

BEYOND THE BEEP: REIMAGINING SCREEN READER USABILITY WITH UX AT THE FOREFRONT

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ABSTRACT

Digital technologies have become deeply embedded within the present computing environments that shape users' daily interactions, emerging as essential tools for education, communication, and information exchange. While users generally engage with these technologies through digital interactions, individuals with visual impairments (VI) or visual disabilities (VD) encounter distinct challenges compared to their sighted counterparts. In the specific context of computer-aided drawing systems for the blind (CADB), existing scholarship has significantly advanced our understanding of assistive technologies and the unique ways in which blind and visually impaired (BVI) users interact with human-computer interfaces. It is crucial to enhance usability, support shape creation, and enable intuitive spatial navigation to fully leverage the potential of these interfaces and foster meaningful engagement. This study sought to identify key user experience (UX) principles relevant to the design of screen readers—critical tools in improving digital accessibility for BVI users. The research analyzed a curated selection of 18 scholarly works employing a systematic literature review methodology. A thematic analysis of these sources produced 86 sub-themes, organized into seven overarching themes: *Navigation*, *Content Creation Tools*, *Interactive Technology*, *UX Design Principles*, *Evolving Technology*, *User Needs*, and *User Skills*. These themes were synthesized into a conceptual model offering actionable insights for UX designers and developers. The resulting framework not only informs the development of more accessible and user-centered screen readers but also contributes to the broader goal of inclusive digital design by ensuring that assistive technologies address the diverse needs of their users.

KEYWORDS

User Experience Principles, Screen Readers, Blind Users, Voice Synthesis, Sightless Users, User Theories, Guidelines, Assessment Tool

1. INTRODUCTION

The Internet has emerged as a highly effective medium for educational endeavors, the exchange of information, and communication between individuals (Fernando, 2021). Visually impaired (VI) or visually disabled (VD) users do not have the same digital user experience as sighted users (Kottmeier, 2020). Recent advancements in research and development have accelerated the study of pictorial data representation by individuals who are blind or visually impaired (BVI) (Fernando, 2021). Such systems must incorporate features that enhance usability, spatial navigation, and shape creation to unlock the full potential of computer-aided drawing systems for the blind (CADB) (Fernando, 2021).

Studies have investigated how learning can be enhanced for screen readers (Buzzi et al., 2009, Yeh et al., 2008, Leporini, 2008). One study considered three factors as UX principles, which include usability, accessibility, and effectiveness (Buzzi et al., 2009). Irrespective of these findings, VI users still experience significant issues when using screen readers; Graham (2015) refers to the emotional experience of a blind user when using screen readers since most websites are designed for visual interaction. The environment within which a screen reader is used can also pose an issue because, for the user to interact with the screen reader, they must be able to hear, which can prove difficult in a noisy environment (Hlaoui et al., 2019). In addition, using screen readers is inherently time-consuming due to its functioning (Buzzi et al., 2009).

Therefore, this study aims to investigate which UX principles can be applied to design a better user experience for blind or VI users using screen readers. User experience (UX) and user interface (UI) design is a broad subject discussed on various platforms and forums (Gonzalez-Holland et al., 2017, Graham, 2015). Notwithstanding previous studies, no clear set of guidelines exists for UX designers to follow to ensure that their product is compatible with screen readers and will provide a satisfactory UX to VI users (Buzzi et al., 2009, Nielsen, 1994, Du Preez et al., 2022). Hence, this research poses the question: *What are the user experience principles applied when designing for screen readers?*

The rest of this paper is structured as follows: In Section 2, we provide the background to this research paper, and in Section 3, we describe the research methodology; Section 4 provides a discussion of the data analysis and findings; Section 5 presents the contribution of the study; and Section 6 concludes the paper.

2. BACKGROUND

When examining UX principles for digital design, it becomes clear that many of these principles are not exclusive to VI users but can also apply to users without visual impairments. For example, Du Preez et al. (2022) note that principles such as user control and freedom are essential for creating intuitive and effective interfaces for all users, regardless of their visual abilities. Similarly, seminal research by Nielsen (1994) highlights that user control—allowing users to navigate and make corrections effortlessly—benefits both VI and non-VI users.

However, the principles often lack specificity regarding how they can be tailored to meet the unique needs of VI users or how they should be implemented in the UX design process to enhance accessibility. As a result, there is a deficiency in existing UX guidelines, which fail to outline the distinct design considerations necessary for creating inclusive and accessible experiences for VI users specifically. This lack highlights the need for more targeted UX

principles that not only address general usability but also account for the particular challenges and requirements of VI users in digital environments.

2.1 User Experience (UX)

No one definition can be applied to what UX entails as it is influenced by multiple factors such as emotions and experimental aesthetics variables (Berni and Borgianni, 2021). In essence, UX represents experiences in everyday life and how humans interact with products and services, whether the encounters are meaningful or personal (Law et al., 2009, Hassenzahl, 2013) Furthermore, UX is not limited to the digital sphere only but also applies to all interactions with humans (Law et al., 2009). According to ISO 9241-210, the international standard for the ergonomics of human–system interaction, UX is defined as "a person's perceptions and responses that result from the use or anticipated use of a product, system or service" (ISO, 2024) Hence, UX design broadly encompasses methodologies, tools, and techniques associated with human–computer interaction (HCI) and user-centered design (UCD), representing both distinct and overlapping areas within these fields (Du Preez et al., 2022).

The technical engagement aspects and the emotional, cultural, social, pragmatic, and aesthetic dimensions of the user experience inform the study of HCI (Minichiello et al., 2018) Therefore, HCI recognizes that effective design must consider a holistic view of users' interactions, including their motivations, feelings, and contexts. Furthermore, UCD emphasizes the user as the central point of the design process, viewing product development as a cyclical, iterative process. The stages of this iterative process, such as analyzing general requirements, conducting contextual task analysis, system prototyping, and user evaluation, are repeated to refine the product continuously (Du Preez et al., 2022). This approach ensures that the final design is not only firmly aligned with end-users' needs, behaviors, and preferences but is also technically efficient. Designers can collect real-time feedback from users and make adjustments that improve the usability, accessibility, and overall experience of a product through active user involvement (Xie et al., 2020). This approach is particularly relevant in complex fields like assistive technologies, where iterative testing and refinement are important to addressing users' diverse needs, such as those with visual impairments (Kuriakose et al., 2022).

2.2 Blind and Visually Impaired Users

Navigation is a commonplace aspect of daily life, whether for work, education, or shopping, and vision plays an essential role in enabling movement between places (Kuriakose et al., 2022). Blindness is a medical term used to describe VD users who cannot observe the visual content of a user interface, whereas VI users cannot view design elements that are too close in color contrast or the font size of the interface that is too small (Bendaly Hlaoui et al., 2018, Jariwala, 2022). VI and VD users utilize either or both braille-based and voice-based (screen reader) computer interfaces (Yeh et al., 2008). Other systems that create shapes and drawings are also available for VI and VD users (Fernando, 2021, Leporini, 2008).

Safe and efficient navigation is one of the predominant challenges to the independence of VI people (Kuriakose et al., 2022). For efficient navigation and given the integration of technological advancements in everyday products, VI users have increasingly adopted assistive technologies (Real and Araujo, 2019). Assistive technologies include devices, equipment, services, systems, and environmental modifications that help individuals overcome physical,

social, infrastructural, and accessibility barriers (Xie et al., 2020). According to Kuriakose et al. (2022) assistive technologies are becoming increasingly important in the lives of BVI users, particularly in navigation. By using assistive technologies, visually impaired individuals can participate as equal members of society and lead active, productive, and independent lives (Xie et al., 2023).

2.3 Screen Readers

Screen readers refer to assistive technologies designed to help BVI users interact with computers by reading on-screen content aloud, often using a computer-generated voice. In addition, other forms of assistive technologies enhance accessibility, for example, through magnification tools that allow users to view larger versions of screen elements and, consequentially, enhance their accessibility (Jariwala, 2022). Screen readers also benefit individuals with learning disabilities, vestibular hypersensitivity, and motion sensitivity and thus enhance their effectiveness (Borodin et al., 2010). Screen readers offer users alternative ways to interact with digital platforms, granting access to content and interfaces that would otherwise be inaccessible. In addition to reading the main text, modern screen readers have enhanced features that improve navigation and interaction (Xie et al., 2023). They allow users to engage with different parts of the screen and move efficiently through systems, enabling a more dynamic and seamless experience (Singh, 2012). An example of such a dynamic interaction refers to specific hotkeys that can trigger announcements of different types of information, such as alerting users to misspelled words in *Microsoft Word* (Singh, 2012).

As an assistive technology, screen readers are highly dependent on the underlying technologies they interact with, highlighting the importance of designing accessible digital content and optimal browsing strategies for screen reader users (Borodin et al., 2010). Braille-based systems are another assistive technology for the visually impaired (Yeh et al., 2008). These systems use braille cells with mechanical pins that raise and lower to simulate braille characters, enabling users to read text tactilely (Yeh et al., 2008). These technologies work in parallel with screen readers to offer diverse methods of accessing digital information, further empowering visually impaired individuals to interact fully with digital environments.

3. MATERIALS AND METHODS

The study gathered data through a systematic literature review (SLR) to gather, evaluate, and integrate existing scholarly, practical, and research work toward a specific goal (Rouhani et al., 2015). For an optimal outcome, an SLR follows a meticulous and methodical approach (Biolchini et al., 2005). This study adopted the methodology outlined by Boland et al. (2017) comprising three key phases: planning, execution, and reporting. *Planning* entails delineating the research question and objectives, formulating a protocol, and establishing criteria for study selection (Boland et al., 2017). *Execution* encompasses searching for pertinent studies, screening them based on predetermined criteria, extracting data from the included studies, and assessing the study quality (Boland et al., 2017). Lastly, *reporting* involves synthesizing data from included studies and presenting findings clearly and concisely (Boland et al., 2017).

The study performed a general search in *Google Scholar* using predefined keywords to select sources. The search string used for this study was as follows: “User experience principles” AND (“Blind users” OR “Visually Impaired” OR “Sightless users”) AND “Screen readers”. Inclusion criteria refer to the characteristics of a targeted group, of which typical inclusion criteria encompass demographic, clinical, and geographic characteristics (Patino and Ferreira, 2018). The following inclusion criteria were applied in this study: blind users, visually impaired users, screen readers, and peer-reviewed studies. These included journal papers, conference proceedings, technical reports, and books.

Conversely, exclusion criteria refer to attributes of potential study participants who satisfy the inclusion criteria yet possess additional traits that might compromise the success of the study or elevate the risk of adverse outcomes (Patino and Ferreira, 2018). The following exclusion criteria were used in this study: Only papers after 2010 were included since this study focused on applications of design principles using modern technology such as smartphones, and only papers written in English were considered; duplicate papers were removed, and papers behind a paywall were excluded.

The researchers collected data on UX principles and screen readers by performing a systematic SLR (Rouhani et al., 2015) and followed two approaches to extract the papers for analysis. Table 1 represents the initial attempts resulting in 15 600 papers for review. Since this result was significant, more searches with different keywords were executed. Table 1 provides the initial search results and refinement of the search terms.

Table 1. Initial extraction attempt and final approach (Source: Researcher’s analysis)

	<i>Attempt one results</i>	<i>Attempt two results</i>	<i>Attempt three results</i>	<i>Final attempt with date exclusion</i>
<i>Keywords</i>	“User experience” AND (“Blind users” OR “Visually Impaired” OR “Sightless users”) AND “Screen Readers”	“User experience” AND “principles” AND (“Blind users” OR “Visually Impaired” OR “Sightless users”) AND “Screen Readers”	“User experience” AND “principles” AND (“Blind users” OR “Visually Impaired” OR “Sightless users”) AND “Guidelines” AND “Screen Readers”	only publications published after 2010–2024
<i>Results</i>	15 600 results	8 210 results	5 770 results	101 results

This search was conducted in academic databases, including *Science Direct*, *SpringerLink*, *IEEE Explore*, *Sage Publications*, and *Taylor & Francis*. Table 2 provides a summary of the databases used and the number of papers found in each database.

Table 2. Various academic databases used during the search phase.

<i>Database</i>	<i>Total papers found</i>
<i>Science Direct</i>	19
<i>SpringerLink</i>	25
<i>IEEE Explorer</i>	10
<i>Sage Publications</i>	17
<i>Taylor & Francis</i>	24
<i>Other</i>	6
Total	101

Figure 1 provides the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) visualization and depicts the outcome of the *conduct review* process step. The search results discussed above produced a corpus of 101 papers for review. Six (6) duplicates were identified, resulting in a corpus of 95 papers. Seventy-two (72) papers were excluded from the initial 101. These papers were excluded based on language, relevance, and paid-for publications, and one paper was published in 1968. This search produced a corpus of 23 papers for review. One paper was added to the corpus of full-text papers as it had been referenced by another study being reviewed and was valuable to the research question. From the full-text articles reviewed, six (6) articles were excluded based on relevance, one was behind a paywall, and another was a duplicate publication under another title. The selected papers resulted in a corpus of 18 papers.

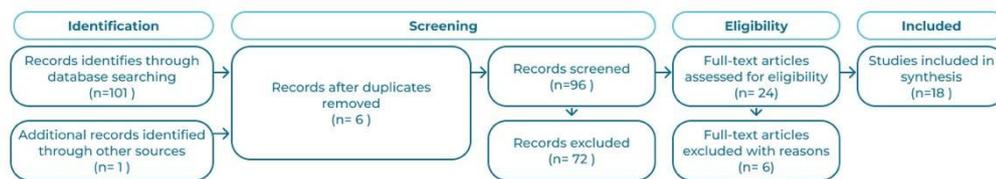


Figure 1. Prisma Flow Chart

The methods used to analyze the corpus extracted as reported in PRISMA were 1) open coding to discover emerging main themes (Leedy and Ormrod, 2015) and 2) descriptive codes to classify themes (Welman et al., 2005). Open coding involves categorizing qualitative data into smaller units and assigning a code to each unit (Leedy and Ormrod, 2015). This process revealed patterns, themes, and categories, enriching the understanding of the data and how it applies to the research question. Open coding is an iterative process; therefore, a researcher revisits the data to refine the codes and categories (Leedy and Ormrod, 2015). Conversely, descriptive codes serve to condense and classify data within a qualitative research study such as an SLR (Welman et al., 2005). These codes, typically brief phrases or words, encapsulate the essence of the data and are often derived from the data itself (Welman et al., 2005). Descriptive codes aid in organizing the data into meaningful categories and facilitate data analysis (Welman et al., 2005).

4. DATA ANALYSIS AND FINDINGS

The thematic analysis of the identified corpus yielded 86 subthemes which were grouped into seven main themes, namely *Navigation*, *Content Creation Tool*, *Interactive Technology*, *UX Design Principles*, *Evolving Technology*, *User Needs*, and *User Skills*. Table 5 lists the main themes, subthemes, and references used.

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Table 3. Main themes extracted from the literature

<i>Theme Derived</i>	<i>Subthemes</i>	<i>References</i>
<i>Navigation</i>	spatial navigation, object detection, Navigation is sequential, Easy navigation / system learning	(Priscah et al., 2021, Kimogol, 2023, Fernando, 2021)
<i>Content Creation Tool</i>	shape creation, thermoform plastic, thermal capsule paper, Hands-on exploration of 3D objects	(Fernando, 2021, Stone and Brown, 2023)
<i>Interactive Technology</i>	user-initiated command-driven interaction, Assistive technologies, Assisting hardware and software, non-visual sensory modalities, Technology, Gesture recognition, Speech processing, Natural language processing techniques, Nontraditional methods of input, Haptic feedback, Voice commands, Vibration feedback, Refreshable braille display, Prerecorded audio, Text-to-Speech convertors, Basic audio feedback, Technology integration, Digital software for learning, Voice assist feature, Custom voice features, Keyboard shortcut accessibility, Screen readers, Braille embosser, Refreshable braille display, Magnifying devices, User choice of audible features, Audio feedback, Video tutorials, Multimodal interaction, Voice-overs, Assistive ALT text, Keyboard shortcuts, Voice commands, Using touch and temperature, Voice over, Tactile feedback, Acoustic feedback, Adapted screen readers, Talking browser, Synchronized audio and vibration signals	(Fernando, 2021, Priscah et al., 2021, Muhsin et al., 2024, Kandalan and Namuduri, 2020, Jariwala, 2022, Stone and Brown, 2023, Guerreiro, 2016, Karim et al., 2023, Kimogol, 2023, Zhefan Ye Ye et al., 2021, Nolen, 2015, Lassfolk, 2023, Lahib et al., 2018)
<i>Evolving Technology</i>	Assisting and adaptive technologies, Smartphone-based assistive applications, Artificial Intelligence, Efficiency of screen readers in scanning, Multivoice assistant feature, Digital Accessibility checkers, Conversational agent, Compatibility of assisting tools, Adaptable screen readers, Refreshable braille display, Sound assigned to objects, Evolving technology, Diverse technology for different groups	(Patino and Ferreira, 2018, Priscah et al., 2021, Kandalan and Namuduri, 2020, Guerreiro, 2016, Karim et al., 2023, Kimogol, 2023, Nolen, 2015, Lassfolk, 2023, Vollenwyder et al., 2023, Martinez et al., 2022)
<i>UX Design Principles</i>	Ability to learn easily, Support for intended activity, Ability to recover, Ability to manage cognitive load, Ability to personalize, Large UI elements, equitable use, flexibility in use, simple and intuitive use, perceptible information, tolerance for error, low physical effort, appropriate size and space for use, Consistency in layouts, Font size, Contrast, Discoverability, Repetition, Hierarchy, perceivable, operable, understandable, robust, Sequence and content structure, Accessibility and usage, People first, Clear purpose, Solid structures, Easy interaction, Helpful way-finding, clean presentations, Plain language, Accessible media, Universal usability, useful, usable, desirable	(Fernando, 2021, Kandalan and Namuduri, 2020, Stone and Brown, 2023, Kimogol, 2023, Lassfolk, 2023, Vollenwyder et al., 2023, Horton and Quesenbery, 2014, Martinez et al., 2022, Bignoli and Stara, 2020)
<i>User Needs</i>	distinguishing between needs to address challenges, User needs	(Muhsin et al., 2024, Horton and Quesenbery, 2014)
<i>User Skills</i>	Digital skills	(Kimogol, 2023)

The first emerging theme is *Navigation*, which refers to how the software navigates the content on the screens, of which one subtheme is Spatial Navigation. Spatial navigation is the ability to move and determine the environment using cues. Another subtheme is object detection, referring to how different objects or elements are detected by the technology. Sequential Navigation was another subtheme derived; the research suggests that most technology used in reading content does so sequentially, which does not allow for quick navigation or scannable content as the technology needs to follow this pattern.

The second theme is *Content Creation Tool*, consisting of Shape Creation as a subtheme. Shape creation is recognizing and creating elements using technology for blind and VI users. Other creation tools can also be used to assist blind and VI users in interacting with different elements by using 3D-created technique objects such as thermoform plastic and thermal capsule paper.

The third theme is *Interactive Technology*, encompassing multiple subthemes. User-Initiated Command-Driven interaction is the first subtheme, which allows the user to give either audible or written commands to the technology on the expected action to take. The second subtheme is Assistive Technology, which includes assistive technology such as screen readers, magnifiers, text-to-speech, and speech processing. The third subtheme is Non-Visual Sensory Modalities, which can be classified into haptic feedback, gesture identification, nontraditional input methods, vibration feedback, braille embossers, and using touch and temperature. Assistive text alternative (ALT) text adds additional information to describe the object or image and is used by technology to explain context to blind and VI users. The fourth subtheme is Keyboard Shortcuts, which allow the user to add shortcuts on their keyboard to perform certain tasks or actions like closing a tab or saving an image.

The fourth theme, *Evolving Technology*, refers to the continuous development and advancement of technological tools, systems, and processes over time. The technology used for blind and VI users must be assistive and adaptive to new technology and methods; accordingly, smartphone-based assistive applications use device features to assist in identifying text and labels or reading text messages. Artificial intelligence (AI) is a subtheme of *Evolving Technology*. AI technology can perform tasks that usually require human intelligence to aid blind and VI users in everyday tasks, such as setting an alarm or opening the news tab each day at a given time. Screen Readers for scanning and Multivoice Assist features are subthemes of *Evolving Technology*. Although they originate from the *Interactive Technology* theme, once these technologies are developed or progress, performing actions, such as scanning content on a page or allowing for multiple voice or audible features, they represent *Evolving Technology*. Digital Accessibility Checkers are also a form of *Evolving Technology*. Here, the technology automatically checks for the conformity of websites to digital guidelines. Another subtheme of *Evolving Technology* is refreshable braille displays. This technology uses tiny pins to represent braille dots. Users run their fingers over these pins to read the content; the pins are easily lowered or refreshed to display the next set of information.

The fifth theme is *UX Design Principles*, which encompass key design considerations when designing digital technologies for blind and VI users, including flexibility of use, easy interaction, simple and intuitive use, and low physical effort. These guidelines refer to how content is added and the cognitive load on the users to interact with elements. Other guidelines are repetition, consistency in layouts, hierarchy, sequence and content structure, and solid structures. These guidelines refer to the structuring of the content and repetition and layout of elements on the screen.

User Needs constitute the sixth theme derived from the research. This theme examines the users' needs and challenges when using technology and the expected outcomes of such usage.

The seventh theme is *User Skills*, which focuses on the user's digital skills level when utilizing technology. Providing for different skill levels should be included when designing technology for blind and VI users.

5. CONTRIBUTION

A study by Du Preez et al. (2022) produced a model for UX design principles when designing computer interfaces for emotionally vulnerable user groups. The proposed model was enriched with findings from this study (blue text), resulting in a UX principles conceptual model for screen reader design shown in Figure 2. The categorization of the eight themes into the model considered the subthemes identified in Table 5 and used the description of the section indicated in italics and quotation marks to inform their placement.

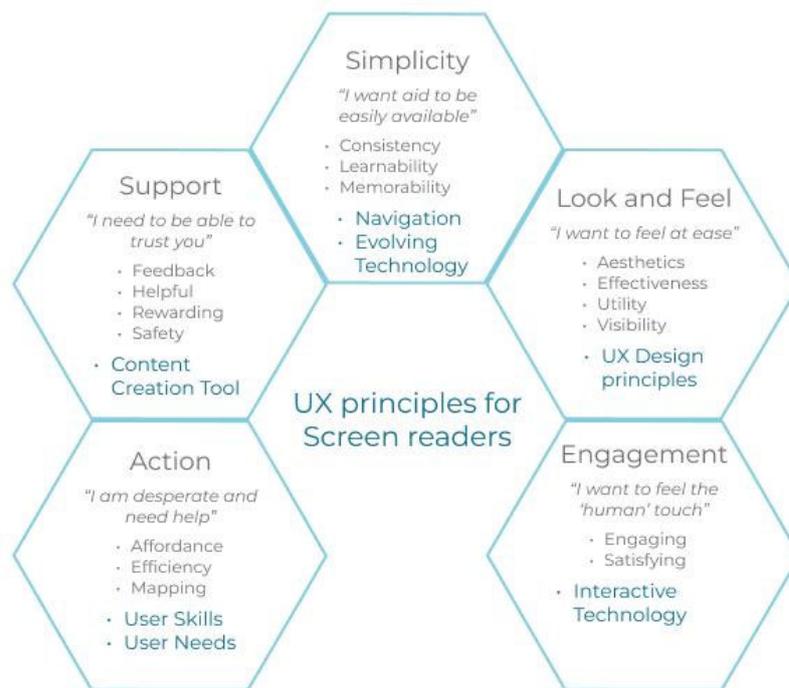


Figure 2. UX Principles Conceptual Model

Figure 2 displays the model used to map the UX principles that can be used to design for VI users and screen readers. Under the Action section, the researcher added *User Skills* and *User Needs*. *User Skills* refer to the user's digital skills. *User Needs* identify the challenges of the application. Support focuses on trust, to which the researcher added *Content Creation Tool*. Along with other helpful tools, this facet must assist the user in their day-to-day life. Under the

Simplicity section, the researcher included *Navigation* and *Evolving Technology*. *Navigation* informs the ease of use and system learning. *Evolving Technology* encompasses several subthemes, as represented in Table 5, which must aid the user of the system. Under the Look and Feel section, the researcher added *UX Design Principles*. The researcher categorized *Interactive Technology* under the Engagement section because a human will use this screen reader, and it should be engaging to use.

5.1 Assessment Tool

By using the UX principles conceptual model, an assessment tool for applying the concepts in the model can be developed. Three questions were created for each UX principle, as shown in Table 4. This assessment tool was used to evaluate interfaces using UX principles.

Table 4. Assessment tool questions

<i>Concept</i>	<i>#</i>	<i>Question</i>	<i>Reference</i>
Action	1	How easily can users identify the primary action on a screen?	(Tenner, 2015)
	2	Do users complete the intended action with minimal difficulties or hesitation?	(Nielsen, 1994)
	3	After an action is taken, are the effects (Error, confirmation message, or redirection) clearly communicated to the user?	(Lodhi, 2010)
Support	4	Does the system help the user to understand and recover from errors or problems?	(Nielsen, 2005)
	5	Does the system provide contextual support (e.g., tooltips, inline hints) at appropriate moments?	(Tidwell, 2010)
	6	Is it easy to recover from errors with helpful guidance without the system making the user feel at fault?	(Nielsen, 2005)
Simplicity	7	Is the interface designed without elements that can distract a user's focus or cause cognitive overload?	(Sandalci, 2021)
	8	Can users complete the main task without extra steps or unnecessary information?	(Nielsen, 2005)
	9	Are key actions and content presented clearly and concisely?	(Nugraha)
Look & Feel	10	Does the visual design align with the brand's personality and create the intended emotional response?	(Rättel, 2021)
	11	Is there consistency in the style of the design elements such as color schemes, typography, and spacing across the interface?	(Saputra and Kania, 2022)
	12	Does the interface look modern, clean, and visually appealing to the target audience?	(Braham et al., 2022)
Engagement	13	Does the interface encourage users to explore or interact further?	(Sutcliffe, 2022)
	14	Do interactive elements, such as animations and micro-interactions, positively enhance the user experience without causing distraction?	(Shwany et al., 2024)
	15	Does the interface incorporate motivational elements or rewards, such as progress indicators, badges, or personalization, to encourage user engagement?"	(Ronkainen, 2023)

A rating system using a five-point Likert scale was employed to use this tool effectively. One (1) represents *strongly disagree*, and five (5) represents *strongly agree*. Each question was rated on this scale to evaluate a digital platform with the UX principles provided in the conception model. The assessment tool was employed to evaluate two different interfaces. The first interface did not use these identified UX principles comprehensively, and the second interface was created by a team of experts who applied the UX principles. Figure 3 below displays the results in a radar graph.

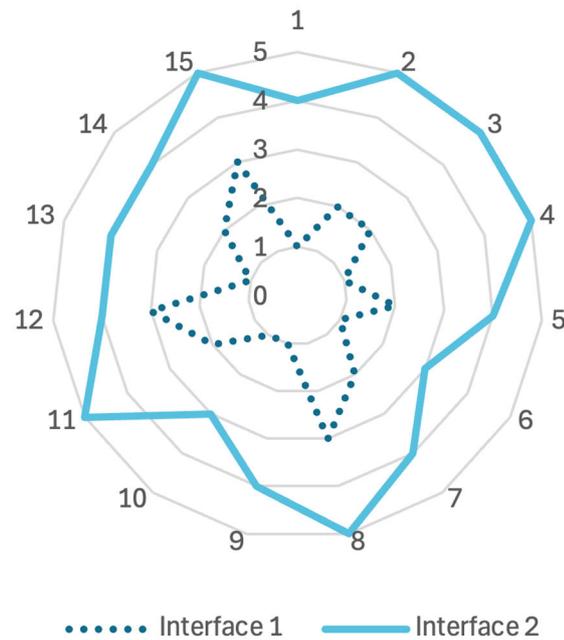


Figure 3. Radar graph

Figure 3 illustrates an assessment of two interfaces using the assessment model, as described in Section 5.1. *Interface 1* was designed with minimal UX principles applied, whereas *Interface 2* was designed by experts applying the UX principles. This assessment tool evaluates the measure to which an interface applies these principles. Moreover, it provides insight for interface designers insight into potential problem areas. For instance, a rating of three (3) was given to *Interface 2* on Question 10 (refer to Table 4). Such a lower rating could provide designers with potential design priorities.

6. CONCLUSION

The Internet has transformed education by providing a powerful platform for information exchange and communication. However, visually impaired (VI) and visually disabled (VD) users encounter unique challenges that significantly differ from the digital experiences of

sighted users. While discussions about accessibility exist, clear guidelines for UX designers in ensuring compatibility with screen readers and enhancing the digital experience for VI users remain limited. This study sought to address this gap by investigating the key UX principles for designing better interactions for blind or VI users who rely on screen readers.

Through a systematic analysis of 18 full-text papers, the study identified 86 sub-themes, which were consolidated into seven main themes: *Navigation*, *Content Creation Tools*, *Interactive Technology*, *UX Design Principles*, *Evolving Technology*, *User Needs*, and *User Skills*. These findings provide valuable insights for optimizing UX design to create more inclusive digital environments.

The conceptual model proposed in this study offers a practical framework for guiding UX design, but it requires further testing in real-world settings. In addition, the identified themes should be validated by building prototypes and applying the guidelines across different scenarios. An assessment tool was designed using the identified UX principles. This assessment tool consists of three questions per UX Principle from the conception model, and each question can be rated on a scale from one (1) to five (5).

The assessment tool was applied to two different interfaces; the first interface did not fully implement the UX principles identified, whereas the second interface was designed by a team of experts using the identified principles. The assessment results are presented visually on a radar graph. Future research should explore how screen readers are used by VI and BVI users for varying purposes and by non-VI users who rely on assistive technologies for other needs.

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