resources Management (NRM) Gateway was performed to identify best practices for enhancing the website for persons with disabilities, including those with visual impairments. The NRM Gateway is a knowledge management system used by over 2,500 Corps of Engineers natural resource professionals. The Gateway contains over 90 thousand pages of content and had over 9 million hits in 2009. The Visitors section of the NRM Gateway, called the Corps Lakes Gateway, targets the general public interested in recreation opportunities provided by the Corps of Engineers. (See Figure 1.) Information is available for each of the lakes within the Corps. This site received over 46 million hits in 2009.

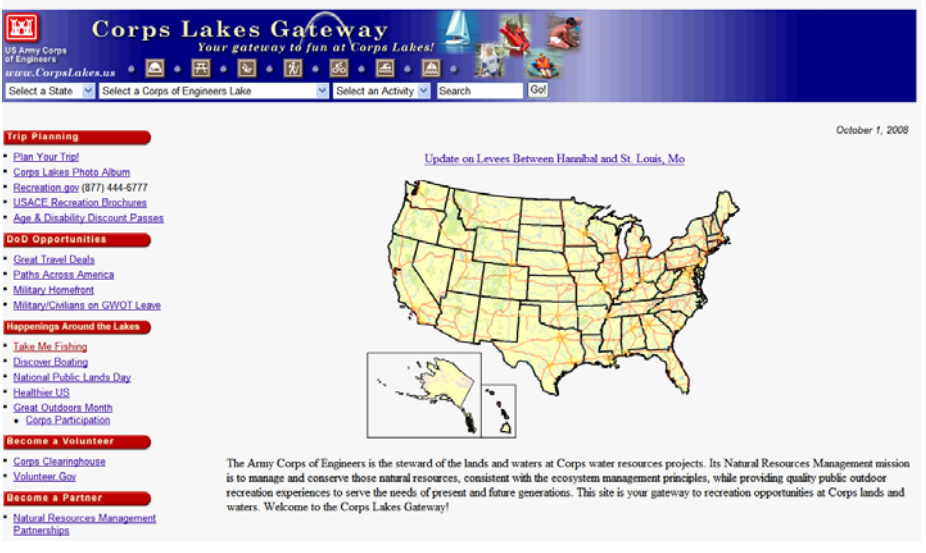

Fig. 1. Corps Lakes Gateway homepage

3 Research Methodology

In order to understand the similarities and differences in browsing strategies across user groups, we evaluated the Corps Lakes Gateway in one-on-one usability sessions with 34 participants, including 18 users with normal vision, 8 users who are blind (working with the JAWS® screen reader), and 8 users with low vision (working with the ZoomText® screen magnifier).

Key usability metrics and goals included effectiveness, which refers to how well a system does what it is supposed to do; efficiency, or the way a system supports users in carrying out tasks; satisfaction, which relates to the subjective responses users have to the system; and accessibility, which addresses whether the system adequately supports users with disabilities (who may rely on assistive technology, such as a screen reader).

Participants completed typical tasks beginning at the Corps Lakes Gateway homepage, and each group's performance was measured by task completion rates, time to complete tasks, errors, satisfaction ratings, and verbal feedback.

4 Results and Recommendations

4.1 Usability Testing Results

Users were successful in finding information within the Corps Lakes Gateway website for pages with concise, straightforward content, but were less successful for pages containing complex tables. User satisfaction ratings demonstrated that, overall, participants found the website useful. Our usability testing identified several design problems, reflected by difficulties encountered by users with visual disabilities.

Many of the difficulties and errors in completing tasks were a result of page layout. Before reaching the main content, users of assistive technology had to wade through confusing links and graphics. Unlike sighted users, persons who are blind or have low vision cannot see the whole page at once. Screen reader users listen to content as it is read from top to bottom and low vision users enlarge the page and can only see a small part of it at any one time. Without additional information to provide context for screen reader users or effective clustering of information for ZoomText users, participants would sometimes find the correct page but miss the relevant content. Complex tables and dropdown menus further decreased success rates and increased the time needed to be successful.

4.2 Duration of Usability Tests for Users with Visual Impairments

In our study, we found that participants with low vision took 2.95 times longer than participants with normal vision to complete tasks, while participants who were blind took 3.44 times longer. The result for individuals who are blind is therefore consistent with the general rule of thumb of 3-4 times the duration of sighted users. Low vision users needed even more time, although there are no rules of thumb for comparison.

The time required for individuals with low vision ranged from being comparable to sighted individuals to taking longer than blind inviduals, with tasks taking from 1.15 to 6.26 times as long as those with normal vision. The time for blind individuals had less variability, from a minimum of 2.96 to a maximum of 4.28 times as long. It is clear that the particular characteristics of a task play a large role in determining how long a participant will take relative to baseline. The results further suggest that pilot testing is more important when working with low vision than blindness in determining the length of time that should be allotted for each task, due to the increased variability.

5 Implications

5.1 Implications for Website Designers

Taking into account performance data, facilitator observations, and user ratings and comments, we provide the following recommendations for information-intensive websites. While we have provided specific recommendations for screen reader and screen magnification users, the general recommendations also apply to persons who are blind or have low vision.

General Recommendations for All Users:

- Ensure that all links are worded clearly and concisely.
  - If you must include two links that have similar wording, offer a brief clarifier or description to indicate where each link leads.
  - For major topics of interest, consider having one page that serves as a portal to other resources on the topic, rather than using similar and potentially confusing links to different pages that contain related information.
- Always warn users when a link will open a new window.
- Provide a concise and simple main navigation menu.
- Place all functionality on the top or left side menus of the Web page where they will be expected, rather than limiting a feature to the content area in the middle of the page.
- Ensure that the search function responds appropriately to common user queries.
  - If text is already present in the search box when the page loads (such as "Search" to indicate the function), automatically remove the text when users click into it to ensure that users do not mistakenly add their search terms to the existing text string.
  - If there are no search results, display a message to that effect instead of displaying an empty page.
- Ensure that drop-down menus function according to users expectations.
  - When the same drop-down menu is present on multiple pages, it should retain the selection when user moves between pages.
  - If a drop-down menu provides more detail than the prior menu, it should only include choices relevant to the prior selection (information should cascade hierarchically).
- Do not bury important information in long paragraphs.
  - Use lists rather than paragraphs to present related information in a concise way whenever possible.
  - Break up large blocks of text into shorter blocks of information to improve readability.

Use paragraph headings to enhance scanning.

Recommendations for Users who are Blind:

- Ensure headings are used to identify sections and subsections so that screen reader users can easily scan pages that contain large amounts of information.
- Provide accurate and descriptive alternative text for all graphics and non-text content.
- Provide a link to the homepage at the top and bottom of all pages.
- Tag PDF files for accessibility so that they render properly with assistive technology.
- Provide a site map to help users understand site organization and content.
- Make sure that drop-down menus work with the "Enter" key, which is the expected behavior for screen reader users.
- Ensure that all form fields and radio buttons have labels that are descriptive and associated with input fields.

Recommendations for Users who have Low Vision:

- Make page information concise to reduce the need for horizontal scrolling and to enable quick scanning.
- Avoid italic type, as it is more difficult to read.

5.2 Implications for Usability Practitioners

Usability practitioners should use a 1:3:3.5 (normal vision : low vision : blind) rule of thumb for determining the amount of time to allot for usability testing of websites. Pilot testing is also recommended whenever possible, as the variability in task times is high, especially for low-vision participants. When pilot testing is not possible and a more conservative estimate is needed, it is recommended that a 1:4:4 ratio be used.

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