How WCAG 2.1 Relates to Online User Experience with Switch-Based Tools

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Abstract

Web Content Accessibility Guidelines (WCAG), organized under the four principles *Perceivable, Operable, Understandable, and Robust*, form the standards for building web pages that are accessible to users with disabilities. The guidelines under the first three principles broadly map to three disability domains: sensory, physical, and cognitive respectively. However, there is little published research examining the relationship between these categories of WCAG guidelines and the user experience of a person with a specific type of disability. We studied the user experience of a person with a physical disability (quadriplegia) while using switch-based tools online in the context of each of the WCAG guidelines. We found the guidelines under *Operable* to be relevant to the user's online experience, but with relatively low dependency on keyboard accessibility and high reliance on multiple input modalities. Most guidelines under *Perceivable* and *Understandable*, which generally map to sensory and cognitive disabilities respectively, were also found to be relevant to this user more for usability that for accessibility. The guideline under *Robust* was found to have no direct relevance to this user's online experience. Further studies of online experience of users with other types of disabilities are required to understand how the guidelines relate to user experience with those disabilities.

Keywords

Online interaction; Web accessibility; WCAG 2.1; Assistive technology; Quadriplegia; Switch-Based access

Introduction

Web accessibility for people with disabilities is receiving increasing attention, with more countries passing digital accessibility regulations. Recent examples include the European Union (EU Accessibility Directive) and Canada (Accessible Canada Act). More than 20 countries, including the EU and Canada, have chosen the Web Content Accessibility Guidelines (WCAG) published by the World Wide Web Consortium (W3C) as the standards underlying their accessibility regulations (Powermapper). WCAG 2.1, the current W3C standards, contain 13 guidelines divided into four principles: *Perceivable, Operable, Understandable, and Robust*. Each guideline is supported by success criteria at three levels of increasing accessibility: A, AA, and AAA. Each success criterion contains techniques to verify whether or not a particular web feature meets the criterion.

The guidelines under the first three principles, *Perceivable, Operable, and Understandable,* broadly map to disability-related needs in the sensory, physical, and cognitive domains. In the absence of studies involving people with disabilities, this mapping tends to guide approaches to design and development aimed at catering to diverse disabilities. In other words, the tendency would be to focus on the guidelines under *Perceivable* while designing for people with sensory disabilities, and so on. This paper presents a research-based understanding of the relationship between the guidelines and the needs of a person with a physical disability using switch-based access tools. A switch is an assistive technology primarily used by people with motor impairments to access and control computers, smartphones, and gadgets (Access Lab.) Switch-based tools map UI actions to a hardware or software device that can be manipulated using a body part or extension.

Typically, software companies that focus on regulatory accessibility compliance test their products for accessibility after they are developed. On the other hand, companies who embrace an inclusive mindset about enabling people with disabilities to use their products adopt an inclusive approach to design and development by building the guidelines into their development process and by involving people with disabilities wherever needed.

D2L Corporation (D2L), vendor of the Brightspace Learning Management System (LMS), is a company that adopts an inclusive design and development approach to deliver great user experience to learners and instructors with disabilities. We integrate WCAG 2.1 standards into our processes and work with users with different disabilities to consult with and test our products. Our partner, Fable Tech Labs (Fable), offers the services of a community of users with disabilities via their cloud-based testing platform. Inspired by our work with Fable community members using a variety of assistive technologies (ATs), we undertook a case study to examine the relationship between the 13 WCAG 2.1 guidelines and the online experience of a quadriplegic Fable member who used switch-based access tools.

Cooper et al. (2012) argued that accessibility lies in the relation between the user and the website, which is always contextually situated and that taking into account the user experience is critical to improving accessibility. Aizpurua, Harper, and Vigo (2016) focused on experience of screen-reader users exploring restaurant websites. Results suggested the websites that met more WCAG guidelines were perceived as more accessible by users and, in turn, websites perceived as more accessible related to a more positive user experience. However, to our knowledge, little research has examined the relationship between meeting specific WCAG guidelines and providing positive user experience for users with specific disability types. More research is needed in this area. In this context, we attempted to answer the following research question:

How do WCAG 2.1 guidelines relate to the online experience of a user with a physical disability who primarily uses switch-based tools for online access?

Participant profile

The participant in this case study is a Fable community member called Janet (pseudonym) with a physical disability. Due to an accident over a decade ago, Janet lost sensations below her shoulders and lives with quadriplegia. She has good sensory and cognitive abilities. Janet spends more than 10 hours per day online, reading magazines and novels, banking, shopping, and organizing. She perceives herself as an Internet user "somewhere between average and expert" and more expert with her computer technologies than the Internet.

Janet worked steadily over the years since the accident to discover and master technologies that now enable her to efficiently use her smart phone, computer, and the Internet. She put together her own unique set of technologies that provide her the necessary access, redundancy, and efficiency. She uses the following assistive technologies for online access: two onscreen switches (Dwell Click® and Dragger®); an onscreen keyboard; a head mouse; a hardware switch device (Sip-and-Puff), and Dragon Naturally Speaking® (Dragon) software for speech input.
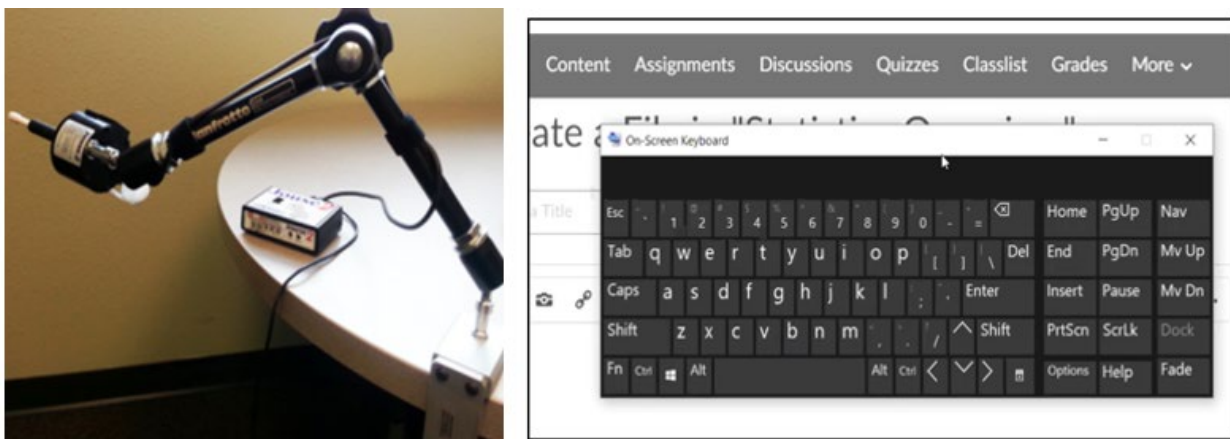

Fig. 1. Sip-and-Puff Device and Onscreen Keyboard

Janet uses a combination of tools to be able to surf the web and do things with her computer. She wears a pair of glasses that don't have lenses in them; but they have a little reflective dot in the center. And that little reflective dot is picked up by Janet's head mouse, which sits on top of her computer. She moves and positions the mouse cursor by moving her head. To click / highlight / drag, she uses either a physical Sip-and-Puff switch or an onscreen switch. She has two onscreen switch programs. One is called Dragger® and one's called Dwell Clicker®. The onscreen switches have buttons for left/right/double click are selected by dwelling (or hovering) on them with the mouse. The Sip-and-Puff switch is operated by sipping or blowing through the straw attached to it to simulate right and left click respectively. Janet uses an onscreen keyboard to input text, numbers, etc. while using the computer. She also uses a speech input software called Dragon Naturally Speaking® for dictating larger chunks of text.

A quick search for contemporary information on technologies used by individuals who are quadriplegic revealed that the technologies used by Janet are comparable. Some examples of other quadriplegics using technology are at: https://www.youtube.com/watch?v=kVjCTF_vqbU; and https://www.youtube.com/watch?v=SwDbh0S0QtE.

Approach and Methods

We chose a single case study approach for our research. Given a case study is bounded or described within parameters (Yin, 1994, 37), it allowed us to focus on the experience of one person, which was set in a real-life context. We observed Janet's experiences with her technologies with no experimental manipulation. Case study can be used in an exploratory manner to generate new ideas to be tested using other methods later (Mariano, 2000, 82) which aligned to our exploratory purpose.

We used two methods for data collection: (1) participant observation with think-aloud during sessions of technology use, and (2) in-depth interviews. The data collection protocol included the following: (a) initial semi-structured interview to understand how Janet works online using her assistive technologies; (b) a second semi-structured interview to go over the WCAG 2.1 AA success criteria; (c) an online session with tasks focused on success criteria Janet previously identified as relevant; and (d) a final debrief interview.

Interviews and online sessions were conducted over Fable's platform using Zoom® video conferencing tool. Data collection was through audio/video recording of the interviews and sessions; interviewer/observer notes; and relevant secondary research. A transcript of the recordings from interviews and online sessions was provided to Janet for member checking and validation so as to enhance the credibility, and thereby the trustworthiness, of the research.

All data gathered were reduced to text format and analyzed using qualitative data analysis methods. We began with a set of a priori tags based on the WCAG success criteria. We added new tags as we identified emotions, attitudes, and thought processes. We coded independently and then met to discuss and resolve discrepancies.

Results

Our analysis of Janet's online user experience in relation to the WCAG 2.1 guidelines is presented in Table 1. We represented the relevance of each guideline in terms of one of these three indicators: (a) *relevant*, the guideline holds a strong relationship with the user's online experience; (b) *helpful*, although the guideline is not directly relevant, the user finds it helpful; or (c) *irrelevant*, the guideline does not hold any relationship with the user's online experience.

Table 1. WCAG Guidelines and their Relevance to Participant's User Experience

Principle	Guideline	Relevance	Supporting Evidence
1. Perceivable	1.1 Text alternatives	Helpful	• "Alt text is helpful when images load slowly."
1. Perceivable	1.2 Time-based media	Helpful	• Video/audio transcripts are helpful to browse through quickly or search for a specific text string. • Closed Captions are helpful if there is background noise or for shows with strong language accents.
1. Perceivable	1.3 Adaptable	Relevant	• Autofill is very useful to avoid filling in passwords; typing special characters is strenuous.
1. Perceivable	1.4 Distinguishable	Relevant	• Text contrast & font magnification are very important because all reading is onscreen. • Pop-up menus that hover on focus and disappear when the mouse is moved are inaccessible. "Brightspace menus stay put. They are accessible." • Narrow scroll bars that animate with the mouse and disappear when mouse is moved away are problematic. "Brightspace scroll bars are good." • Hovering over some ads start playing audio/video on hovering. These are often tricky to close.
2. Operable	2.1 Keyboard accessibility	Helpful	• Doesn't use solely keyboard navigation because with her set tech up, she needs the mouse to click on the keyboard and the controls anyway.
2. Operable	2.2 Enough Time	Relevant	• Being signed out and having to sign back in requires typing special characters, which is tedious with the onscreen keyboard.
2. Operable	2.3 Seizure	Irrelevant	• Not affected
2. Operable	2.4 Navigable	Helpful	• Focus highlighting shows the current cursor spot. • Headings provide a cue to content structure

Principle	Guideline	Relevance	Supporting Evidence
2. Operable	2.5 Input Modalities	Relevant	• Multiple modalities are essential. "Head mouse, microphone, and some sort of switch, I call them a triad of essential technologies" • Needs sip-and-puff device for accessibility for login, when the software switch is not yet loaded. • Janet uses two switch control software programs (Dwell Clicker and Dragger) as redundant options. • To type, she uses both speech input using Dragon Naturally Speaking® and the onscreen keyboard.
3. Understandable	3.1 Readable	Relevant	• Contextual glossary example from a New York magazine website that shows up on the side margin and does not vanish when mouse is defocused.
3. Understandable	3.2 Predictable	Relevant	• Consistency in navigation is important. • Ability to search the page makes navigation easy.
3. Understandable	3.3 Input Assistance	Relevant	• Returning to top and highlighting errors in submission forms are useful in Brightspace.
4. Robust	4.1 Compatible	Irrelevant	• In Janet's view, this is irrelevant.

Discussion

Analysis of the data presented in Table 1 revealed several interesting insights, which are discussed below under four sections based on the four WCAG principles: *Perceivable, Operable, Understandable, and Robust.*

Perceivable: There are four guidelines under this principle: *Text Alternatives, Time-based Media, Adaptable, and Distinguishable.* Of these, the guideline *Distinguishable* offered the most significant outcome. Given Janet does not have any sensory disability, it is interesting that the requirement for adequate colour contrast under this guideline is found to be relevant to her online experience. However, this is because Janet spends 10 hours or more online every day

and reads novels and long articles for school on the screen, sometimes for several hours at a stretch. Unless the colour contrast on the user interface is good, it gets tedious for her to read for more than 15 minutes. Websites that allow text size to be increased also make reading easier. In Janet's words, "*I would do anything I can to try and save my eyes a little and make it easier to avoid having to drive up closer to the screen.*"

Under the *Adaptable* guideline, Janet found the autofill feature to be very useful to avoid filling in passwords because typing special characters with the head mouse and onscreen keyboard can get very strenuous. With regard to *Text* Alternatives*,* Janet found alternative text for images useful and usable although not mandatory for accessibility. Likewise, under *Time-based Media*, Janet found captions for videos helpful and convenient even though not a necessity for accessibility.

Operable: This principle has five guidelines – *Keyboard Accessible, Enough Time, Seizure, Navigable, and Input Modalities*. A significant outcome of our study is that the *Keyboard Accessible* functionalities were not found to be relevant to Janet. She regularly uses a head mouse to click on controls and to use the onscreen keyboard, thus exploding the common myth that people with motor disabilities will not be able to use a mouse and will rely exclusively on the keyboard. Likewise, under the *Navigable* guideline, Janet found focus highlighting to show the current cursor spot helpful but did not see it as a critical requirement.

A second important outcome is the significant relevance of *Input Modalities*. In particular, Janet uses multiple input technologies: "*Head mouse, microphone, and some sort of switch, I call them a triad of essential technologies.*" Janet sets herself up for success by negotiating her technologies and creating her own 'best practices'. She finds the Sip-and-Puff device **critical** for logging in because only after logging in the software switch tools can be

loaded and accessed. Janet uses two switch control software programs (Dwell Clicker® and Dragger®) to allow for building in a much-required **redundancy**. When one software froze, or otherwise became unavailable, the other could be used. There was yet another interesting efficiency factor in having two software switches: "*One of my onscreen switches always loaded at the bottom of the screen every time my computer rebooted. That made it impossible for me to use it. And then, I just downloaded another switch that I don't like as much but when the computer reloads it is in a better spot of prominence. So, I use that to drag up the one I really want.*" This is how Janet puts her software switches to innovative use.

Using a combination of speech input software and onscreen keyboard for typing also helps Janet improve input **efficiency**: "*I found that if I write using my voice and then do the editing with voice as well with commands like 'go to end of the document' and 'scratch that' then my voice gets a bit fatigued. So, I do most of editing with the onscreen keyboard.*"

Janet found the *Enough Time* guideline relevant because being signed out and having to sign back in required typing special characters, which is tedious with the onscreen keyboard. *Seizure* was not found to be relevant.

Understandable: Janet found the three guidelines – *Readable, Predictable, and Input Assistance* under this principle to be relevant to her online experience. She found contextual glossaries provided on some websites to be relevant to making the content more easily *Readable*. She also found consistent navigation and having the search function on every page to be important for *Predictable* user experience. She found highlighting errors and being returned to the top when submitting forms to be useful forms of *Input Assistance*. While these guidelines would map more with cognitive needs, our study shows these needs to be important for a person with physical disability as well.

Robust: This fourth WCAG principle has one guideline *Compatibility,* which is about ensuring that the underlying code adheres to software standards so as to ensure interoperability of assistive technologies with web pages. Janet did not find this guideline under Robust to be relevant. This is understandable because *Compatibility* is a factor that works in the background to ensure that her assistive technologies work well with web pages.

Attitude towards technology

Working with users with disabilities also uncovers other interesting and related facts about them such as their attitude towards technology. Janet holds a healthy and daring attitude towards technology: "*I'm not afraid to mess up; it's not the end of the world,*" she says. When it comes to managing the technologies, she is comfortable with "*jumping in, making mistakes and figuring out how to fix it.*" She knows that "*there is always a workaround."* When faced with a problem, most of the time she is able to find a different method of input and, sort of, feel protected and confident that there's usually always a way to get out of any sort of problem or glitch. She usually feels *"comfortable fixing things wherever possible."* Everything tangible and physical for Janet is on her computer. At the same time, she does not want anything that tethers her to the computer with a cord. This is to afford her the freedom and flexibility of physical movement when needed.

Conclusion

Our paper presented a case study of a person living with quadriplegia, who primarily uses switch-based access tools. We examined her online experience through interview and hands-on tasks within the framework of the WCAG guidelines. The objective was to study how her user experience with online work, education, entertainment, and life management relates with WCAG

guidelines. Brightspace LMS by D2L was used to conduct online tasks providing a specific situational context (Cooper et al., 2012).

We recorded and analyzed Janet's perceptions about WCAG criteria along with her online task journey data. The results showed significant overall relevance of WCAG guidelines to the user experience of the switch access user, including some surprising outcomes. We found the guidelines under the principle *Operable,* which theoretically maps with physical disabilities to be relevant to the user's online experience, but with a difference, in that there was relatively low dependency on keyboard accessibility and high reliance on multiple input modalities. Most guidelines under the principles *Perceivable* and *Understandable*, which broadly map with sensory and cognitive disabilities respectively, were also found to be relevant to this user for creating a positive user experience. Further studies with users with sensory and cognitive disabilities will help expand the matrix of relationship between the guidelines and user experience.

Overall, our work reaffirmed the importance of studying users with disabilities to gain better insights for creating more accessible user experiences rather than going by theoretical assumptions as implied by the WCAG guidelines. At D2L, we believe in enabling accessible learning by focusing on providing a great learning experience for people with disabilities rather than through mere implementation of WCAG guidelines.

W3C is leading the development of Silver Guidelines as the potential successor to the Web Content Accessibility Guidelines (WCAG). These guidelines are derived from research with people with disabilities. We believe there is a need for continued research examining user experience of people with disabilities to help guide new standards.

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