An Embodied and Ethical Approach to Teaching Web Accessibility: A Case Study of An Elective Engineering Communication Course

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ABSTRACT

CONTEXT

Despite substantial efforts by governments, academic institutions, and the computing industry to address accessibility concerns over the past few decades, web accessibility remains a significant and widespread challenge. In higher education, many computing faculty members have integrated accessibility into software engineering, web development, and design courses. However, research reveals that computing students often neglect accessibility when designing or developing technologies and fail to apply their knowledge in their coursework. Additionally, they lack motivation to enhance their accessibility skills and do not perceive accessibility as a critical competency in their professional domain.

PURPOSE OR GOAL

The research proposes an embodied and ethical approach to teaching web accessibility within an elective engineering communication course. The purpose is to explore whether and to what extent this approach can enhance students' awareness and motivation regarding web accessibility by engaging them in embodied experiences.

APPROACH OR METHODOLOGY/METHODS

The research was conducted in a one-credit elective course, "Creating and Communicating Your Digital Professionalism," in the College of Engineering Communications Program at an ivy league university during two semesters. Approval for the study was obtained from the university's IRB. 44 computer science students participated in the research. Their memos were collected for data analysis. The study adopts a grounded theory approach, aiming to generate themes that demonstrate increased student awareness and motivation regarding web accessibility.

ACTUAL OR ANTICIPATED OUTCOMES

The simulation experience significantly heightened the students' interest in accessibility, raised their awareness of its importance, and motivated them to actively address web accessibility issues on their own websites. All participants adhered to basic accessibility protocols. Additionally, the students explicitly stated that they would apply the ethics of accessibility learned in class to their future work.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY

This study demonstrates the importance of enhancing accessibility education within the computing curriculum. By incorporating more comprehensive and focused instruction on accessibility principles, tools, and practices, we can better prepare future computing professionals to create inclusive and accessible digital experiences.

KEYWORDS

Ethical awareness, web accessibility, engineering communication.

Introduction

According to the 2023 World Report on Disability, approximately 16% of the global population, equivalent to 1.3 billion people, are significantly disabled (World Health Organization, 2023). In the United States, the Centres for Disease Control and Prevention reported that 27% of adults have some form of disability (Centres for Disease Control and Prevention, 2023). Despite these numbers, a Pew Research Centre study in 2021 found that 67% of disabled Americans aged 18 to 64 have access to a desktop or laptop computer and the internet (Pew Research Centre, 2021). Given the necessity for people with disabilities to utilize the internet for social interactions, accessing information, and exploring economic opportunities, addressing web accessibility is paramount. Over the past few decades, there has been increasing recognition of web accessibility globally. Governments have enacted legislation and regulations aimed at improving online accessibility, while leading technology companies such as Meta, Google, PayPal, and Microsoft have integrated accessibility into their engineering practices, participating in initiatives like Teach Access to encourage universities to include more accessibility instruction in their computing curricula (Conn et al., 2020).

In response to the demand for professionals skilled in accessibility, university faculties have undertaken various efforts. Faculty members have incorporated accessibility into software engineering and web development/design courses, transforming their teaching methodologies by embracing diverse perspectives and active learning strategies such as project-based learning, guest lectures, and field trips (Ko & Ladner, 2016; Martin-Escalona et al., 2013; Shinohara et al., 2016). Despite these innovative pedagogical approaches, a study by Conn et al. (2020) at a U.S. university revealed that final-year computing students often overlook accessibility considerations in their technology design and development projects, even after receiving instruction on accessibility. Additionally, they lack motivation to enhance their accessibility skills and fail to recognize accessibility as a critical competency in their professional domain. Consequently, the imperative of preparing and motivating students to incorporate accessibility into their future work becomes evident. This research endeavours to address this challenge by focusing on a case study of an elective Engineering Communication course. It proposes an embodied and ethical approach to teaching web accessibility and examines how it may enhance students' awareness and motivation in this crucial area.

An Embodied and Ethical Approach

Research shows that computing students' interest in accessibility and motivation to apply and expand expertise on it is affected by extrinsic factors such as peers and career goals (McCartney et al., 2016). If students are part of a group where other members possess proficient accessibility skills, they are more likely to be motivated to continue their learning to avoid appearing ignorant (McCartney et al. 2016). Research also reveals that computing students exhibited high motivation to learn programming topics when the content was directly linked to their career goals (Jenkins, 2001). Building on prior research and recognizing the challenges in recruiting students with disabilities, this study proposes an embodied and ethical approach to enhance students' interest in accessibility. The aim is to motivate them to consistently learn and apply accessibility principles in their future workplaces.

This embodied and ethical approach centres around two key perspectives: embodiment and rights-based ethics. Embodiment underscores the importance of the bodily experience in perceiving and comprehending ethical situations (Michel, 2011), while rights-based ethics highlights the fundamental aspect of morality, which involves respecting and protecting the basic and equal rights of individuals within society (Spinello,1997). These two perspectives are closely interconnected, as one's body plays a vital role in self-relations and interactions with others (Liu and Maitlis, 2014; Michel, 2011), serving as a significant medium of communication (Quinn and Dutton, 2005). Put it simply, this approach emphasizes how bodily experience plays a crucial role in guiding and informing the development of moral actions. Specifically, with the approach to teaching web accessibility, students are asked to simulate the experiences of individuals with

physical disabilities by using assistive technologies to access website features like alt texts, images, captions, and colours. They are then required to reflect on their personal encounters, including any frustrations they may have faced while attempting to read online articles with visual elements. The approach assumes that the embodied nature of ethical encounters and interactions are especially relevant as bodily experiences enable students to recognize, empathize, and effectively respond to the needs of those with disabilities (Atkins and Parker, 2012). As rising computing professionals, students would come to recognize that ensuring website content accessibility is not merely a matter of doing what is morally right, but also a matter of fairness and justice (Spinello,1997).

In addition, this embodied and ethical approach informs pedagogical practices in several ways. First, incorporating simulation exercises encourages active learning and reflection, allowing students to engage deeply with accessibility challenges. By integrating real-world contexts—such as legal requirements and ethical considerations—educators can effectively connect theoretical concepts to practical applications, enhancing students' understanding of their responsibilities in creating accessible content. Emphasizing universal design principles benefits all users, promoting inclusivity from the outset of design processes. Additionally, encouraging critical reflection on their simulation experiences deepens students' awareness of the ethical implications of accessibility and prompts meaningful discussions about social justice and equity. By integrating these experiential learning components into the curriculum, educators cultivate a generation of professionals who are not only aware of accessibility challenges but are also committed to advocating for inclusive practices in their future careers.

This study was designed to explore whether the students were motivated by the teaching approach to apply web accessibility in their future workplace. The research questions are as follows:

1. Did the students experience any frustrations while using assistive technologies, such as a screen reader, to navigate through the assigned online article?
2. Were they motivated to consider accessibility in their future workplace?
3. How did they plan to address the web accessibility issue on their own professional website?

Course Introduction

The research was conducted during the Fall 2022 and Spring 2023 semesters in a one-credit elective course titled "Creating and Communicating Your Digital Professionalism" within the College of Engineering Communications Program at an ivy league university. The study received approval from the university's Institutional Review Board (IRB). 44 students who enrolled in this course and participated in the research were computer science majors. They were required to develop a professional website to establish their engineering identity and convey engineering professionalism. The course curriculum encompassed the following topics and contents:

- Introducing rhetorical situation analysis, rhetorical choices, and CRAP design principles.
- Conducting rhetorical situation analysis and genre conventional analysis of resumes, engineering professionals' LinkedIn profiles, GitHub repositories, and professional websites provided by the instructor.
- Analysing constraints and opportunities of student resumes, engineering professionals' LinkedIn profiles, GitHub repositories, and professional websites, with a focus on engineering identity construction.
- Addressing web accessibility concerns.
- Conducting three rounds of usability testing, targeting different user groups, and utilizing various evaluation methods.

The final deliverables for the course included a completed personal website and an individual design rationale essay.

Overview of the Approach

This approach was implemented during the web accessibility sessions, which began with an introduction to the number of disabled individuals worldwide and in the USA, highlighting how many rely on computers for social interactions and accessing information. Additionally, the session covered relevant laws and regulations aimed at making the web accessible to people with disabilities. This introduction helps students understand that web accessibility is a human right and an ethical obligation. Following this, key concepts such as accessibility, web accessibility, and usability were introduced. Through the provided materials, the students learned that usability refers to how effectively, efficiently, and satisfactorily a user can interact with a digital product, while accessibility ensures that digital content is usable by people with disabilities, addressing barriers in perception, navigation, and interaction Bureau of Internet Accessibility, 2019). Recognizing the importance of both usability and accessibility in website design, the session included a thorough discussion of their relationship. The students identified the overlapping and distinct aspects of the two concepts and decided to integrate usability and accessibility in their website design process. This integration helps prevent issues where a product might technically meet accessibility standards but is still difficult for users with disabilities to use effectively (Petrie and Kheir, 2007). It ensures that websites are both inclusive and practical, benefiting all users, including those with (temporary) disabilities, older adults, and people in challenging environments (Petrie and Kheir, 2007).

As mentioned earlier, it is difficult to involve students with disabilities in the design process to gather feedback and insights that can guide accessible and usable design. To instil a sense of seriousness about web accessibility, the students were tasked with simulating the experience of users with disabilities, specifically blindness. This approach was chosen because it is more feasible to simulate blindness compared to other disabilities, allowing students to better understand the challenges faced by these users. They used assistive technologies to access online materials and gain first-hand experience. Subsequently, they engaged in discussions and wrote reflections on their personal encounters during the simulation. Additionally, they formulated plans to address the web accessibility issues in their own websites. As web accessibility is part of the course content and due to the limited time, only three assignments are included as follows:

- Description of Assignment 1 (individual homework): Find a scientific or technical PDF or website. Use a free screen reader to listen to your chosen piece and then answer the two questions:
    1) How well does the screen reader handle the article and its figures and/or tables?
    2) How are you going to approach your own website accessibility?
- Description of Assignment 2 (in-class activity): Access the article via the Proceedings of the National Academy of Science: Bridging scales in a multiscale pattern-forming system, then answer the following questions:
    1) Do you think it's common for videos to be in scientific publications? Why or why not?
    2) Did the movie help you understand anything?
    3) Was there narration? Were you expecting any?
    4) If you were blind, would this video work for you? Explain why or why not.
    5) Discuss with teammates your answers to the above questions, along with your personal experience using screen readers.
- Description of Assignment 3 (individual homework): Please submit a memo reflecting on your simulation experience, including your use of assistive technologies while navigating the online materials. In your memo, also outline how you plan to address accessibility issues on your own professional website.

Once the students completed their websites, they were required to conduct three rounds of usability testing to evaluate web accessibility. The first round involved teamwork, employing a heuristic engineering approach aimed at meeting established accessibility criteria. During this initial testing phase, students collaborated to identify potential usability issues based on

recognized heuristics and guidelines. The subsequent two rounds involved real users completing specific tasks on the websites. Based on the feedback received from these testing sessions, students were expected to refine their websites to enhance accessibility for a wider range of audiences.

Method and Data collection

During the exploratory stage of this study, the students' responses to the assignments served as the primary data source. A total of 44 students participated, and their submissions for the assignments were collected for data analysis. The dataset comprised 44 memos in response to the first assignment, 44 memos in response to the second assignment, 44 memos addressing the third assignment, and 6 teamwork memos answering the fourth assignment.

The research adopts a grounded theory approach to analyze the students' work. Grounded theory is particularly effective when the goal is to generate themes or patterns directly from the data, especially when the focus is on understanding processes, experiences, and interactions. This approach helps to identify and theorize how students engage with screen readers and how their perceptions of accessibility evolve. It can reveal the complexities of their experiences that may not surface through less detailed methods, enabling a rich, nuanced understanding of these multifaceted experiences.

The students' memos were analysed using an open coding process, in which key phrases were carefully highlighted and grouped based on similarities to generate themes. These themes primarily focused on the challenges the students encountered and the evolution of their perceptions of accessibility. The themes were then organized into several distinct categories. To enhance the validity and reliability of the coding process, it was repeated three times, with a two-day interval between each round.

Findings and Analysis

The data analysis revealed several recurring themes that were prominently centred around their frustration experienced while navigating online materials with accessibility issues, strategies and approaches to address accessibility concerns, the importance of transferring this accessibility mindset to their future workplaces, and ethical considerations related to web accessibility. These themes were categorized into five distinct categories, as follows:

- frustration
- sympathy and empathy
- basic accessibility protocols, such as alt text, audio, video, and colours
- web accessibility awareness
- transfer and transformation

During the simulation of disabilities, such as visual impairment and colour blindness, all the students expressed experiencing frustration when using assistive technologies. Their complaints mainly focus on the insufficient information provided in the captions. One student said,

> "*With figures, the screen reader would read the caption and associate the caption with the image, but it wouldn't describe anything about the image; it would simply say "Image" when a specific figure is selected. While the caption was descriptive about how to interpret the figure, it didn't provide enough information for users to actually have the same information using the screen reader as actually seeing the visual. For example, they wouldn't know that a graph had a downward trend in the data, or if there were outliers; they would just know what the graph's title / axes were from the caption. This limits the number of useful conclusions and understanding that users can derive from the article*".

One student complained that "*the descriptions of the images didn't really fully explain the content, so the reader doesn't get a full grasp of what the image is trying to communicate*". Another student stated,

"If I try to read the image it gives a description of the image but fails to explain that it is an image. It just explains what is happening, where it was taken, and what time it was taken. Which, although it is helpful information, is confusing without knowing that it is an image. If I had not been able to see the image and know that that was what I was trying to read I would have been very confused because it sounded like a random fact was being dropped in the middle of the article and then immediately followed by the caption. Then the voice immediately reverts to the article, which is strange. Based on this I think that the captions for the image should definitely include the figure so that it is easy to communicate to a listener that what they are seeing is an image and not a random piece of text".

One stated that "*the alt text was not informative about the message that the figure was attempting to display. On top of that, there was no caption which the screen reader could read in order to tell a visually impaired user what they should be able to take away from the figure. This drastically reduces the usability of the website for visually impaired users, since they would not get the same meaning out of the page as someone with visual abilities would*".

Several students conveyed their sympathy and empathy towards users with disabilities after the simulation. Furthermore, the experience heightened their interest in accessibility matters and motivated them to approach accessibility with greater seriousness in the future. For example, one student said，

"[t]he screen reader did quite well reading the text on the page. However, as someone who is a visual learner, I definitely had more difficulty processing the information as compared to if I was reading it. If I developed a visual disability, I imagine it would be a massive adjustment for me to learn how to absorb information that way. Additionally, I was unable to understand what was going on in the figures from the screen reader output. Even worse, the captioning in the article did not take accessibility into account. As a result, a lot of information was lost and the article was much more difficult to understand than it needed to be. More considerate and comprehensive captioning could have made a big difference."

One student stated,

"[o]verall, I found this exercise useful and it certainly broadened my perspective. I'm lucky that I haven't needed to use screen reading technology before. A prior CS partner did have a severe hand injury that required her to use dictation technology to write code, but that's one of the more notable prior experiences I've had with assistive technology. It's super important that this technology exists, but as evidenced by the limitations reading figures in the article, current technology doesn't go far enough. It's also necessary for authors to cater to a wider and diversely-abled audience, carefully considering accessibility concerns."

Another student demonstrated her interest in accessibility. She said, *"[t]his is something that I never would have even realized was possible until experimenting with a tool like this and now I am very interested in incorporating accessibility features such as that one*".

As a result of their frustrating experiences, all the students formulated specific protocols to tackle web accessibility issues. Their approach extended beyond the fundamental elements like colors, alt text, and informative captions. They recognized the importance of creating web and document designs that are simple and easy to navigate for users with disabilities. This realization prompted them to consider a more holistic approach to ensure inclusivity in their designs. For example, one student said,

"[f]or my own website, there are different elements of accessibility implemented both with front-end and more code-based design. One tip I saw specifically in the resources was to encode the language of the website in the header. Also, to prevent issues with information only being available in image format, I can add more helpful alternate text to images to provide more context when necessary (or null alt text if the image is purely decorative). I

also want to be careful in terms of actual design elements displayed to users. I will limit my color scheme to a few, distinct colors, to avoid any potential color blindness issues. I also in general want to limit the clutter on a single page, because having many items on a page or different animations can be difficult for some people to process. I also want to keep navigation very simplistic and follow conventions like having a menu bar, because using design patterns like that will mean it will be easier for everyone to navigate which increases overall useability for everyone, and is more likely to be recognized appropriately by assistive software." And one said that "I will try not to make the page too complicated because the user will get confused if they are moving their mouse down the page in a logical fashion but the information on the page is not presented like that. Like some of the accessibility articles suggested I will add null text to images with not information on them so that the user can easily skip over them."

Several students explicitly expressed that they had gained a better understanding of the significance of web accessibility and would incorporate accessibility principles into their future work continually, recognizing its importance in ensuring an inclusive and user-friendly experience for all users. For example, one student came to realize the crucial importance of website accessibility. She also recognized the challenges associated with achieving full accessibility using the tools available at present. This recognition of the difficulties serves as a valuable reminder for the need to continuously improve and develop more effective tools and practices to make websites more accessible to all users, regardless of their abilities or disabilities. One student stated that the simulating experience had strengthened his resolve to prioritize accessibility, affirming the decisions he had already made in its favor. It also served as a reminder to ensure accessibility is at the forefront of all future websites he will work on.

Conclusion

The simulation experience significantly heightened the students' interest in accessibility, raised their awareness of its importance, and motivated them to actively address web accessibility issues on their own websites. Drawing from the challenges they encountered, they formulated comprehensive protocols to tackle potential inaccessible aspects during the design and coding processes of their websites. Interestingly, only one student fully grasped the complexity of accessibility and expressed a commitment to continue working on this aspect in the future. However, several other students acknowledged the valuable lessons they learned from the frustrating experience and expressed their intention to apply this knowledge in their future workplace.

This study underscores the urgent need to enhance accessibility education within computing curricula. To better prepare future computing professionals for creating inclusive digital experiences, it is essential to incorporate comprehensive instruction on accessibility principles, tools, and practices. Educators should integrate embodied learning experiences, such as simulations, allowing students to understand firsthand the challenges faced by users with disabilities. Emphasizing ethical considerations surrounding accessibility fosters a sense of responsibility among students. In Human-Computer Interaction (HCI) courses, this embodied and ethical approach can significantly strengthen accessibility education. Educators can implement simulation activities where students engage in tasks while experiencing disabilities, utilize real-world case studies to discuss ethical dilemmas related to accessibility, and assign design projects prioritizing inclusive practices. Additionally, inviting guest speakers with accessibility expertise, fostering interdisciplinary collaboration, and facilitating reflective discussions can deepen students' understanding of ethical design responsibilities. Community engagement with local organizations supporting individuals with disabilities and introducing relevant ethical frameworks will help students recognize the social impact of their designs, ultimately fostering a more inclusive approach to technology development.

Limitations and Implication

This research involves a limited number of participants, which may restrict its generalizability to broader contexts, particularly regarding the five identified themes. A larger participant pool would introduce more complexities of embodied experiences, providing a more comprehensive understanding of web accessibility. It should be noted that the study is at a very preliminary stage, and the data coding was conducted without validation from scholars in the fields of usability, accessibility, and technical and professional communication. Consequently, the research's reliability could be further enhanced with additional input and review. Future studies may benefit from expanding the participant pool to include a larger group to thoroughly assess the effectiveness of the embodied and ethical approach to teaching web accessibility. Additionally, surveying the students after 5 to 10 years of working experience could provide insights into whether they apply accessibility in their design work and continue learning about the topic.

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