



MSC PROJECT PROPOSAL

An Investigation into Accessibility and Usability Standards for
Individuals with Limb Loss: A Research-Based System
Development Study



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An Investigation into Accessibility and Usability Standards for Individuals with Limb Loss: A Research-Based System Development Study

Bridging the Gap: Accessibility, Usability, and Resource Awareness for the Limbless Community

2. Background and Literature Review

2.1 Introduction to the Subject Area

The digital world offers significant opportunities for individuals to access information, engage with services, and participate in society. However, for people living with physical disabilities such as limb loss, these opportunities can be limited by the way digital systems are designed. Without inclusive practices, many websites and applications remain difficult or even impossible to use for individuals who rely on assistive technologies or alternative interaction methods due to the loss of one or more limbs.

Accessibility and usability are two critical, interrelated concepts in the design of inclusive digital systems. Accessibility refers to the extent to which a system can be used by people of all abilities and disabilities, particularly those who rely on assistive tools such as screen readers, alternative input devices, or voice navigation. Usability, on the other hand, focuses on how effectively, efficiently, and satisfactorily a system can be used by its intended audience. While accessibility aims to remove barriers, usability ensures that the experience is intuitive and user-friendly – both are necessary for meaningful inclusion.

Several international standards and guidelines have been developed to support the creation of accessible digital systems, such as the Web Content Accessibility Guidelines (WCAG), Accessible Rich Internet Applications (ARIA) specifications, and the work of the Web Accessibility Initiative (WAI). These standards offer best practices for making content perceivable, operable, understandable, and robust. However, many digital tools either fail to implement these guidelines fully or adopt a one-size-fits-all approach that does not account for the unique needs of specific disability communities, especially those with limb loss.

While accessibility is governed by formal standards such as the ones mentioned above, usability is typically guided by non-standardised best practices, such as Nielsen's 10 usability heuristics.

For individuals who have lost one or more limbs, the way they interact with digital interfaces can vary greatly depending on factors such as the number of limbs lost, which limbs were lost, and their stage in the recovery journey (pre-surgery, during rehabilitation, or post-surgery). Despite this, there is limited research that focuses specifically on how accessibility standards apply to this group and whether they adequately support their needs in real-world contexts.

This dissertation investigates how effectively existing accessibility and usability standards can be applied to support people with limb loss. The aim is to understand current best practices, evaluate their implementation, and develop a prototype system that demonstrates how such standards can be used to improve access to resources throughout the different stages of a user's recovery journey. In doing so, the project seeks to bridge the gap between theoretical accessibility standards and practical, usable solutions tailored to this underrepresented community.

2.2 Critical Literature Review

2.2.1 Theoretical Foundations

2.2.1.1 Disability Models

Before diving into the concepts of accessibility, usability, and inclusive design, it is crucial to understand the foundational models that have shaped how disability itself is framed in society. These models, particularly the medical and social models of disability, not only influence public perception and policy but also inform how systems are designed, who they prioritise, and what forms of inclusion are considered valid.

2.2.1.1.1 Medical Model of Disability

The medical model of disability locates the “problem” of disability within the individual's body or mind, framing impairments as abnormalities to be cured or normalised [2]. Coined by psychiatrist Dr. Thomas Szasz in the mid-1950s, it originally critiqued psychiatry's pathologisation of human emotions and behaviours, treating them as diseases to be managed with medication rather than addressing stigma or social injustice. By the 1970s, this model had become the dominant paradigm for both mental and physical conditions: people with limb loss came to view medical treatments such as surgery, prosthetics, and therapy as instruments of normalisation. Under this model, disabled individuals are sorted into “normal” and “abnormal” categories, which denies them access to resources, curtails life opportunities, and strips away agency. Large-scale institutionalisation and segregation in special programs reinforced perceptions of inferiority, while a deficit-based diagnostic and therapeutic industry continually framed disability as a personal burden. Terminology such as “afflicted” or “suffering,” along

with practices like forced sterilisation, eugenics, and genocidal policies, further entrenched the view that disabled lives are expendable. Although the medical model advanced certain treatments, it also cemented power imbalances, empowering professionals to define “normalcy” and marginalising disabled people in law, education, and daily life [2].

2.2.1.1.2 Social Model of Disability

In contrast, the social model of disability shifts the focus from individual impairments to the barriers erected by society [2]. Sparked by disability rights activism in the 1970s, most notably the 1975 manifesto of the Union of the Physically Impaired Against Segregation and sociologist Mike Oliver’s naming of the model, it asserts that disability is a constructed phenomenon. Cultural norms, institutional practices, and inaccessible environments “disable” people more than their bodies or minds. Features of this model include identifying architectural, policy-based, and attitudinal obstacles; demonstrating how social expectations and economic systems can either disable or enable participation; and mobilising collective action through demands for accommodations, legislative reform, and cultural advocacy. By framing disabled individuals as a minority group entitled to equal rights, the social model empowers communities to dismantle oppressive structures and reshape societal attitudes [2].

Together, these models provide the conceptual lenses through which accessibility and usability must be understood. They lay the groundwork for interpreting design decisions, not as neutral acts, but as responses to broader ideologies about human difference. The following section builds on these foundations to examine how accessibility and usability have emerged within Human-Computer Interaction (HCI), directly influenced by assumptions and critiques embedded in these disability perspectives.

2.2.1.2 Accessibility & Usability

Accessibility and usability are closely related concepts within the field of Human-Computer Interaction (HCI), often treated as two sides of the same coin. According to Mosconi and Porta [1], Accessibility refers to the ability of all users, including those with disabilities, to access digital content and services, often by removing barriers through the use of assistive technologies or inclusive design choices [1]. Usability, on the other hand, focuses on how intuitively, efficiently, and satisfactorily users can interact with a system, once access has been established [1]. While accessibility aims to expand *who* can use a system, usability addresses *how* effectively and comfortably they can do so. Some scholars consider accessibility as a subset of usability, particularly when accessibility is framed as designing “effective, efficient and satisfying user interfaces for more people in more situations” [1]. The distinction also lies in their primary focus: accessibility often addresses physical, sensory, and motor limitations,

whereas usability typically deals with cognitive aspects such as memorability, error management, and user satisfaction [1]. For instance, making subtitles large and legible would be an accessibility concern, while optimising line breaks for easier reading pertains to usability [1]. Unlike accessibility, which can often be validated with technical checks, usability requires deeper insights from HCI research, especially into how users think and behave [1]. As a result, improving usability tends to involve broader knowledge drawn from psychology, ergonomics, and cognitive science, making it a more complex and user-centred challenge [1].

2.2.1.3 Design Theories

2.2.1.3.1 Universal Design

Universal Design is a concept introduced by Ronald L. Mace, an architect and designer who emphasised the importance of designing environments and products that accommodate the needs of all people, regardless of age, ability, or status in life. The approach emerged from earlier frameworks like barrier-free and accessible design, but builds on them with a more comprehensive view. Mace highlighted that removing a barrier for one person might inadvertently create a barrier for someone else, so a broader perspective is required to truly achieve inclusive design solutions. Universal Design is defined as “the design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialised design” [3].

One of the most widely cited tools to explain this concept is the Seven Principles of Universal Design. These include:

- **Equitable Use:** Ensuring the design is useful to people with diverse abilities.
- **Flexibility in Use:** Accommodating a variety of preferences and abilities.
- **Simple and Intuitive Use:** Keeping the design easy to understand regardless of user experience or cognitive load.
- **Perceptible Information:** Communicating information clearly, regardless of sensory ability or environmental conditions.
- **Tolerance for Error:** Reducing hazards and the effects of accidental actions.
- **Low Physical Effort:** Enabling efficient and comfortable use with minimal fatigue.
- **Size and Space for Approach and Use:** Designing for a range of body sizes, postures, and mobility levels.

An example of Universal Design in action is Toyota’s approach to vehicle interfaces. They’ve standardised many car controls to be easily replaceable, allowing features like steering or

acceleration to be adapted for different users with minimal extra cost, enhancing accessibility while maintaining affordability [3].

2.2.1.3.2 Inclusive Design

Inclusive Design is a term most commonly used in the UK, and it has been formalised in standards like the British Standard on Managing Inclusive Design. While it shares similarities with Universal Design, Inclusive Design introduces the idea of *reasonable possibility*, suggesting that products and services should be designed to be usable by as many people as reasonably possible, and without the need for specialised adaptation [3].

One working definition reads:

“The design of mainstream products and/or services that are accessible to, and usable by, as many people as reasonably possible on a global basis, in a wide variety of situations and to the greatest extent possible without the need for special adaptation or specialised design.”

The use of the word “*reasonably*” is key here. It sets Inclusive Design apart from other frameworks by recognising that full inclusion may not always be feasible in every design case. However, this contrasts with the stance of frameworks like the UN Convention on the Rights of Persons with Disabilities, which argues for accessibility as a non-negotiable right [3].

There’s also a more philosophical and evolving view of Inclusive Design, especially within design education. This view sees Inclusive Design not as a fixed checklist but as a continuously evolving process, shaped by a growing understanding of users’ needs and expectations. It focuses on designing beautiful and functional environments that serve everyone equally, regardless of age, gender, or disability [3].

2.2.1.3.3 User-Sensitive Inclusive Design/Design for Dynamic Diversity

User-Sensitive Inclusive Design (USID) emerged as a refinement of User-Centred Design (UCD), particularly in response to critiques that traditional UCD methods were not well-equipped to handle the diversity and complexity of user needs, especially those of disabled individuals. Researchers in Dundee argued that the inclusive and universal design goals may be overly ambitious or even counterproductive when applied to all products [3].

USID suggests modifying UCD by replacing “centred” with “sensitive.” This shift acknowledges that disability and user diversity, including communication difficulties, make it difficult to define a truly representative user sample. The term *inclusive* here is also used more realistically, reflecting the limits of who can be reasonably included in a product’s user group [3].

The concept of Design for Dynamic Diversity is discussed alongside USID. It is particularly relevant when designing interfaces for older adults, whose cognitive, physical, and sensory

abilities often change over time. This approach emphasises the need to design with an understanding of this ongoing, individualised change in mind [3].

By grounding our work in Universal Design, Inclusive Design, and User-Sensitive Inclusive Design (including Design for Dynamic Diversity), we establish the principles that will guide every stage of this Dissertation. Universal Design reminds us to aim for solutions usable by the widest range of people without special adaptation. Inclusive Design tempers that ambition with “reasonable” constraints, helping us focus on what’s feasible for our specific user group—people with limb loss, while still striving for broad applicability. Finally, User-Sensitive Inclusive Design/Design for Dynamic Diversity push us to remain attentive to the evolving, individualised needs of our users, ensuring our system can adapt as their abilities change over time or across their recovery journey. Together, these theories form the blueprint for both the architecture of our prototype (e.g., how information is structured and presented) and our evaluation criteria (e.g., how we judge success in terms of both access and long-term usability).

2.2.2 Current State of Research

2.2.2.1 Accessibility Standards

The development of accessibility standards has played a crucial role in guiding designers and developers towards more inclusive digital environments. The Web Content Accessibility Guidelines (WCAG) 2.2, developed by the World Wide Web Consortium (W3C), define how to make web content more accessible to people with a broad range of disabilities, including visual, auditory, physical, speech, cognitive, and neurological impairments. WCAG is based on four core principles: Perceivable, Operable, Understandable, and Robust (POUR), and serves as an internationally recognised framework for accessibility compliance and evaluation [4]. The guidelines are designed to be technology-agnostic and testable through a combination of automated tools and human evaluation, although limitations still exist, especially in addressing complex cognitive and learning disabilities [4].

Complementing WCAG is the Accessible Rich Internet Applications (WAI-ARIA) specification, which provides a framework for enhancing the accessibility of dynamic web content and user interface components developed with technologies like JavaScript. ARIA defines roles, states, and properties that allow assistive technologies, such as screen readers, to interpret and interact with advanced elements like sliders, menus, and modal dialogs [5]. While ARIA enables developers to make rich interfaces accessible, incorrect or excessive use can sometimes decrease accessibility rather than enhance it [5]. These standards have been widely adopted in web development but are inconsistently implemented, often resulting in accessibility barriers

that still affect users with physical disabilities, such as those relying on one-handed interaction or voice control.

A notable real-world implementation of these standards can be seen in Mobility Mojo's collaboration with Threadable, which aimed to improve the accessibility of digital tools designed to support inclusive travel and accommodation environments. Mobility Mojo is a platform dedicated to enhancing accessibility in the hospitality and tourism sectors by helping businesses assess and communicate how accessible their premises are for users with a wide range of disabilities [6]. In their partnership, Threadable conducted a WCAG 2.2 audit of Mobility Mojo's "Evaluation Journey," identifying barriers related to navigation, readability, and assistive technology compatibility. The project also included the development of a responsive HTML popup, designed with accessibility in mind and tested across platforms to comply with WCAG AA standards [7].

This case study highlights the practical application of accessibility standards in industry and demonstrates a tangible commitment to inclusive design. However, it also illustrates a core limitation of such universal standards. While WCAG 2.2 offers valuable high-level guidance, its successful implementation does not necessarily equate to full accessibility for individuals with more specific needs, such as those with upper-limb loss. For example, interactions that involve drag-and-drop elements, fine cursor movements, or two-handed gestures may still be present in "compliant" systems but pose significant barriers to this user group. Therefore, the lived experiences of people with limb loss may not be fully accounted for in generalised accessibility audits. This reinforces the need for research that explores whether existing standards are sufficiently granular or if additional design considerations and evaluation approaches are necessary to ensure truly inclusive interfaces for users with upper-limb loss.

3. Research Rationale and Justification

Research on accessibility and usability standards rarely addresses the specific challenges faced by people with limb loss, despite broad international frameworks mandating inclusion. While guidelines like WCAG and national laws (e.g., the CRPD, Equality Act 2010) set baseline expectations, they rarely account for one-handed navigation, prosthetic use, or stage-specific recovery needs. This study will fill that gap by developing evidence-based, user-sensitive criteria grounded in the lived experiences of individuals with upper and lower limb loss.

3.1 Justification for the Study

3.1.1 Topical relevance

The rise of digital service platforms ranging from telehealth portals to smart assistants, and the growing emphasis on Universal and Inclusive Design in HCI have made accessible interfaces more urgent than ever. At the same time, global increases in limb loss (due to chronic illness, conflict injuries, and accidents) mean that a significant and growing user group remains underserved by current digital standards. By focusing on how people with limb loss actually interact with web and mobile systems, this project aligns with ongoing policy initiatives while addressing a concrete, real-world need.

3.1.2 Practical significance

People with limb loss often rely on alternative input methods like voice control, single-switch interfaces, or adaptive mice. But many mainstream applications remain difficult or impossible to use. This research will produce clear, actionable recommendations for updating WCAG, ARIA, and usability best practices to account for one-handed and adaptive workflows. The resulting guidelines and prototype slider system will inform digital service design (e.g., healthcare portals, e-learning platforms) and improve autonomy, reduce dependency, and enhance the psychosocial well-being of users with limb loss.

3.1.3 Academic contribution

Although prior work has explored general digital accessibility and usability, little has concentrated on the intersection of HCI and limb loss. By synthesising disability models, design theories (Universal, Inclusive, User-Sensitive Inclusive Design), and real-world standards, this project will extend academic discourse on user-centred accessibility. It will demonstrate how a social-model approach can be operationalised in a novel, adaptive slider interface representing different stages of limb loss adjustment, thereby broadening our understanding of how exclusion persists even within well-intentioned frameworks.

3.1.4 Methodological innovation

Employing mixed methods, this study combines comparative policy analysis, heuristic and task-based usability testing, and qualitative interviews with people at various stages of their limb-loss journey. A participatory co-design phase, where users help shape both content and interaction mechanics, ensures the research remains grounded in real needs. Finally, the project proposes a bespoke evaluation framework for limb-difference accessibility, offering a transferable model for future HCI studies and commercial implementations.

4. Research Aim and Objectives

4.1 Research Aim

Primary Aim:

To investigate how effectively current digital accessibility standards (e.g., WCAG 2.2, ARIA) support the needs of users with limb loss, with the hypothesis that applying these standards in combination with usability best practices can improve access to support tools and information for this group.

Primary Research Question:

How well do existing digital accessibility standards support the real-world needs of users with limb loss, and how can these standards be applied or adapted in the design of support systems to improve accessibility and usability?

4.2 Research Objectives

Objective 1: To analyse the suitability of existing accessibility standards for users with limb loss

- Sub-objective 1.1: Review and summarise WCAG 2.2, ARIA, and WAI guidelines
- Sub-objective 1.2: Evaluate their relevance to physical disabilities, particularly limb loss

Objective 2: To investigate the usability needs of users at different stages of limb recovery

- Sub-objective 2.1: Identify common challenges faced pre- and post-surgery
- Sub-objective 2.2: Determine how these challenges affect digital interaction

Objective 3: To design and develop a prototype support system guided by accessibility best practices

- Sub-objective 3.1: Implement interface features based on WCAG and ARIA
- Sub-objective 3.2: Tailor content delivery based on recovery stages (via user slider)

Objective 4: To assess the accessibility and usability of the developed system

- Sub-objective 4.1: Conduct usability testing or heuristic evaluation
- Sub-objective 4.2: Analyse how well the system meets the needs of users with limb loss

5. Expected Outcomes and Deliverables

5.1 Primary Deliverables

Dissertation Document:

- Comprehensive written report (approximately 15,000 words)
- Critical analysis of findings
- Recommendations for practice, policy, and further research

5.2 Secondary Deliverables

- **Interactive Prototype System:**
A React-based web application with a slider interface that tailors content to users' recovery stage, fully compliant with WCAG 2.2 and ARIA standards
- **Usability & Accessibility Evaluation Report:**
Detailed findings from heuristic reviews and user testing with participants who have upper-limb loss
- **Design Guidelines for Limb-Difference Accessibility:**
A concise framework mapping WCAG, ARIA Universal/Inclusive Design principles to one-handed and adaptive interaction patterns

5.3 Resource Requirements

Hardware:

- Development workstation or laptop with modern web-development capabilities
- Test devices (desktop, tablet, smartphone)
- Adaptive input hardware (e.g., one-handed keyboard, switch interface, voice-control microphone)

Software:

- React/Next.js development environment
- Accessibility testing tools (axe DevTools, WAVE)
- Screen readers (NVDA, VoiceOver)
- Version control (Git/GitHub)

Data & Participants:

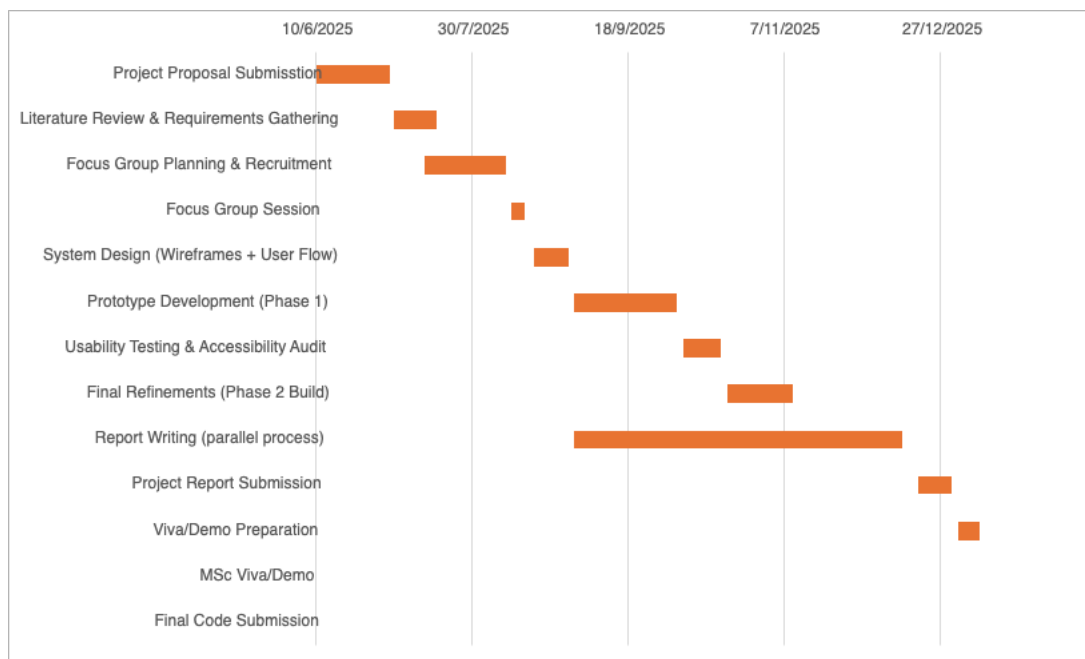
- Recruitment of 8–10 participants with upper-limb loss (across recovery stages)

- Ethical approval and informed consent procedures

Other:

- Access to a web hosting environment or an institutional server
- Supervisor/stakeholder feedback sessions

6. Project Timeline and Gantt Chart



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