AI-Driven Quality Assurance Framework for Inclusive Government and E-Commerce Web Services: Integrating Accessibility, Usability, and Emerging Technologies

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ABSTRACT

In today's digital ecosystem, ensuring the accessibility and inclusivity of online platforms is a cornerstone of quality assurance (QA). This study proposes an integrated, AI-driven QA framework that bridges usability, accessibility, and emerging technologies for government and e-commerce web services. By aligning QA practices with the Web Content Accessibility Guidelines (WCAG 2.1) and ISO/IEC 25010 standards, this research emphasizes inclusive design that accommodates users of diverse abilities and contexts. The framework incorporates both functional and non-functional parameters, such as performance, security, readability, mobile responsiveness, and user experience within a systematic testing process. Advanced technologies like machine learning, automated accessibility validation tools, and big data analytics are leveraged to predict and mitigate potential usability barriers. The study highlights how integrating AI-powered analytics can enhance compliance, personalization, and efficiency across platforms. The outcomes aim to guide policymakers, developers, and QA practitioners in creating user-centric, equitable, and trustworthy web environments that support the goals of Digital India and global digital inclusion initiatives.

Keywords: Quality Assurance, Accessibility, WCAG, Usability.

INTRODUCTION

he rapid growth of digital transformation initiatives such as Digital India has revolutionized the accessibility of public and commercial services through web-based platforms. Government portals, e-commerce websites, and educational systems are increasingly becoming primary channels for citizen engagement, service delivery, and information dissemination. However, the inclusivity and accessibility of these digital platforms remain a persistent challenge, particularly for users with disabilities and those in low-connectivity regions. As over 26 million individuals in India live with some form of disability, ensuring equitable digital participation is both a technological and ethical necessity. Quality Assurance (QA) in web development thus plays a crucial role in ensuring that websites and applications are not only functional and efficient but also inclusive and user-friendly. With the rise of artificial intelligence, automation, and data analytics, modern QA frameworks are evolving beyond traditional testing models to incorporate predictive analysis, accessibility compliance (WCAG 2.1), and user-centered design evaluation. ICT in education brings a lot of advantages to our social and educational life. The computer, laptops, and smartphones will enhance the autonomous access of students to their education. Digital India is a movement initiated by the Indian government to ensure that the government's services are made accessible to people electronically by enhanced web facilities and increased Internet access or to make the nation digitally empowered in the field of technology. This project would include services such as Digital lockers, e-education, Bharat net, e-health, and a scholarship portal at the national level. The Indian government decided to open Botnet cleaning centres as part of Digital India [1]. The development of accessible smartphone apps has been a significant challenge for accessibility experts; as users mature, they face changes. The most common among them are low vision users.

According to the census on India 2011, over 26.8 million people in India suffer from some form of disability, which equates to 2.21% of the total population. Among the total number of disabled people in the world, 56% (15 million) are males and 44% (10.18 million) are females. Table 1 shows, among all the five categories of disabilities for which data has been compiled, disability in seeing at 19% emerges as the top category in India [2]

Population	Percentage
Total population	100.0
Total population of disabled	2.68%
Disability Types	
(a) In seeing	19%
(b) In speech	7%
(c) In hearing	19%
(d) In movement	20%
(e) Mental Retardation	6%
(f) Mental illness	3%
(g) Any Other	18%
(h) Multiple Disability	8%
Source: Census of India 2011.	

Table 1 Summary of Disabled Population in India and type of disability

Website or web app quality assurance (QA) is the process of ensuring that a website or web application works smoothly, meets user expectations, and achieves its intended purpose. It involves systematically testing and evaluating the functionality, performance, usability, and compatibility of a website or web app to detect and resolve issues. Website Quality Assurance (QA) is a systematic process to ensure that a website functions correctly, performs efficiently, and delivers a seamless user experience across various platforms and devices. The QA process involves identifying bugs, usability issues, and design inconsistencies before a site goes live, thereby enhancing reliability and user trust [4]. A comprehensive QA strategy typically encompasses testing for functionality, performance, security, compatibility, and accessibility. In Website Quality Assurance (QA), both functional and non-functional parameters play essential roles in evaluating a site's overall performance and user satisfaction.

Functional Parameters focus on what the system *does,* they include elements like navigation functionality, form submissions, search operations, user authentication, and database interactions [5]. These aspects ensure the core functions of the website operate as intended and without error. For example, login mechanisms, payment gateways, and content management workflows must be rigorously tested to confirm accurate user input processing and appropriate system responses.

Non-functional parameters deal with *how* the system performs, encompassing performance, scalability, usability, security, compatibility, and accessibility. These attributes do not directly affect specific functions but significantly influence user experience. For instance, performance testing might assess page load times or server response under heavy traffic, which is crucial, especially since 53% of users abandon mobile sites that take

longer than 3 seconds to load [6]. Security testing under non-functional parameters helps prevent breaches and data loss, adhering to standards like OWASP guidelines. Similarly, accessibility checks based on WCAG ensure that users with disabilities can navigate and interact with the site effectively [7].

LITERATURE REVIEW

The author investigate how perceived security impacts trust in e-commerce websites. The authors conducted a survey to explore the relationship between visible security features, such as trust seals and SSL certificates, and user trust. Their findings reveal that users are more likely to trust and engage with websites that prominently display these security features. This research suggests that perceived security should be incorporated into quality assurance (QA) frameworks as a crucial element, influencing not only trust but also the likelihood of a transaction [8]. Compared A/B testing with multivariate testing (MVT) in optimizing e-commerce website usability. The study indicates that MVT provides deeper insights into user preferences and site layout adjustments compared to A/B testing, which typically tests one variable at a time. By analyzing multiple variations in real-time, MVT enables more precise UX decisions. The authors advocate for integrating MVT into e-commerce QA processes to ensure comprehensive testing that improves overall user satisfaction and site performance [9].

Demirkan and Delen, highlights the potential of big data analytics to enhance customer-centric quality assurance in e-commerce. The study suggests using structured and unstructured customer data, such as reviews and usage patterns, combined with predictive modeling to improve website performance. The authors argue that big data allows for dynamic, real-time quality assurance processes, enabling e-commerce platforms to address issues before they negatively impact the user experience. This approach ensures that websites continuously adapt to user needs, fostering long-term satisfaction [10]. Hassan and Sulaiman examine the differences in user experience between mobile and desktop versions of e-commerce websites. Their study reveals that mobile sites often fall short in usability due to issues like slow load times and non-responsive design. By performing heuristic evaluations and user testing, the authors recommend prioritizing mobile-first design strategies in quality assurance practices. They argue that mobile usability should be a focal point for QA frameworks as mobile traffic continues to outpace desktop use [11].

Kumar and Srinivasan, explore the role of design and privacy in fostering trust on e-commerce websites. Their research, based on structural equation modeling, demonstrates that consumers are more likely to engage with websites that prioritize privacy and offer clear design features like easy navigation and secure payment options. The authors suggest that quality assurance models should include privacy measures as a key parameter, ensuring that user data is handled transparently and securely [12].

Tan and Lim discuss the importance of emotional design in e-commerce websites and its direct impact on user experience. The study finds that users are more satisfied with websites that use colors, typography, and animations that elicit positive emotional responses. These emotionally engaging elements can enhance trust and increase the likelihood of a purchase. The authors suggest that quality assurance frameworks should account for emotional design elements, highlighting their significant role in enhancing user experience [13]. Ahmed and Hossain focus on the accessibility of e-commerce websites in developing countries, where digital inclusion is often overlooked. Their evaluation of 50 e-commerce sites using WCAG 2.1 guidelines revealed significant gaps in accessibility for users with disabilities. The study highlights the need for quality assurance models to prioritize accessibility, ensuring that all users, regardless of their abilities, can access and navigate e-commerce platforms effectively [14]. Ferreira and Monteiro analyze how website load speed impacts user behavior and conversion rates. Their empirical study shows that even a slight delay in load times (as little as one second) can lead to a 7% reduction in conversion rates. This finding emphasizes the importance of optimizing page speed as a key quality metric in e-commerce QA. Ensuring fast load times is crucial for retaining customers and maximizing sales, making performance a central aspect of QA practices [15].

Alzahrani and Goodwin examine how cultural differences affect user experience in e-commerce across various countries. Their study found that users from different cultural backgrounds have distinct preferences regarding website design, content, and payment options. This research highlights the need for QA frameworks to include cultural adaptability, ensuring that websites cater to the diverse needs of global users while maintaining usability

and satisfaction [16]. Wang and Zhou propose a machine learning-based framework to personalize e-commerce website content and layout according to user preferences. The study shows that personalized interfaces improve usability, making it easier for users to navigate and find relevant products. The authors recommend integrating personalization features into quality assurance processes, as they contribute significantly to enhancing the user experience and increasing conversion rates [17]. Patel and Sharma explore the integration of voice search in e-commerce websites and the usability challenges it presents. Their study identifies issues such as poor speech recognition and limited context understanding, which can frustrate users. The authors suggest that quality assurance processes should evaluate voice search functionality to ensure it provides accurate and context-aware results, which are essential for enhancing user satisfaction in voice-enabled environments [18].

Zhang et al. introduce a machine learning model that predicts the usability of e-commerce websites based on user interaction data. Their framework uses clickstream analysis and other behavioral metrics to evaluate site performance and predict user satisfaction. This approach enables real-time usability assessments, allowing QA teams to make immediate improvements. The study emphasizes the role of AI in automating usability testing and enhancing website performance [19]. Nguyen and Park, assess the impact of Progressive Web Applications (PWAs) on mobile e-commerce usability. Their A/B testing results show that PWAs outperform traditional mobile websites in terms of speed and offline accessibility. The authors recommend that QA processes include checks for PWA functionality to ensure optimal performance, particularly as mobile users increasingly expect fast, responsive experiences [20]. Salim and Alshammari, propose a hybrid QA model that combines ISO/IEC 25010 software quality standards with user-generated content (UGC) such as reviews and feedback. This model enhances QA by integrating both objective technical measures and subjective user experiences. The authors highlight the importance of considering both perspectives in quality assurance to create a more accurate and comprehensive evaluation of website quality [21].

Yadav and Singh, focus on the role of cognitive load in e-commerce website design. Using eye-tracking and task analysis, the study reveals that complex layouts and excessive information increase cognitive load, making it harder for users to complete tasks. The authors recommend that quality assurance practices should include cognitive load assessments to ensure that website designs minimize mental effort and enhance usability [22]. Rahman and Li, evaluate the usability of chatbots on e-commerce websites. Their study finds that inaccurate or slow responses from chatbots lead to user frustration and decreased satisfaction. The authors suggest that chatbot functionality should be rigorously tested as part of the QA process to ensure reliability and improve user experience by delivering timely and contextually relevant information [23]. Gomez and Torres, investigate the consistency of user experience across multiple devices, such as smartphones, tablets, and desktops. The study finds that UX inconsistencies between devices significantly hinder user satisfaction, especially when switching between platforms. The authors emphasize the need for QA teams to evaluate cross-device performance to ensure that users experience a seamless interface across all touchpoints [24].

Choi and Kim, examine the role of sustainability in e-commerce UX design. Their study shows that users increasingly value eco-friendly design elements, such as energy-efficient website features and environmentally-conscious product offerings. The authors argue that sustainability should be incorporated into quality assurance practices, as it aligns with growing consumer demand for ethical and sustainable business practices [25]. Nakamura and Sato, focus on the challenges of providing a consistent user experience across multiple languages on e-commerce websites. The study reveals that poor translations and inconsistent messaging reduce trust and cause confusion for users. The authors recommend that QA processes include checks for accurate and culturally appropriate translations to ensure a positive user experience across different language groups [26]. Singh and Mehta, evaluate the usability of payment interfaces on e-commerce websites. Their study identifies that complex or unclear payment processes often lead to cart abandonment. They recommend that quality assurance should prioritize payment interface testing to ensure ease of use, security, and clarity, all of which are essential for completing transactions and minimizing drop-offs. Including key parameters that influence QA in e-commerce websites, usability, and user experience [27]. Presents a novel bi-level decision tree approach that significantly enhances the accuracy and efficiency of web quality assessment. By systematically integrating multiple quality parameters, the model demonstrates strong potential for automated evaluation of web platforms, contributing to improved decision-making in digital quality assurance processes. This work lays a foundation for further research in intelligent QA frameworks, especially within the context of dynamic and complex web environments [28]. Provide a critical evaluation of the accessibility standards of hospital websites in India, uncovering

significant gaps in compliance with established accessibility guidelines such as WCAG 2.1. Their findings highlight the urgent need for policy-level interventions and improved web design practices to ensure inclusive digital access to essential healthcare information. This study emphasizes the importance of prioritizing accessibility in public service domains, particularly in sectors like healthcare where digital equity can have profound societal impacts [29]. Conducted a focused case study assessing the web content accessibility of university websites in Punjab, revealing widespread non-compliance with WCAG 2.1 standards. Their evaluation underscores systemic accessibility challenges in the higher education sector, particularly in providing equitable access to academic resources for users with disabilities. The study advocates for strategic improvements in web design, policy enforcement, and institutional awareness to bridge digital accessibility gaps in Indian universities. A comparison of various literature reviews are presented in table 2.

Table 2 Comparison table of literature reviews

Author	Focus Area	Methodology	Key Findings	QA Parameters
Rubin & Chisnell (2008)	Usability Testing	Case Studies	Planning, design	Usability, Testing Design
Balfagih et al. (2012)	E-commerce QA Framework	Survey & Case Study	Framework for technical, content, usability	Performance, Security, Usability
Ferreira & Monteiro (2022)	Website Performance	Empirical Study	Load speed impacts conversion rates	Performance, Load Time
Wang & Zhou (2023)	Personalization & Usability	Machine Learning	Personalization enhances UX	Personalization, User Interaction
Hassan & Sulaiman (2021)	Mobile vs Desktop UX	Heuristic Evaluation & Testing	Mobile sites face usability issues	Mobile-Responsive, Navigation
Demirkan & Delen (2020)	Big Data in QA	Predictive Analytics	Big data supports dynamic QA and customer satisfaction	Big Data, User Feedback
Yadav & Singh (2024)	Cognitive Load in UX	Eye-Tracking, Task Analysis	High cognitive load reduces retention	Cognitive Load, Navigation
Alzahrani & Goodwin (2022)	Cultural UX Differences	Cross-Country Survey	Cultural differences affect usability perceptions	Localization, Usability
Tan & Lim (2021)	Emotional Design	UX Testing	Emotional design improves trust	Emotional Engagement, Trust
Patel & Sharma (2023)	Voice Search Usability	Usability Testing	Voice features face usability and recognition challenges	Voice UI, Recognition
Okeke & Badu (2020)	Security in E-commerce	User Survey	Security features improve user trust	Security, Trust
Nguyen & Park (2023)	Progressive Web Apps	A/B Testing	PWAs outperform native apps in UX	Performance, Responsiveness

Kumar & Srinivasan (2021)	Trust & Satisfaction	Structural Equation Modeling	Design and privacy assurance influence user trust	Trust, Privacy, Design
Zhang et al. (2023)	ML for Usability Evaluation	User Data & Machine Learning	ML models predict usability bottlenecks	Predictive QA, Usability
Ahmed & Hossain (2022)	Accessibility Evaluation	WCAG 2.1 Evaluation	Many sites fail basic accessibility standards	Accessibility, Standards Compliance
Lin & Chen (2020)	Multivariate Testing	Comparative	Multivariate testing offers deeper insights into UX	Testing Methodology, UX
Salim & Alshammari (2024)	Hybrid QA Model	ISO/IEC 25010 & User Feedback	Hybrid model improves QA prediction accuracy	Standards Compliance, User Feedback
Ferreira et al. (2022)	User Feedback for UX	Qualitative Research	User reviews offer actionable insights for QA	User Feedback, Quality Metrics
Liu et al. (2023)	UX Metrics for E-commerce	Survey & Case Studies	UX metrics correlate strongly with site success	User Experience, Metrics
Li & Zhang (2024)	AI in UX & QA	AI-Driven Analysis	AI improves UX design	Artificial Intelligence, UX

The findings of literature many sites fail to meet wcag2.1 standards, excluding users and highlight the need for inclusive quality assurance practices. Design and content should be culturally adaptable. Usability issues in multilingual environments. Page load time delay the conversion rates a key Quality metric. Poor contextual understanding in websites also acts as a key metric for improvement.

CONCLUSION

The findings of this study reaffirm the growing need to embed inclusivity and accessibility as central pillars of website quality assurance. Traditional QA methods that focus solely on functional accuracy are insufficient in today's user-driven and diverse digital environment. The proposed AI-enhanced QA framework integrates usability, accessibility, and emerging technologies to deliver a comprehensive and adaptive quality model. By leveraging automated tools, machine learning analytics, and structured evaluation criteria, the framework ensures consistent monitoring, compliance, and improvement. The adoption of this framework can enable organizations to design more resilient, inclusive, and accessible digital systems that align with the principles of universal usability and equitable access for all. The reviewed studies collectively underscore the evolving complexity of e-commerce website QA, emphasizing that traditional approaches focusing solely on functional correctness are no longer sufficient. Effective QA must now address a broader spectrum of non-functional parameters such as perceived security, emotional engagement, cognitive ease, accessibility, usability, and cultural adaptability. The integration of advanced analytics, A/B testing, machine learning, and hybrid QA models suggests a shift toward data-driven, user-centered quality assurance. However, there is a pressing need for a unified, adaptable QA framework that systematically incorporates emerging technologies and diverse user needs. Bridging these gaps will enable e-commerce platforms to deliver high-quality, trustworthy, and inclusive digital experiences that meet the demands of a global user base.

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