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# Co-Designing Inclusive Interfaces: Participatory Approaches to Accessible E-Learning for Learners with Disabilities

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**ABSTRACT:** Inclusive e-learning environments are essential for equitable access to education, especially for the over one billion people worldwide living with disabilities. However, many e-learning platforms fail to meet accessibility standards due to top-down, non-participatory design approaches. This study aims to evaluate how iterative participatory design methods, including low- and high-fidelity prototyping, impact the accessibility and usability of specific UI elements such as navigation, readability, and input modalities for learners with visual, motor, and cognitive disabilities. The research utilized an iterative participatory design framework involving 15 participants with diverse disabilities (visual, motor, cognitive). Through three stages—needs identification, low-fidelity prototyping, and high-fidelity UI development—users co-designed and evaluated inclusive UI features. Usability was measured through System Usability Scale (SUS) scores, task success rates, completion times, and qualitative interviews. Quantitative results showed a 37% increase in task success rate, a 45% reduction in error count, and an increase in SUS score from 61 to 84. Preferred features included keyboard navigation (93%), font size adjustment (87%), and high contrast modes (82%). Qualitative feedback highlighted the importance of layout consistency, minimal visual clutter, and labeled icons. The study found that participatory design yielded more functional and satisfying UIs than conventional methods and aligned well with accessibility standards like WCAG, UDL, and COGA, while also revealing their practical limitations. Participatory UI design significantly enhances the accessibility and usability of e-learning platforms. Involving users with disabilities as co-creators ensures better alignment with real needs and reinforces the ethical imperative of inclusive education. The findings support institutional adoption of participatory methods to create more equitable digital learning environments.

**Keywords:** Participatory Design, Inclusive Interface, Accessibility, E-Learning, Usability, Disability, Universal Design For Learning.



## INTRODUCTION

Inclusive digital education has become a critical area of academic and technological interest as the global population of people with disabilities surpasses one billion. With the integration of

technology into learning environments, the digital divide has evolved, encompassing not only access to devices and connectivity but also to the accessibility of digital content and user interfaces. Recent data illustrates a concerning trend: in the U.S. alone, the proportion of postsecondary students identifying as having a disability rose from 6% in 1996 to approximately 19% in 2022 (Blasey et al., 2022). This rise underscores the urgency of addressing inclusion at the interface level. The COVID-19 pandemic further exposed these gaps, disproportionately affecting students with disabilities and increasing dropout rates due to inaccessible digital learning environments (Figard & Carberry, 2024; Lister et al., 2022).

Globally, especially in developing regions, disparities in digital access are compounded by a lack of adapted educational tools, weak infrastructure, and systemic inequities (Dube et al., 2021; Rohman & Pitaloka, 2023)d. These barriers extend beyond technical access, encompassing cultural and institutional constraints that marginalize learners with disabilities in online education settings (Bentley et al., 2019). As digital learning becomes a normative model, failing to address these intersecting factors risks deepening educational inequalities.

Historically, the design of e-learning platforms has not fully accounted for the accessibility needs of users with disabilities. Early platforms often neglected basic standards of inclusion, reflecting broader societal oversight (Ştefan et al., 2021). Progress has been made due to pressure from advocacy groups and the formalization of web accessibility standards like WCAG (Beyene et al., 2020), but significant gaps persist. Many educators and developers still do not integrate accessibility into instructional design or platform development, even when they acknowledge its importance (Kapasheva et al., 2024).

Conventional UI design models often reinforce exclusionary practices. Aesthetic-focused, generalized interfaces frequently lack support for screen readers, offer limited keyboard navigation, or use inconsistent structures that hinder user interaction for those with impairments (Azar et al., 2020). Moreover, many development processes do not involve users with disabilities, which limits their capacity to recognize or solve real user needs (Degtyareva et al., 2024). This exclusion perpetuates a cycle where technologies designed for learning become barriers themselves (Meleo-Erwin et al., 2021).

The Social Model of Disability reorients this conversation by shifting the focus from individual impairments to the societal structures that restrict participation. According to this model, disability is not inherent to the individual but arises from interactions with non-inclusive environments (Bentley et al., 2019). This paradigm encourages UI designers to eliminate structural barriers and support diverse modes of interaction, thus expanding opportunities for inclusion(Mohammad & Aldakhil, 2024).

A compelling theoretical response to the limitations of conventional approaches is participatory design (PD), which invites end users—particularly marginalized groups—to co-create technological solutions. Participatory methods are rooted in frameworks like Actor-Network Theory, which posits that user perspectives and agency actively shape technological systems (Fichten et al., 2023). By incorporating the lived experiences of users with disabilities, designers

can challenge normative assumptions and ensure functional, meaningful design outcomes (Qaadan et al., 2024). PD not only enhances system usability but also democratizes the development process, reinforcing digital inclusion as a social justice imperative (Lister et al., 2019).

This study adopts such a participatory framework to examine how inclusive UI prototyping can enhance accessibility in e-learning environments. It utilizes widely adopted frameworks WCAG, UDL, and COGA to guide the interface features tested with participants. WCAG emphasizes perceivability, operability, understandability, and robustness (Ştefan et al., 2021), while UDL encourages presenting information in multiple ways and supporting diverse methods of engagement (Lister et al., 2020). COGA, in turn, addresses the needs of users with cognitive and learning disabilities, offering recommendations such as simplified language and predictable navigation (Beyene et al., 2020).

Despite the availability of these frameworks, implementation often remains inconsistent or superficial. Thus, this study tests how participatory UI prototyping with users with visual, motor, and cognitive impairments can bridge the gap between theory and practice. It aims to identify not only what features enhance usability, but also how users experience those features and contribute to their development.

By positioning learners with disabilities as co-designers rather than passive recipients, this research challenges prevailing design norms. It asserts that inclusive digital education must be co-constructed and continually revised based on user feedback. The objective is twofold: to demonstrate that participatory design improves measurable usability outcomes, and to advocate for its adoption as a standard methodology in educational interface design. In doing so, the study aims to shift inclusive UI development from a peripheral concern to a central design principle.

## METHOD

This study employed a participatory design (PD) approach to involve users with disabilities in the co-creation of accessible e-learning interfaces. The methodology integrates qualitative and quantitative techniques across iterative design phases, ensuring that user experiences directly informed the design outcomes. This approach was selected to reflect the principles of inclusive design and to align with the Social Model of Disability.

### Participatory Design Methods

Participatory methods were central to this research. The study utilized collaborative workshops, user interviews, and usability testing sessions where participants with disabilities actively engaged in shaping the UI prototypes. These workshops fostered interaction between designers, users, and stakeholders, allowing for nuanced perspectives to be collected (Haines et al., 2021; Weilan, 2023). The "think aloud" protocol was applied during usability tests to capture real-time user feedback and identify usability concerns as they emerged (Campbell & Kester, 2023).

Narrative techniques were also used to gather rich experiential data, enabling participants to share stories and explain how interface design affected their learning engagement (Weilan, 2023). Digital tools including interactive prototypes and accessible online surveys allowed broader participation and iterative feedback across different disability groups. All digital materials were adapted for screen reader compatibility, keyboard navigation, and flexible content formats.

### Usability Evaluation Strategy

To assess the effectiveness of the inclusive UI designs, the study combined quantitative and qualitative evaluation strategies. The System Usability Scale (SUS) was employed to quantify user satisfaction and perceived ease of use (Smith-Turchyn et al., 2021). In parallel, task-based usability metrics such as task success rate, error count, and completion time were tracked to measure actual performance.

Qualitative insights were gathered through post-test interviews and structured observation. These allowed the research team to understand users' emotional and cognitive responses, usability pain points, and adaptation preferences (Yackel et al., 2024). Scenarios and personas reflecting diverse user backgrounds were used to simulate realistic tasks and ensure contextual relevance during testing.

### Sample Size and Participant Diversity

A total of 15 participants with various types of disabilities (visual, cognitive, and motor) were recruited through purposive and snowball sampling methods. This sample size, consistent with recommendations for usability testing, allowed the identification of common usability barriers while ensuring deep engagement with each user (Bassett-Gunter et al., 2016). Diversity was a key inclusion criterion, with participants selected to represent different ages, genders, and socio-economic backgrounds.

Stratified sampling ensured equitable representation across disability types. Gender and ethnicity balance were maintained to prevent biases and to reflect intersectional dimensions of accessibility (Alruwaili et al., 2023). The study prioritized inclusive recruitment by engaging with community organizations and disability advocacy groups.

### Research Process Overview

The design process comprised three main phases:

1. Needs Identification – Initial interviews and surveys identified accessibility barriers in existing UIs.
2. Low-Fidelity Prototyping – Sketches and wireframes were co-designed with users to reflect their preferences.
3. High-Fidelity Design & Validation – Refined prototypes were evaluated through usability testing, yielding quantitative and qualitative insights.

This systematic approach ensured iterative refinement, grounded in the lived experiences and feedback of the participants. The methodology reflects a commitment to inclusive technology development that is both empirically rigorous and ethically grounded.

## RESULT AND DISCUSSION

This section presents the empirical outcomes of the study, focusing on usability metrics, feature preferences, and qualitative insights derived from participatory design with learners with disabilities.

Quantitative assessments revealed marked performance gains, including a 37% increase in task success rate and a 45% reduction in error counts when using inclusive user interfaces. The task success rate increased from an average of 58% in standard UIs to 95% in the inclusive prototype. This trend is supported by external research, which shows that accessible designs can elevate task completion for users with cognitive and visual impairments by up to 30% over standard counterparts (Bashir et al., 2021).

Error rates also declined significantly. Users averaged 2.9 errors per task on standard UIs, compared to just 1.2 errors when using the inclusive design. These improvements reduced user frustration and enhanced system interaction efficiency (Turner et al., 2022).

The System Usability Scale (SUS) scores rose from 61 to 84, reflecting a marked increase in user satisfaction. Literature suggests that while SUS is generally reliable, accessibility-focused enhancements can improve its accuracy in disability contexts (Hauri et al., 2017). Inclusive UI enhancements such as tailored navigation and voice command systems have shown to improve usability scores by up to 25% (Rawlings et al., 2022).

Analysis of user feedback highlighted several features favored across disability categories. Font resizing and adjustable spacing were prioritized by 82% of visually impaired users for enhancing readability (Thorpe et al., 2024). Motor-impaired users preferred adaptive input methods such as voice commands and simplified touch navigation (Struck et al., 2024). For users with cognitive challenges, 75% favored simplified layouts that reduce distractions and support focus (Pollock et al., 2019).

Color contrast ranked highest among visually impaired users, followed by text alternatives for images. Motor-impaired users prioritized enhanced keyboard navigation and low-effort input features. Those with learning disabilities appreciated tools for clarity and feedback, such as interactive hints and highlight features (Nkohla et al., 2021).

Universal features favored across all groups included semantic structure, closed captioning, and multimodal input. Studies confirm that multimodal systems enhance usability by over 40% for users with physical impairments (Delgado et al., 2019).

User feedback underscored clarity, responsiveness, and simplicity as cornerstones of effective design. Participants emphasized the importance of intuitive UIs that anticipate user needs and reduce navigational complexity. Poor accessibility was linked to cognitive overload, frustration, and reduced engagement (Bonafede et al., 2018).

Users reported cognitive dissonance and emotional distress when encountering non-inclusive designs, particularly due to inconsistent layouts and visual clutter. Consistency in layout structure was repeatedly cited as a facilitator of confidence and ease of use (Naclerio et al., 2018).

Visual clutter was particularly detrimental for users with learning disabilities, with 78% stating it hindered their ability to process information effectively (Wang & Naveed, 2019). Participants advocated for a minimalist design philosophy that emphasizes content over decorative elements (Perez et al., 2021).

These findings reinforce the value of integrating user feedback in iterative design cycles to create genuinely inclusive e-learning environments. Designers are encouraged to treat feedback not as supplementary but as foundational to the accessibility design process.

This study contributes to the growing field of inclusive interface design by analyzing the practical application of participatory methods in developing accessible e-learning platforms. While frameworks such as WCAG, UDL, and COGA have provided foundational guidance for digital accessibility, their implementation in real-world contexts reveals several challenges and limitations.

The Web Content Accessibility Guidelines (WCAG), while offering comprehensive criteria, often suffer from over-complexity and legalistic language that alienates developers lacking in accessibility expertise (Single et al., 2023). Many institutions adopt WCAG as a compliance checklist rather than a dynamic tool for fostering genuine inclusion, which limits its usability impact. Similarly, the Universal Design for Learning (UDL) provides broad pedagogical principles but lacks the specificity required for UI implementation, particularly within digital platforms (Howes et al., 2019). The COGA guidelines, although conceptually valuable, remain under-operationalized, resulting in inconsistent application across platforms and systems. To bridge the gap between theory and practice, these frameworks must evolve to offer more actionable examples that accommodate the real-world constraints of developers and designers (Andrade et al., 2020).

In contrast to top-down accessibility improvements, participatory design (PD) methodologies invite users especially those with disabilities to serve as active contributors throughout the design cycle. Unlike expert-driven approaches, which often rely on assumptions or generalized needs, PD emphasizes lived experience, contextual adaptation, and iterative refinement (Jung et al., 2022). Research confirms that PD yields interfaces that are more usable and meaningful because users directly influence the features and interactions (Reichold et al., 2021). However, PD is resource-intensive and may be difficult to scale across large institutions or broad user groups without significant structural support (Ackermann et al., 2024). A hybrid strategy, blending the systemic benefits of top-down design with the experiential depth of PD, may offer a viable model for broader implementation (Walsh et al., 2022).

Institutional and policy frameworks provide an enabling environment for participatory UI development. Legal mandates such as the Americans with Disabilities Act (ADA), Section 504, and international conventions like the CRPD create strong obligations for inclusivity in education (Sarmiento et al., 2024). Simultaneously, educational initiatives based on UDL principles advocate for flexible, learner-centered engagement that dovetails with participatory philosophies (Castel et al., 2018). Additionally, institutional policies that mandate community involvement and user-centered research have begun to normalize collaboration between designers, educators, and learners in digital accessibility projects (Ramadhan et al., 2021). These frameworks not only legitimize participatory methods but can also embed them into the structural fabric of technology development in education.

Looking ahead, future research should explore the use of emerging technologies such as AI-driven adaptive UIs that respond dynamically to user preferences and accessibility needs. There is also a pressing need to account for intersectionality in disability studies, examining how overlapping identities such as socioeconomic status, race, and cultural background influence digital engagement (Stadler et al., 2023). Moreover, longitudinal studies assessing the real-world impact of inclusive UI designs on user satisfaction and academic performance are critical for validating current practices and informing policy changes (Moradian et al., 2018). Lastly, the ethical implications of inclusive design, particularly regarding data privacy and the unintended consequences of digital interventions, deserve increased scholarly attention (Gomez-Hernandez et al., 2023).

In sum, this study highlights that inclusive UI design extends beyond compliance requirements, emphasizing user engagement and contextual adaptation as essential elements in effective accessibility strategies.

## CONCLUSION

This study demonstrates that participatory design methodologies significantly improve the accessibility and usability of e-learning interfaces for learners with disabilities. By engaging users with visual, motor, and cognitive impairments throughout the design process, the research identified specific interface features such as keyboard navigation, font customization, and high-contrast modes that enhanced task success rates, reduced error frequencies, and increased user satisfaction. These findings support the argument that participatory approaches yield more functional and user-aligned digital environments compared to conventional top-down design models.

Furthermore, the study critiques the limitations of existing accessibility frameworks WCAG, UDL, and COGA noting that their theoretical guidance often falls short in real-world application. Integrating these frameworks with participatory methods enables more context-responsive design practices. The results advocate for institutional and policy-level support to embed participatory design as a standard practice in educational technology development, ensuring that accessibility is treated not merely as a compliance issue but as a cornerstone of equitable digital education.

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