

# ENHANCING WEB ACCESSIBILITY - NAVIGATING THE UPGRADE OF DESIGN SYSTEMS FROM WCAG 2.0 TO WCAG 2.1

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## **ABSTRACT**

*In this research, we explore the vital transition of Design Systems from Web Content Accessibility Guidelines (WCAG) 2.0 to WCAG 2.1, emphasizing its role in enhancing web accessibility and inclusivity in digital environments. The study outlines a comprehensive strategy for achieving WCAG 2.1 compliance, encompassing assessment, strategic planning, implementation, and testing, with a focus on collaboration and user involvement. It also addresses the challenges in using web accessibility tools, such as their complexity and the dynamic nature of accessibility standards. The paper looks forward to the integration of emerging technologies like AI, ML, NLP, VR, and AR in accessibility tools, advocating for universal design and user-centered approaches. This research acts as a crucial guide for organizations aiming to navigate the changing landscape of web accessibility, underscoring the importance of continuous learning and adaptation to maintain and enhance accessibility in digital platforms.*

## **KEYWORDS**

*Web accessibility, WCAG 2.1, Design Systems, Web accessibility tools, Artificial Intelligence*

## **1. INTRODUCTION**

The WCAG (Web Content Accessibility Guidelines), established by the Web Accessibility Initiative (WAI) group under World Wide Web Consortium (W3C), serves as a globally recognized collection of guidelines and principles designed to make web content accessible to those with disabilities. This set of guidelines provides a structured approach to enhance the inclusivity and usability of digital content, including websites and web applications, for individuals with various disabilities, including visual, auditory, motor, and cognitive challenges. Web accessibility standards have become essential to government website compliance because they accord with equitable access, inclusion, and government agencies' legal responsibility to serve all residents [1], [2]. WCAG 2.1 significantly improves web accessibility requirements, expanding on the foundation established by WCAG 2.0. A critical component of the new criteria is that they address the changing landscape of digital interactions, with a particular emphasis on mobile accessibility. In today's world, when mobile devices are omnipresent, WCAG 2.1 recognizes this trend and provides criteria explicitly geared toward mobile platforms [3]. A significant success requirement, for example, is ensuring that all functionality can be accessed via touch gestures recognizing the widespread use of touchscreens on smartphones and tablets. This is especially important in situations where individuals with motor disabilities rely primarily on touch-based interactions to navigate and interact with digital material.

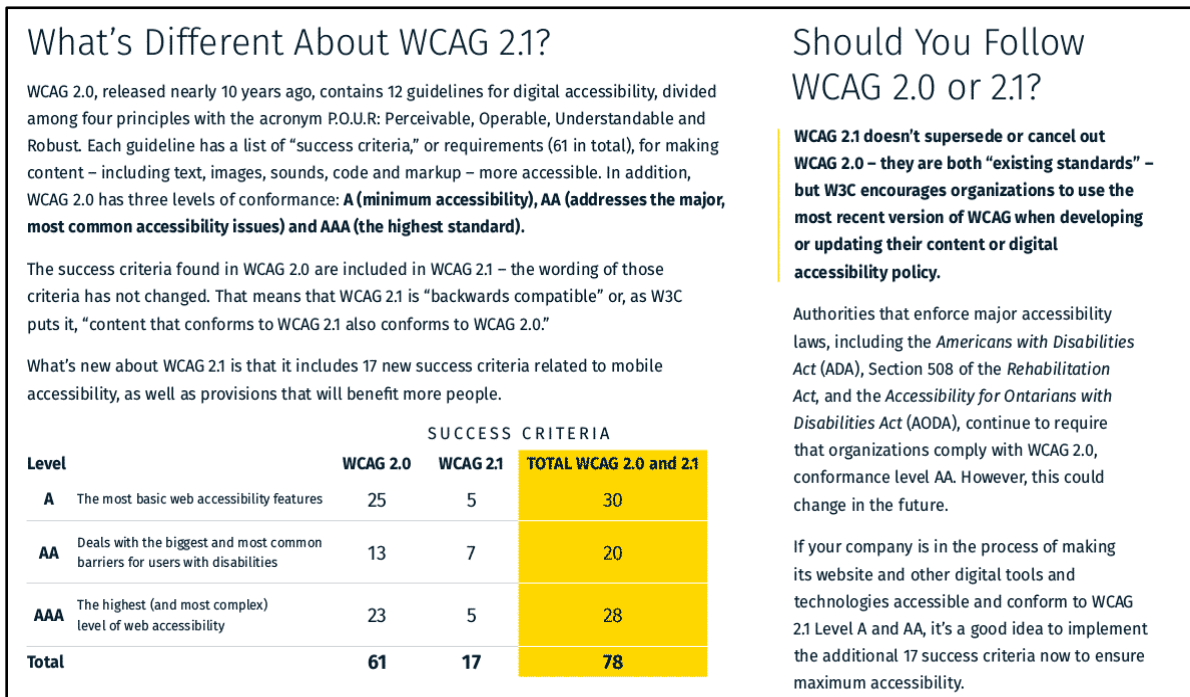


Figure 1: WCAG 2.1 scope and success criteria explained. Source: Adapted from [4]

Furthermore, WCAG 2.1 emphasizes the importance of delivering an inclusive experience for people with impaired vision [5]. New success criteria emphasize adjustable text spacing and contrast ratios to improve assistance for users with varied degrees of visual impairment. Consider the following scenario: a user with low vision visits a website on a desktop or mobile device [6]. The standards emphasize the necessity of ensuring that text is not just resizable but also adaptable in spacing, ensuring reading for people who need larger fonts or a unique visual presentation.

WCAG 2.1 also addresses cognitive and learning disabilities in depth. The new criteria emphasize developing a more cognitively accessible digital world, lowering possible barriers for people with various cognitive abilities. Consider the following scenario: a website with sophisticated terminology and extensive navigation [7]. The amended recommendations advocate for more straightforward language, predictable navigation, and fewer distractions, resulting in a more user-friendly experience for people with cognitive impairments [3]. The migration to WCAG 2.1 is not without its challenges. The complexity of web accessibility tools, the dynamic nature of web accessibility standards, and the need for continuous adaptation of these tools present significant hurdles. Moreover, integrating these tools into established development workflows can be disruptive, requiring training and adjustment for developers and designers. Additionally, the paper explores the future of web accessibility tools, highlighting emerging trends like the integration of AI, ML, and user-centered design principles, which promise to revolutionize the field of web accessibility.

Failure to comply with web accessibility regulations has resulted in litigation against governments and businesses [8]. Transitioning to WCAG 2.1 offers multiple benefits such as enhanced accessibility, a better user experience, adherence to legal standards, broader audience engagement, readiness for future developments, advantages in search engine optimization, ethical commitments, and a stronger position in the online marketplace [9]. It is a worthwhile investment promoting diversity while ensuring your digital information remains relevant and accessible in an ever-changing internet world. This research presents a clear roadmap for businesses and teams

wanting to achieve WCAG 2.1 compliance by thoroughly examining the migration process. This roadmap includes assessing the accessibility status of the current Design System, understanding the subtleties of WCAG 2.1 standards, planning the migration, implementation, testing, and continuous compliance.

## **2. LITERATURE REVIEW**

The evolution of web accessibility standards from the Web Content Accessibility Guidelines (WCAG) 2.0 to WCAG 2.1 marks a significant shift in designing inclusive digital experiences [6]. This literature review explores various scholarly works and industry practices that guide the transition of design systems to comply with the updated standards.

### **2.1. Understanding WCAG 2.0 and its Limitations**

WCAG 2.0, established by the World Wide Web Consortium (W3C), has been the benchmark for web accessibility since its inception in 2008. It provided a comprehensive framework for making web content more accessible to people with disabilities [10]. However, research studies have pointed out its limitations, particularly in addressing the needs of users with cognitive disabilities and those relying on mobile devices. It emphasized the need for guidelines that evolve with technological advancements and also highlighted the gaps in WCAG 2.0 in catering to a broader range of disabilities [7].

### **2.2. The Emergence of WCAG 2.1**

In response to these limitations, WCAG 2.1 was introduced in 2018. This version extends WCAG 2.0 by adding 17 additional success criteria focused on improving accessibility for mobile users, people with low vision, and those with cognitive and learning disabilities [8]. Another research work provides an in-depth analysis of these new WCAG 2.1 criteria, demonstrating how they enhance the user experience for a wider audience [9].

### **2.3. Transition Challenges and Strategies**

The transition from WCAG 2.0 to 2.1 poses challenges for web developers and designers. They identified the need for updated training and awareness among professionals [11]. Similarly, a study conducted revealed the lack of preparedness in the industry for this transition, suggesting a need for comprehensive guidelines and tools to aid in the process [12].

### **2.4. Tools and Frameworks for WCAG 2.1 Compliance**

Several researchers have developed tools and frameworks to assist in the transition. For instance, the work on the WAI-Tools Project provides automated testing tools that help in evaluating WCAG 2.1 compliance [13]. Additionally, a design framework has been introduced that integrates WCAG 2.1 principles into the design process, making accessibility a foundational component of web development [14].

### **2.5. Case Studies and Best Practices**

Practical applications of WCAG 2.1 in real-world scenarios are crucial for understanding its impact. The study by [10] presents a case study of a university website's transition to WCAG 2.1, offering insights into best practices and challenges faced during the process [5]. Furthermore,

[15] provided an analysis of how major corporations have adapted their design systems to comply with WCAG 2.1, highlighting the business benefits of accessibility.

## **2.6. Future Directions in Web Accessibility**

Looking forward, studies like [16] discuss the future of web accessibility standards beyond WCAG 2.1. They emphasize the importance of continuous adaptation and the potential integration of emerging technologies like AI and machine learning in enhancing web accessibility.

In conclusion, the transition from WCAG 2.0 to WCAG 2.1 is a crucial step towards more inclusive web environments. The literature presents a comprehensive view of the challenges, strategies, and tools available for this transition. It also underscores the importance of ongoing research and development in the field of web accessibility to keep pace with technological advancements and the diverse needs of users.

## **3. IMPORTANCE OF DESIGN SYSTEMS**

In the realm of web development, Design Systems have emerged as a fundamental framework, providing a structured approach to creating and managing digital products. These systems are not merely a collection of UI components and style guides; they represent a cohesive set of principles, patterns, and practices that guide the design and development process [6]. The importance of Design Systems lies in their ability to ensure consistency, improve efficiency, and foster collaboration among teams, ultimately leading to a more coherent user experience across various digital platforms.

A well-implemented Design System serves as a single source of truth for both designers and developers. It streamlines the design process by providing a library of reusable components and patterns [17]. This not only accelerates the development cycle but also ensures that the final product maintains visual and functional consistency [3]. By standardizing UI components, Design Systems reduce redundancy in the design process, allowing teams to focus on solving unique user problems rather than reinventing the wheel with each project. Moreover, Design Systems play a crucial role in enhancing the scalability of digital products [5]. As organizations grow and evolve, their digital products need to adapt without losing their core identity. Design Systems provide a flexible yet consistent framework that can accommodate new features and functionalities while maintaining the brand's visual language and user experience standards.

The strategic incorporation of Web Content Accessibility Guidelines (WCAG) 2.1 into Design Systems presents a significant advantage. WCAG 2.1 extends beyond the provisions of WCAG 2.0 by addressing a wider range of disabilities, including those related to vision, hearing, physical, speech, cognitive, language, learning, and neurological disabilities [16]. Integrating WCAG 2.1 directly into a Design System, as opposed to retrofitting accessibility into individual web applications, ensures that accessibility is not an afterthought but a foundational aspect of the design process.

This proactive approach to accessibility has several benefits. Firstly, it ensures that all components in the Design System are accessible from the outset, reducing the need for costly and time-consuming modifications later in the development process [10]. Secondly, it fosters an inclusive design philosophy, encouraging designers and developers to consider a diverse range of user needs and preferences from the beginning [12]. Through embedding WCAG 2.1 standards into the Design System, organizations can ensure compliance with legal requirements, thereby avoiding potential legal ramifications and enhancing their reputation as inclusive and socially

responsible entities. In conclusion, Design Systems are indispensable in modern web development, offering a structured, efficient, and scalable approach to design and development. The integration of WCAG 2.1 into these systems is not just a strategic advantage but a necessity in today's digital landscape, where accessibility and inclusivity are paramount [11]. By embracing this approach, organizations can create digital experiences that are not only aesthetically pleasing and consistent but also accessible to a broader audience, including those with disabilities.

#### **4. UNDERSTANDING WCAG GUIDELINES AND KEY CHANGES IN WCAG 2.1**

The Web Content Accessibility Guidelines (WCAG), established by the World Wide Web Consortium (W3C), serves as a globally recognized set of guidelines and principles designed to make web content accessible to those with disabilities. This set of guidelines provides a structured approach to enhance the inclusivity and usability of digital content, including websites and web applications, for individuals with various disabilities, including visual, auditory, motor, and cognitive challenges. Web accessibility standards have become essential to government website compliance because they accord with equitable access, inclusion, and government agencies' legal responsibility to serve all residents [1], [2]. Failure to comply with web accessibility regulations has resulted in litigation against governments and businesses [8]. WCAG 2.1 encompasses a mix of normative and informative guidelines [11], mirroring the structure found in WCAG 2.0, and it introduces an additional 17 success criteria aimed at advancing web accessibility [12]. Transitioning to WCAG 2.1 offers numerous benefits such as enhanced accessibility, an enriched user experience, adherence to legal standards, broader audience engagement, preparation for future requirements, advantages in search engine optimization, ethical considerations, and gaining a competitive edge in the online marketplace [9]. It is a worthwhile investment promoting diversity while ensuring your digital information remains relevant and accessible in an ever-changing internet world. This research presents a clear roadmap for businesses and teams wanting to achieve WCAG 2.1 compliance by thoroughly examining the migration process. The roadmap includes assessing the accessibility status of the current Design System, understanding the subtleties of WCAG 2.1 standards, planning the migration, implementation, testing, and continuous compliance.

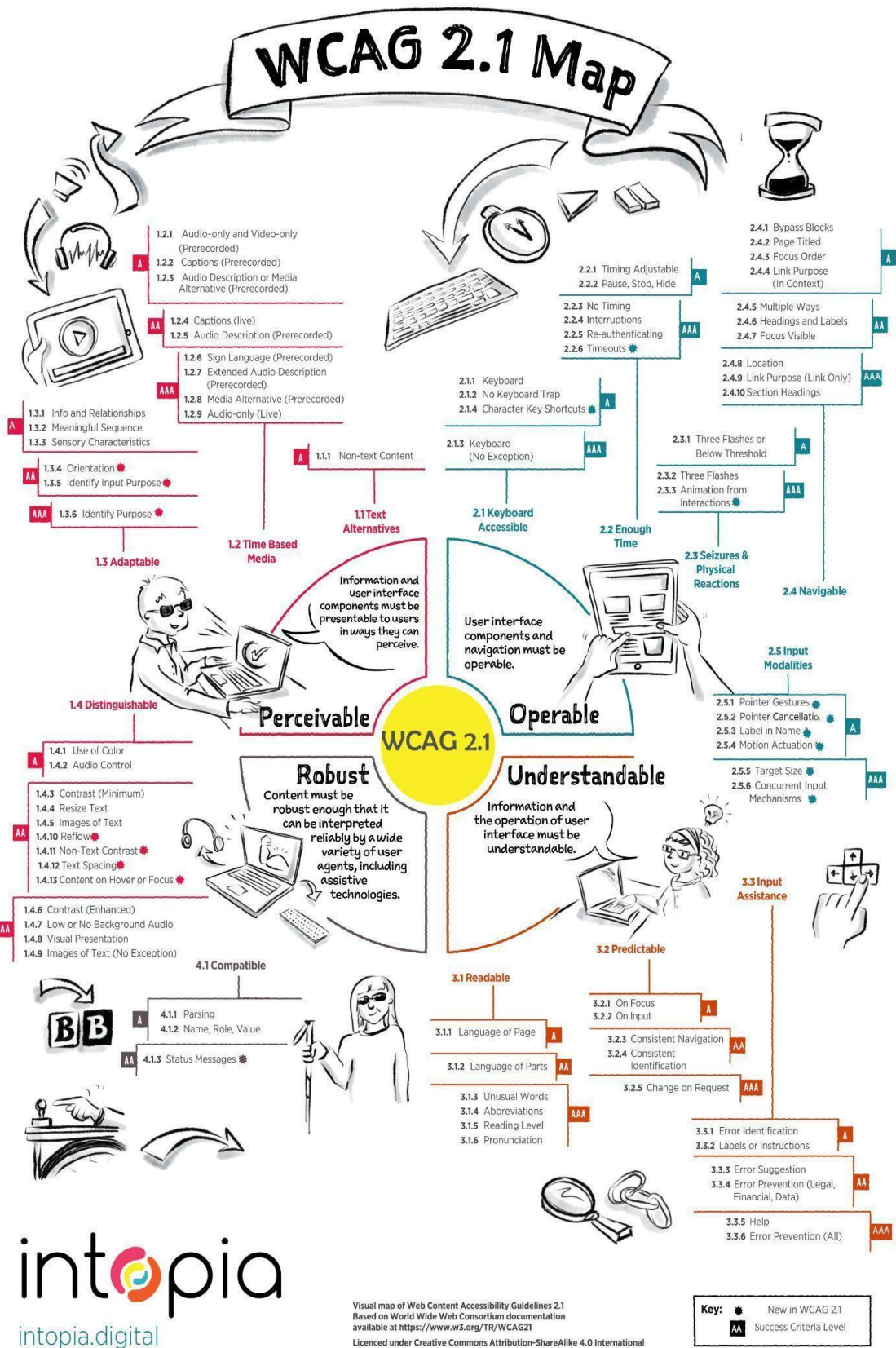


Figure 2: Key changes in WCAG 2.1. Source: Adapted from [13]

## **5. BENEFITS OF ADDING WCAG 2.1 SUPPORT IN DESIGN SYSTEMS**

In the evolving landscape of web development, the importance of accessibility cannot be overstated. The Web Content Accessibility Guidelines (WCAG) 2.1 represent a significant step forward in making web content more accessible to a wider range of people with disabilities [18]. Transitioning design systems from WCAG 2.0 to WCAG 2.1 is not just a compliance measure, but a strategic enhancement that brings numerous benefits.

### **5.1. Enhanced User Experience for a Broader Audience**

WCAG 2.1 extends the accessibility considerations of WCAG 2.0 by including additional criteria to cater to users with cognitive and learning disabilities, users with low vision, and users with disabilities on mobile devices [19]. By integrating WCAG 2.1 into design systems, developers and designers can create websites and applications that are more usable and inclusive, thereby reaching a wider audience [20]. This inclusivity is not only a moral imperative but also expands the potential user base, which can be particularly beneficial for commercial websites.

### **5.2. Improved Compliance with Legal Standards**

Many countries are adopting stricter regulations regarding web accessibility. By aligning design systems with WCAG 2.1, organizations can ensure they are compliant with current and future legal requirements [21]. This proactive approach can prevent potential legal challenges related to accessibility, which can be costly and damaging to an organization's reputation.

### **5.3. Enhanced SEO and Online Visibility**

Search engines increasingly favor websites with higher accessibility standards. WCAG 2.1's focus on clarity, navigation, and responsiveness contributes to better SEO. Websites that adhere to these guidelines are likely to rank higher in search engine results, leading to increased visibility and traffic [6].

### **5.4. Future-Proofing Web Assets**

WCAG 2.1 is designed with future technologies in mind, including mobile and emerging assistive technologies. By adopting WCAG 2.1, design systems are better prepared for the evolving technological landscape [17]. This forward-thinking approach ensures that web assets remain relevant and accessible as new technologies emerge.

### **5.5. Enhanced Brand Image and Corporate Social Responsibility**

Implementing WCAG 2.1 demonstrates an organization's commitment to diversity, equity, and inclusion [6]. This can enhance the brand's image and reputation, showing potential customers and partners that the organization values accessibility and inclusivity.

### **5.6. Reduced Maintenance and Development Costs**

In the long run, incorporating WCAG 2.1 into design systems can lead to reduced maintenance and development costs. Accessible design is often cleaner and more efficient, leading to faster load times and reduced bandwidth usage [6]. Additionally, accessible websites tend to be more robust and easier to maintain, with fewer compatibility issues across different browsers and devices.

In conclusion, the integration of WCAG 2.1 into design systems is not just about adhering to standards; it is a strategic decision that enhances user experience, ensures legal compliance, improves SEO, future-proofs web assets, boosts brand image, and can lead to cost savings. As the digital world becomes increasingly inclusive, the transition from WCAG 2.0 to WCAG 2.1 is a crucial step for any organization committed to providing equitable access to its digital content.

## 6. MIGRATING A DESIGN SYSTEM FROM WCAG 2.0 TO WCAG 2.1

Transitioning from WCAG 2.0 to WCAG 2.1 in your Design System guarantees accessibility for all users, encompassing individuals with disabilities. This migration process entails a systematic approach to aligning your design system with the most recent accessibility requirements. The first step is to assess your existing WCAG 2.0 compliance [11]. This entails thoroughly assessing your existing Design Systems to determine which components already meet WCAG 2.0 criteria and which areas need improvement. You will detect accessibility difficulties, semantic markup practices, and color contrast concerns through automated and manual testing across the Design System's components, template layouts, and demonstration examples [1]. Documenting these findings and developing a repair plan is critical to resolving WCAG 2.0 compliance issues.

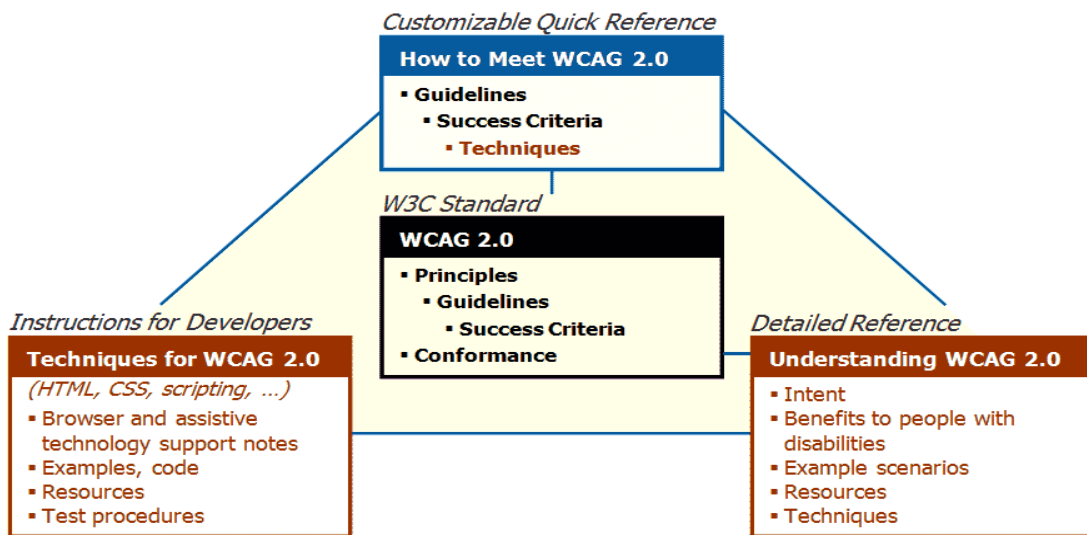


Figure 3: WCAG 2.0 migration - Quick Reference. Source: Adapted from [22]

When initiating the migration process, understanding the differences between WCAG 2.0 and WCAG 2.1 is essential. This information lays the groundwork for a smooth transition to the upgraded rules, ensuring you know the new success criteria, guidelines, and strategies provided in WCAG 2.1. The next step is to identify appropriate success criteria in WCAG 2.1 that are specific to your design system [21]. Because not all success criteria will have an immediate influence on your Design Systems, concentrate on those that will immediately impact the accessibility of your website or applications [14]. With a firm grasp of your starting point and the differences in the rules, it is essential to develop a complete migration strategy. This approach should encompass detailed methods, a timeline, designated roles and responsibilities for the migration process, and potential impacts on continuous design and development activities.

Several organizations have successfully transitioned from WCAG 2.0 to WCAG 2.1 by implementing effective tactics. Microsoft, for example, adopted a comprehensive effort to align



its products, including Office 365 and Windows, with WCAG 2.1 criteria [21]. Microsoft promoted user interaction, doing extensive testing with people of varying abilities and incorporating comments to improve the accessibility of their products [19]. Another example is the BBC, which overhauled its design systems to meet WCAG 2.1 requirements. Prioritizing mobile accessibility and addressing cognitive disabilities through simplified language and navigation was part of the BBC's approach [5]. These examples highlight the significance of comprehensive assessment, strategic planning, and user participation in the migration process [6]. To ensure that their staff understood and supported the new standards, Microsoft and the BBC demonstrated proactive communication, transparent documentation, and regular training [21]. These real-world examples not only highlight successful transitions but also demonstrate the iterative nature of accessibility, urging firms to consider compliance as a journey rather than a one-time chore.

Prioritization is essential during your migration process. Prioritize accessibility improvements depending on their importance and urgency. Determine which situations require immediate attention and which can wait, allowing you to manage resources more effectively. As you progress, it is critical to review and update your accessibility rules and best practices documents [8]. Keeping your reference documents up to date can assist your design and development teams in keeping up with the current guidelines. The core of the migration process involves adopting the newly established success criteria set forth by WCAG 2.1 [11]. To achieve these revised accessibility standards, you must modify or add code, styles, and interaction patterns to your Design Systems [2]. The journey, however, continues after implementation. Conduct extensive accessibility testing to guarantee your Design Systems are entirely WCAG 2.1 compliant. This testing uses automated tools, manual evaluations, and assistive technology testing to identify and address any remaining issues.

Web accessibility is built on inclusivity; user testing and feedback are vital. Involve disabled persons in testing to obtain insights and feedback and fix any usability issues that may develop during this vital time. Provide training and awareness sessions on the new accessibility requirements set by WCAG 2.1 to empower your team for success [10]. It is critical for effective execution that your design and development teams grasp these requirements. Accessibility is a continuous effort. Create a procedure for continuing compliance that includes regular evaluations and changes to keep your Design Systems in line with WCAG 2.1 and future accessibility requirements. The importance of broad user participation in ensuring the success of the transition from WCAG 2.0 to WCAG 2.1 cannot be emphasized. Diverse user engagement gives a richness of viewpoints from a diverse range of skills, limitations, and user experiences [21]. This inclusivity serves as a litmus test for the efficacy of the modifications undertaken, allowing organizations to detect and address any accessibility hurdles that could otherwise go unnoticed [17]. Organizations obtain essential insights into the real-world usability of their digital assets by actively engaging users with varied needs, including those with visual, auditory, motor, and cognitive impairments. This user-centric approach not only adheres to essential accessibility standards but also develops a more empathic and responsive design attitude.

Furthermore, incorporating varied users in the testing phase helps to create a digital environment that caters to a larger audience [21]. It guarantees that the improvements implemented not only meet compliance criteria but also resonate with end users, resulting in a genuinely inclusive online experience. As a result, the depth and diversity of user involvement throughout the testing process are inextricably related to the migration's success.

Throughout this procedure, effective communication is critical. Changes and upgrades to your Design System should be communicated as it transitions to WCAG 2.1 compliance, engaging stakeholders to ensure everyone is informed and on board with the accessibility advances [12].

Maintain thorough documentation of the migration process and seek expert support from accessibility experts or organizations as needed [15]. Their advice can be invaluable in ensuring full WCAG 2.1 compliance and offering an inclusive user experience. Finally, remember to see WCAG 2.1 compliance as a critical step toward establishing a more accessible and inclusive digital world [6]. It acknowledges the commitment and hard work of your team in enhancing the accessibility of digital content for a wider audience.

## **7. THE ROLE OF MANUAL AND AUTOMATED TESTING IN THE MIGRATION PROCESS**

The significance of automated testing and manual audits in ensuring that Design Systems adhere to the most recent accessibility standards is critical when migrating from one set of accessibility guidelines to another, such as WCAG 2.0 to WCAG 2.1. Automated Scanning Tools are a helpful first step in the evaluation process. Organizations should proactively stay educated about developing rules as they anticipate future accessibility requirements such as WCAG 2.2 and WCAG 3.0 [6]. It is critical to embrace a culture of continual learning and adaptability [3]. Participating in pilot programs and early adoption activities for beta versions might provide valuable insights. Collaboration with user communities and the adoption of future technology, such as AI-powered accessibility solutions, will be critical [18]. Creating a structure for continuing accessibility reviews and encouraging a user-centric approach can help organizations move to and exceed forthcoming standards. This strategic vision not only assures compliance but also places enterprises at the forefront of providing inclusive digital experiences in a rapidly changing technology context. These tools are helpful for quickly finding common accessibility concerns in your Design System examples. Scanners excel at detecting flaws such as missing alt text for photos, incorrect markup structures, and text with insufficient contrast ratios [10]. They provide a rapid and systematic way to identify any issues with your Design System [5]. The W3C validation service, WebAIM Contrast Checker, Chrome Lighthouse, WAVE Web Accessibility Evaluation programs, and Accessibility Insights are well-known examples of automated scanning programs [14]. Utilizing these tools can accelerate the detection and resolution of simple difficulties. Manual testing, on the other hand, remains an essential component of the accessibility review process [1]. While automated technologies are beneficial, they may not detect all accessibility concerns. Human-led testing introduces a personal touch to the evaluation process, enabling a more detailed and subtle analysis [16]. It is critical to examine each design component in your Design System examples through the lens of accessibility during manual testing. This includes extensive testing with keyboard navigation, screen readers, and other assistive technology people with impairments use. Manual testing emphasizes key aspects such as proper management of focus, operability through keyboard input, and compatibility with screen readers. By doing extensive manual audits, you can uncover finer flaws that may not be detectable automatically.

## **8. CONSIDERATIONS IN USING WEB ACCESSIBILITY TOOLS FOR WCAG 2.1 MIGRATION OF DESIGN SYSTEMS**

In the process of utilizing web accessibility tools for the migration of Design Systems to WCAG 2.1, several key considerations come into play. The first is the selection of appropriate tools. It's essential to choose tools that not only align with the specific requirements of WCAG 2.1 but also cater to the unique aspects of the Design System being upgraded [23]. Tools vary in capabilities, ranging from automated testing to color contrast analysis, and each plays a distinct role in the migration process.

Another critical aspect is ensuring comprehensive coverage of WCAG 2.1 guidelines. The tools must be capable of evaluating the new criteria introduced in WCAG 2.1, which include considerations for mobile accessibility, cognitive disabilities, and enhanced contrast requirements, alongside the existing standards.

The integration of these tools into the existing development and design workflow is equally vital. This integration ensures that accessibility checks are embedded in the development process, thereby fostering a culture of continuous accessibility compliance.

However, while web accessibility tools can automate the detection of many issues, the interpretation of results often requires expert judgment. Developers and designers must be adept at distinguishing between genuine accessibility issues and false positives, making informed decisions based on the tool's output.

In addition to automated assessments, incorporating user-centered testing is crucial. This involves real users, including those with disabilities, testing the Design System to provide qualitative feedback [24]. Such testing can uncover usability issues that automated tools might miss, offering insights into the practical application of accessibility standards.

Maintaining WCAG 2.1 compliance is an ongoing process, necessitating regular monitoring and updating of the Design System. Tools that offer continuous monitoring and can adapt to evolving standards and technologies are particularly beneficial in this regard.

Lastly, the effectiveness of these tools is significantly influenced by the knowledge and awareness of the team using them. Training and resources for developers, designers, and content creators about WCAG 2.1 and the effective use of these tools are essential. This ensures that the team is not only reliant on tools but also deeply understands the principles of web accessibility and can apply them effectively in their work.

## **9. CHALLENGES IN USING WEB ACCESSIBILITY TOOLS FOR WCAG 2.1 MIGRATION OF DESIGN SYSTEMS**

The migration of Design Systems to comply with WCAG 2.1, while crucial, is fraught with challenges, particularly in the effective utilization of web accessibility tools. These challenges stem from a variety of factors ranging from the complexity of the tools themselves to the nuances of the WCAG 2.1 guidelines.

One of the primary challenges lies in the complexity and inherent limitations of web accessibility tools. While these tools are invaluable for automating parts of the compliance process, they are not infallible. Many tools are designed to identify only specific types of accessibility issues, often missing subtler, context-dependent problems [25]. For instance, a tool might flag missing alternative text for images but cannot ascertain the appropriateness or accuracy of the text provided. This limitation necessitates manual review and interpretation, adding layers of complexity to the migration process.

The dynamic nature of web accessibility standards poses another significant challenge. As digital technologies evolve, so do the standards and best practices for accessibility. Tools that were once state-of-the-art may quickly become outdated if they do not adapt to the latest guidelines and technologies. Ensuring that the tools used for WCAG 2.1 migration are up-to-date and capable of handling the latest requirements is a continuous and demanding task.

Integrating web accessibility tools into existing development workflows can be disruptive. Many organizations have established processes and tools for design and development. Introducing new accessibility tools often requires significant adjustments to these workflows. Developers and designers must be trained to use these tools effectively, which can be time-consuming and may temporarily reduce productivity.

The interpretation of WCAG 2.1 guidelines and the implementation of their recommendations can be challenging. Accessibility guidelines are often broad and open to interpretation, leading to ambiguity in compliance efforts. Designers and developers must not only understand the technical aspects of these guidelines but also their practical implications on user experience for people with disabilities.

Finally, resource constraints play a significant role in the challenges faced during migration. Comprehensive accessibility testing and remediation can be resource intensive. Smaller organizations or teams may lack the necessary budget, time, or expertise to effectively utilize web accessibility tools and implement the required changes [26]. This constraint can lead to partial or inconsistent application of WCAG 2.1 guidelines, undermining the overall goal of accessibility.

In conclusion, while web accessibility tools are essential for the migration of Design Systems to WCAG 2.1, their effective utilization is beset with challenges. These include the limitations of the tools themselves, the need to keep pace with evolving standards, integration into existing workflows, the complexity of interpreting and implementing guidelines, and resource constraints. Addressing these challenges requires a multifaceted approach involving continuous learning, process adaptation, and a commitment to the principles of digital accessibility.

## **10. FUTURE OF WEB ACCESSIBILITY TOOLS**

As we look towards the future of web accessibility tools in the context of WCAG 2.1 migration for Design Systems, several emerging trends and technological advancements promise to further revolutionize this domain. The continuous evolution of web technologies and user interfaces necessitates a dynamic and forward-thinking approach to accessibility [27]. In this landscape, the role of web accessibility tools is not static; it is expected to evolve, embracing new challenges and opportunities.

One of the key trends is the increasing integration of Artificial Intelligence (AI) and Machine Learning (ML) in accessibility tools. AI and ML algorithms are poised to enhance the capability of these tools in identifying complex accessibility issues that are currently difficult to detect through manual testing or standard automated tools. For instance, AI can be used to predict and learn from user interactions, offering more personalized and adaptive accessibility solutions. This could lead to the development of more intelligent and context-aware tools that can anticipate user needs and adapt the user interface accordingly.

Another significant advancement is in the realm of natural language processing (NLP). NLP can be leveraged to improve the interpretation and vocalization capabilities of screen readers, making them more intuitive and human-like. This would be particularly beneficial for users with visual impairments, as it would provide a more seamless and engaging interaction with web content [28].

The integration of Virtual Reality (VR) and Augmented Reality (AR) in web accessibility tools is another area of potential growth. As VR and AR technologies become more prevalent, there is a growing need to ensure that these immersive experiences are accessible to all users, including

those with disabilities. Accessibility tools will need to evolve to address the unique challenges posed by these technologies, such as ensuring navigability in a 3D space and providing alternative ways to interact with VR/AR content [29].

Furthermore, the concept of universal design is gaining traction, advocating for the creation of systems and tools that are inherently accessible to everyone, regardless of their abilities or disabilities. This approach would shift the focus from making existing systems compliant to designing systems that are accessible from the ground up [30]. In this context, web accessibility tools will play a crucial role in guiding and validating the design of such universally accessible systems.

In addition, there is an increasing emphasis on user-centered design in the development of web accessibility tools. This involves engaging users with disabilities in the design and testing process, ensuring that the tools are not only technically compliant with WCAG 2.1 but also genuinely usable and beneficial for the end-users. This user-centered approach is crucial for developing tools that effectively address the real-world needs and challenges faced by users with disabilities.

Lastly, as global regulations around web accessibility become more stringent, there will be a greater demand for tools that can ensure compliance with various international standards and guidelines [31]. This will likely lead to the development of more sophisticated tools that can cater to a diverse range of requirements and help organizations stay compliant with evolving legal standards.

In conclusion, the future of web accessibility tools for WCAG 2.1 migration of Design Systems is marked by technological innovation, a shift towards more inclusive and user-centered design principles, and an alignment with global accessibility standards. These advancements will not only enhance the effectiveness of these tools but also contribute to a more inclusive and accessible digital world.

## **11. CHALLENGES FACED IN WCAG 2.1 MIGRATION OF DESIGN SYSTEMS**

During the transition from WCAG 2.0 to WCAG 2.1, organizations may face a number of problems that must be carefully considered. One significant source of concern is the possible resource strain, both in terms of time and labor, that will be necessary for the complete evaluation and implementation of new success criteria. Furthermore, updating existing digital assets to match the revised requirements may provide technological challenges, particularly for sophisticated systems or outdated applications [19]. The foundation of application architecture on HTML native elements and Component-Based Software Engineering (CBSE), plus the organizational culture's resistance to change may prevent the seamless adoption of WCAG 2.1 recommendations [32]. Furthermore, ensuring that all team members have a thorough understanding of the new criteria may take time and effort [5]. Addressing these potential complaints necessitates a proactive approach that includes strong communication, resource planning, and ongoing training to promote a joint commitment to the long-term benefits of improved web accessibility [8]. Realistic expectations and a phased implementation strategy can reduce these issues, resulting in an easier transition and long-term compliance.

Organizations migrating from WCAG 2.0 to WCAG 2.1 may face a number of obstacles. One significant source of concern is the time and work required for a complete examination and implementation of new success criteria. Technological problems may occur, particularly for

complicated systems or out-of-date applications, demanding extensive modifications to meet changed needs [17].

Furthermore, resistance to change within an organization's culture can inhibit the smooth implementation of WCAG 2.1 recommendations. Another area for improvement is ensuring that all team members understand the complexities of the new criteria [7]. To address these difficulties, a proactive approach comprising excellent communication, resource planning, and continual training is required. Realistic expectations and a phased implementation strategy can allay fears, promoting a smoother transition and long-term compliance while respecting the nuanced challenges that companies may experience in their pursuit of improved web accessibility [33].

## **12. FUTURE WORK**

The research on migrating Design Systems from WCAG 2.0 to WCAG 2.1 provides essential insights into the changing landscape of web accessibility [14]. However, certain limits must be acknowledged. The paper focuses primarily on technical factors, potentially ignoring the socio-cultural components of accessibility. Future research could address the intersectionality of accessibility, considering varied user requirements and experiences beyond the mentioned disabilities [6].

Additionally, while the handbook promotes collaboration, more significant inquiry into efficient interdepartmental cooperation and communication tactics during relocation could boost its practical application. The study's ramifications extend beyond compliance to broader ethical problems in digital design [20]. A more extensive investigation of the societal impact of accessible design and the potential for encouraging innovation and creativity in the digital world is a path for future inquiry.

## **CONCLUSION**

Transitioning a Design System from WCAG 2.0 to WCAG 2.1 is a substantial undertaking, reflecting a deep commitment to fostering diversity and user-focused design in the evolving domain of digital accessibility. This paper's conclusion highlights that such a transition extends beyond a simple technological shift; it represents a critical step towards crafting a digital landscape that is both more inclusive and fairer. The insights presented in this study illustrate that the shift to WCAG 2.1 is a transformative process, one that narrows the accessibility divide and contributes to the broader goal of a universally inclusive digital realm. The paper further details the intricacies and challenges encountered when utilizing web accessibility tools for this migration, including the limitations of these tools, the need to stay updated with changing standards, integrating them into existing workflows, interpreting guidelines, and managing resource limitations. Overcoming these challenges necessitates ongoing learning, process adaptation, and dedication to the principles of digital accessibility. Recognizing that migrating to WCAG 2.1 presents both hurdles and opportunities is crucial. This shift not only unlocks new possibilities but also prepares organizations and developers for a seamless transition to forthcoming standards like WCAG 2.2 and WCAG 3.0, ensuring that digital experiences continue to evolve in a manner that benefits all users.

## REFERENCES

- [1] E. Aspinall, A. Drayer, G. Ormsby, and J. Neveau, "Considered Content: a Design System for Equity, Accessibility, and Sustainability," *The Code4Lib Journal*, no. 50, Feb. 2021, Accessed: Oct. 01, 2023. Available:<https://journal.code4lib.org/articles/15639>
- [2] M. Campoverde-Molina, S. Luján-Mora, and L. Valverde, "Accessibility of university websites worldwide: a systematic literature review," *Univ Access Inf Soc*, vol. 22, no. 1, pp. 133–168, Mar. 2023, doi:10.1007/s10209-021-00825-z.
- [3] Boyalakuntla, K., Venigalla, A. S. M., &Chimalakonda, S. (2021). WAccess--A Web Accessibility Tool based on the latest WCAG 2.2 guidelines. arXiv preprint arXiv:2107.06799. <https://ask.qcloudimg.com/draft/8841464/5o9og5u0lp.pdf>
- [4] K. M. A. Manager, "What is WCAG - WCAG Checklist for 2.1," Kiosk Manufacturer Association. Accessed: Nov. 14, 2023. Available: <https://kma.global/what-is-wcag-wcag-checklist-for-2-1/>
- [5] S. Kumar, J. Shree DV, and P. Biswas, "Comparing ten WCAG tools for accessibility evaluation of websites," *Technology and Disability*, vol. 33, no. 3, pp. 163–185, Jan. 2021, doi:10.3233/TAD-210329.
- [6] G. Klingofström and L. Runsten Fredriksson, *Accessibility in e-commerce: A comparative study of WCAG 2.1 and EU Directive 2019/882*. 2023. Accessed: Nov. 15, 2023. Available:<https://urn.kb.se/resolve?urn=urn:nbn:se:su:diva-219602>
- [7] R. Rayl, "How to Audit Your Library Website for WCAG 2.1 Compliance," *Weave: Journal of Library User Experience*, vol. 4, no. 1, Art. no. 1, Jul. 2021, doi:10.3998/weaveux.218.
- [8] M. Chee and K. D. Weaver, "Meeting a Higher Standard: A Case Study of Accessibility Compliance in LibGuides upon the Adoption of WCAG 2.0 Guidelines," *Journal of Web Librarianship*, vol. 15, no. 2, pp. 69–89, Apr. 2021, doi:10.1080/19322909.2021.1907267.
- [9] M. Chee, Z. Davidian, and K. D. Weaver, "More to Do than Can Ever Be Done: Reconciling Library Online Learning Objects with WCAG 2.1 Standards for Accessibility," *Journal of Web Librarianship*, vol. 16, no. 2, pp. 87–119, Apr. 2022, doi:10.1080/19322909.2022.2062521.
- [10] I. A. Doush, A. Al-Jarrah, N. Alajarmeh, and M. Alnfai, "Learning features and accessibility limitations of video conferencing applications: are people with visual impairment left behind," *Univ Access Inf Soc*, Sep. 2022, doi:10.1007/s10209-022-00917-4.
- [11] "Understanding WCAG 2.1 | WAI | W3C." Accessed: Sep. 21, 2023. Available: <https://www.w3.org/WAI/WCAG21/Understanding/>
- [12] W3C Web Accessibility Initiative, "What's New in WCAG 2.1." Aug. 13, 2020. Accessed: Sep. 21, 2023. Available: <https://www.w3.org/WAI/standards-guidelines/wcag/new-in-21/>
- [13] R. Onsmann, "Intopia Launches WCAG 2.1 Map," Intopia. Accessed: Sep. 24, 2023. Available:<https://intopia.digital/articles/intopia-launches-wcag-2-1-map/>
- [14] J. Nakatumba-Nabende, B. Kanagwa, F. N. Kivunike, and M. Tuape, "Evaluation of accessibility standards on Ugandan e-government websites," *Electronic Government, an International Journal*, vol. 15, no. 4, pp. 355–371, Jan. 2019, doi:10.1504/EG.2019.102615.
- [15] M. Jonsson, S. Johansson, D. Hussain, J. Gulliksen, and C. Gustavsson, "Development and Evaluation of eHealth Services Regarding Accessibility: Scoping Literature Review," *Journal of Medical Internet Research*, vol. 25, no. 1, p. e45118, Aug. 2023, doi:10.2196/45118.
- [16] K. Zdravkova, F. Dalipi, and V. Krasniqi, "Remote Education Trajectories for Learners with Special Needs During the Covid-19 Outbreak: An Accessibility Analysis of the Learning Platforms," *International Journal: Emerging Technologies in Learning*, vol. 17, no. 21, pp. 89–122, 2022, doi:10.3991/ijet.v17i21.32401.
- [17] Boyalakuntla, K., Venigalla, A. S. M., &Chimalakonda, S. WAccess--A Web Accessibility Tool based on WCAG 2.2, 2.1, and 2.0 Guidelines. arXiv preprint arXiv:2107.06799. Sep: 2021, doi: 10.48550/arXiv.2107.06799.
- [18] J. R. de O. G. Pimenta, E. F. Duarte, and M. C. C. Baranauskas, "Evaluating Accessibility in Ubiquitous Environments: a Case Study with Museum Installations," in *Anais do Seminário Integrado de Software e Hardware (SEMISH)*, SBC, Jul. 2021, pp. 88–96. doi: 10.5753/semish.2021.15810.
- [19] S. Paul, "Accessibility analysis using WCAG 2.1: evidence from Indian e-government websites," *Univ Access Inf Soc*, vol. 22, no. 2, pp. 663–669, Jun. 2023, doi:10.1007/s10209-021-00861-9.

- [20] Jessica Dawn Brown, MLIS, “Analysis of Free Browser-based Accessibility Tools: WCAG 2.1 Evaluation of Mississippi Gulf Coast Public Library Websites,” *SLIS Connecting*, vol. 10, no. 2, p. 101, Feb. 2022, doi:10.18785/slis.1002.10.
- [21] P. Acosta-Vargas *et al.*, “Accessibility Assessment in Mobile Applications for Android,” in *Advances in Human Factors and Systems Interaction*, I. L. Nunes, Ed., in *Advances in Intelligent Systems and Computing*. Cham: Springer International Publishing, 2020, pp. 279–288. doi:10.1007/978-3-030-20040-4\_25.
- [22] Hidde de Vries and Shadi Abou-Zahra, “The WCAG 2.0 Documents.” Oct. 05, 2023. Accessed: Nov. 14, 2023. Available: <https://www.w3.org/WAI/standards-guidelines/wcag/docs/>
- [23] Emma J. Rose, Craig Macdonald, and Cynthia Putnam, “Design Systems: A scalable model for teaching design systems for UX | Proceedings of the 5th Annual Symposium on HCI Education,” in *ACM Other conferences*, Apr. 2023, pp. 5–7. doi: 10.1145/3587399.3587403.
- [24] C. Putnam, E. J. Rose, and C. M. MacDonald, “‘It could be better. It could be much worse’: Understanding Accessibility in User Experience Practice with Implications for Industry and Education,” *ACM Trans. Access. Comput.*, vol. 16, no. 1, p. 9:1-9:25, Mar. 2023, doi: 10.1145/3575662.
- [25] S. Hadadi, Z. Sarsenbayeva, and J. Kay, “Starting well on design for accessibility: analysis of W3C’s 167 accessibility evaluation tools for the design phase,” in *Proceedings of the 25th International ACM SIGACCESS Conference on Computers and Accessibility*, in *ASSETS ’23*. New York, NY, USA: Association for Computing Machinery, Oct. 2023, pp. 1–7. doi: 10.1145/3597638.3614474.
- [26] Hidde de Vries and Shadi Abou-Zahra, “The WCAG 2.0 Documents.” Oct. 05, 2023. Accessed: Nov. 14, 2023. Available: <https://www.w3.org/WAI/standards-guidelines/wcag/docs/>
- [27] J. Abascal, M. Arrue, and X. Valencia, “Tools for Web Accessibility Evaluation,” in *Web Accessibility: A Foundation for Research*, Y. Yesilada and S. Harper, Eds., in *Human–Computer Interaction Series.*, London: Springer, 2019, pp. 479–503. doi: 10.1007/978-1-4471-7440-0\_26.
- [28] J. Zong, C. Lee, A. Lundgard, J. Jang, D. Hajas, and A. Satyanarayan, “Rich Screen Reader Experiences for Accessible Data Visualization,” *Computer Graphics Forum (Proc. EuroVis)*, Jun. 2022, doi: 10.1111/cgf.14519.
- [29] B. Muczyński *et al.*, “VR Accessibility in Distance Adult Education.” arXiv, Sep. 08, 2023. doi: 10.48550/arXiv.2309.04245.
- [30] S. Horton, W. Quesenbery, and A. Gustafson, *A Web for Everyone: Designing Accessible User Experiences*, 1st edition. Brooklyn: Rosenfeld Media, 2014. Available: <https://www.amazon.com/Web-Everyone-Designing-Accessible-Experiences/dp/1933820977>
- [31] K. M. A. Manager, “What is WCAG - WCAG Checklist for 2.1,” Kiosk Manufacturer Association. Accessed: Nov. 14, 2023. Available: <https://kma.global/what-is-wcag-wcag-checklist-for-2-1/>
- [32] H. Shah, “Harnessing customized built-in elements -- Empowering Component-Based Software Engineering and Design Systems with HTML5 Web Components,” in *Computer Science & IT Conference Proceedings*, in 22, vol. 13. Academy & Industry Research Collaboration Center, Nov. 2023, pp. 247–259. doi:10.5121/csit.2023.132219.
- [33] H. Shah, “Advancing Web Accessibility -- A guide to transitioning Design Systems from WCAG 2.0 to WCAG 2.1,” in *Computer Science & IT Conference Proceedings*, in 22, vol. 13. Academy & Industry Research Collaboration Center, Nov. 2023, pp. 233–245. doi:10.5121/csit.2023.132218.

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