

Managing Accessibility Requirements in Web Application Development Projects: The Perspectives from Research and the Industry

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Abstract - This paper focuses on the management of accessibility requirements in web application development projects. First, it presents a map that integrates the methods for assessing web accessibility, the factors contributing to accessibility barriers, the consequences of accessibility barriers and the possible solutions for enhancing the accessibility of web applications. Second, it provides insights into industry practices related to every theme in that map and the working knowledge that can help improve the accessibility of web applications. Findings show that applying accessibility standards and using effective evaluation methods and tools help better manage accessibility requirements in web application development projects. Implications for practice are discussed.

Keywords - Web accessibility, Accessibility requirements, Information system development project, Multi-methods

I. INTRODUCTION

Web accessibility refers to web applications (including websites) that are usable by all individuals, including those with disabilities. Web applications have become an important element of human life, so it is essential that they be accessible by everyone regardless of disability. Web accessibility creates an inclusive digital experience, helps improve the usability of applications for all individuals [1] and provides alternatives for non-disabled users [2]. Web accessibility also fulfills various countries' legal requirements such as conforming to the Web Content Accessibility Guidelines (hereafter WCAG) and related frameworks [3]. Although such frameworks provide direction for building accessible web applications, development teams continue to deliver digital products with limited accessibility [4]. This may indicate that accessibility barriers continue to exist, and that appropriate solutions have not been applied to the development process of web applications. In this context, a better management of accessibility requirements during web application development projects should help improve the accessibility of the delivered products.

The first objective of this study is to provide, through a structured and comprehensive review of relevant research, a map that integrates four key logically related themes namely, (i) the methods for assessing web accessibility, (ii) the factors contributing to accessibility barriers, (iii) the consequences of accessibility barriers and (iv) the possible solutions for enhancing the accessibility of web applications. The second objective of

this study is to survey industry practices related to the themes from that map. Findings should help better manage accessibility requirements during web application development projects and ultimately improve the accessibility of the delivered products. In the rest of this article, Section 2 maps the relevant research on web accessibility, Section 3 covers the methodologies used to investigate industry practices, Section 4 presents the findings, and Section 5 discusses them.

II. MAPPING RELEVANT RESEARCH

IEEE Xplore, ACM Digital Library, ScienceDirect, and ProQuest were searched using keywords relevant to each of the four themes of interest. A careful review of all the publications retrieved helped identify 52 relevant papers. Two more pertinent papers found in the citation lists of the retained articles were added. In total, 54 research papers (not all listed in this paper due to space limitation) were used to build a map of the key logically related themes covered by relevant research on web accessibility. In terms of relative importance in research, the methods for evaluating web accessibility are the most commonly investigated theme (55.6% of the papers), followed by the factors contributing to web accessibility barriers (31.5% of the papers), the possible solutions for enhancing web accessibility (24.1% of the papers) and the consequences of web accessibility barriers (12.9% of the papers). All themes are discussed below.

A. Methods for evaluating web accessibility

Evaluating the accessibility of a web application to determine whether it complies with the accessibility guidelines involves various aspects, including the user interface, content, functionality, and compatibility with assistive technologies. Evaluation methods include automated testing tools and manual testing. Automated testing tools are software designed to (automatically) evaluate the level of accessibility of web applications based on applicable WCAG success criteria. Research shows that automated accessibility testing is the most commonly used evaluation method and tends to focus on identifying the most widely used tools [3][5][6].

In the case of manual testing, individuals -typically quality assurance specialists and accessibility specialists- assess the accessibility of web applications based on applicable requirements guidelines. They may use

assistive technologies or simulation tools to mimic the experience of users with disabilities and detect possible accessibility issues and they may also apply accessibility metrics (i.e., quality ratings) to assess the accessibility of web applications [5][6]. Research on manual testing tends to focus on the effectiveness and efficiency of methods, formula, and scales. A possible variation of manual testing is relying on users with disabilities to assess the accessibility of web applications.

B. Factors contributing to web accessibility barriers

Research has identified 11 factors linked to web applications with limited accessibility. The two most frequently discussed factors are the lack of accessibility considerations in the development process, as stakeholders -clients included- often overlook accessibility requirements [7][8] or only consider them if legally obligated [4][9], and the limitations of tools used for testing [10][11] and of assistive technologies expected to address accessibility issues [12]. Two other key factors are the lack of accessibility awareness among IT professionals involved in the development process [13][14] and the lack of accessibility training for such professionals [4][7][9][10]. Both factors can lead development teams to wrongly assume all users can use a web application without any difficulties and to continue to build applications with limited accessibility.

The other important factors are the complexity of accessibility guidelines, the difficulty to implement accessibility requirements, the lack of accessibility knowledge among IT professionals, and the time constraint. The complexity of accessibility guidelines refers to the difficulty for relevant IT professionals, particularly novices, to understand and interpret accessibility guidelines [10]. In the case of the WCAG, the complexity extends to the difficult navigation of over 450 pages with a large number of navigation links on each page [12]. The difficulty for developers to implement accessibility refers to advanced technical skills needed to build user interface components and widgets for accessible web applications [8][10], whereas the lack of accessibility knowledge -including relevant challenges and guidelines- among developers and UX designers seems quite common [7][9]. As for the lack of time, building, testing and fixing problems of accessible web applications tend to be more time-consuming [7].

Finally, research has identified the lack of familiarity with assistive technologies among IT professionals, [4], the limited integration of people with disabilities in web application development projects [15], and the cost constraint [10] as the remaining factors linked to building web applications with limited accessibility.

C. Consequences of web accessibility barriers

Accessibility barriers can have significant effects on individuals using web applications and on organizations that implement them. Research shows that web

applications that meet relevant accessibility requirements improve the user experience and efficiency -as measured by the time users need to complete given tasks- for individuals regardless of their disabilities, but that accessibility barriers have a negative impact on usability and user experience [1]. Findings suggest that web accessibility can also benefit non-disabled users [2]. As for organizations, they could face legal complications, such as lawsuits or fines, for failing to comply with applicable accessibility laws and regulations [3].

D. Solutions for enhancing web accessibility

Different factors can contribute to accessibility barriers and no single solution addresses all accessibility barriers at once. Research has identified 7 possible solutions that address the different accessibility barriers.

A first solution is the use of relevant technological tools such as visual impairment simulators or dyslexia simulators that help developers simulate the experience of people with disabilities and become more aware of the accessibility challenges imposed by the web applications they build [10]. This solution can also involve the use of more effective refactoring tools that check source code, detect accessibility errors and automatically fix them [16]. A second solution is introducing new phases in the application development process to specifically address accessibility requirements [17]. The new steps can focus on accessibility requirement elicitation, accessibility test, accessibility correction and accessibility review. They make accessibility requirements a fundamental part of the development process and should help resolve accessibility issues before deploying web applications to end users [17]. A third solution is restructuring the WCAG to help with a better understanding of the guidelines and ultimately improve web accessibility. Organizing the guidelines based on related job titles (i.e., analyst, designer, developer, etc.), simplifying the language and facilitating the search for specific content should help IT professionals better understand and implement accessibility requirements [10]. A fourth solution is increasing the number of accessibility specialist in web application development teams [10][12]. Accessibility specialists greatly benefit development teams, particularly in areas that cannot be addressed using accessibility tools [10]. A fifth solution is increasing accessibility awareness among all application development stakeholders, because if they all understand web accessibility, they are more likely to prioritize it in their work, resulting in the development of products with improved accessibility [12]. Increasing exposure to people with disabilities and emphasizing the value of web accessibility helps increase accessibility awareness [12]. The last two solutions are enforcing accessibility law and regulations as legal obligations can be the primary reason why organizations consider digital accessibility [9][12] and integrating users with disabilities in the development process as this gives development teams better insights into the challenges faced by users with impairments when interacting with

web applications and would help develop digital products with improved accessibility[13].

III. METHODOLOGIES FOR ANALYZING RELATED INDUSTRY PRACTICES

A survey and a content analysis were used to analyze industry practices related to the web accessibility themes covered in Section 2. The survey of IT professionals involved in the development of accessible web applications used seven-point Likert scales (1 = strongly disagree, 4 = neutral, 7 = strongly agree) to measure all the variables related to the web accessibility themes this study focuses on. Table 1 presents the variables included in the questionnaire. A pool of IT professionals with relevant job titles and expertise working in North America was contacted through LinkedIn in March 2023, and 35 of them returned valid questionnaires.

The content analysis of 60 relevant job postings helped identify the specific abilities needed for IT professionals expected to effectively manage accessibility requirements in web application development projects. The employment websites Monster.com and Indeed.com were selected as the source for the postings because of their popularity. The key words “web accessibility” and “digital accessibility” in the field “Job Titles” were used to extract relevant postings published in May 2023. The analysis focused on the skills specific to web accessibility, so “generic” skills like “attention to details” or “effective communication” required for virtually any position were not considered. The calculated frequencies indicate the number of times a particular skill or working knowledge is mentioned in each of the postings analyzed.

IV. FINDINGS

A. Descriptive statistics from the survey

In terms of sample characteristics, the respondents were software developers (37.1%), quality assurance specialists (20%), system analysts (8.6%), project managers (5.7%) or other (28.6%), had on average 9.3 years of experience and worked for large (42.9%), medium-sized (34.3%) and small (22.8%) organizations.

Findings in Table 1 show that, with regards to standards (Item 1 to 3), respondents tend to follow formal web accessibility guidelines in their line of work (Mean = 5.09), to be familiar with the WCAG (Mean = 5.60), to apply them (Mean = 5.37) and to achieve a rather high level of web accessibility for the applications they help build as measured hereafter by the mean score of Items 4 to 7 (Mean score = 5.17). An analysis of frequencies shows also that 65.7% of the respondents report applying the WCAG and 62.7% report delivering accessible web applications. As for the methods for assessing the accessibility of web applications (Item 8 to 10), respondents identified manual testing using simulation

tools or accessibility metrics as the most effective method (Mean = 5.63), followed by automated testing (Mean = 5.26), and relying on the accessibility evaluations by users with disabilities (Mean = 5.03).

Concerning the accessibility barriers (Item 11 to 20), findings show that the lack of accessibility awareness (Mean = 6.77), of accessibility training (Mean = 6.63), and of accessibility knowledge among IT professionals (Mean = 6.54) and the lack of accessibility consideration in the development process (Mean = 6.54) are the most significant factors contributing to building web applications with limited accessibility. To a lower degree, findings show that lack of familiarity with assistive technologies, the complexity of accessibility guidelines, and the limited integration of people with disabilities into development projects (the means for each of the three factors vary between 5.06 and 5.60) are also a contributing factor to accessibility barriers. As for the limitations of testing tools, the difficulty for developers to implement accessibility requirements, the cost constraint and the time constraint, they are reported as the least contributing factors (the means for each of the four factors vary between 4.66 and 4.91).

These web accessibility barriers ultimately affect users and organizations (Item 22 to 24). Averages show that the primary consequence is usability challenges for users (Mean = 6.40), followed by the negative impact on end-user satisfaction (Mean = 6.20) and the increased risk of legal complications for organizations (Mean = 5.74).

Finally, with respect to enhancing the accessibility of web applications (Item 25 to 31), average scores show that the top three most reported solutions are increasing accessibility awareness among all stakeholders (Mean = 6.54), increasing the number of accessibility specialists in the development process (Mean = 6.40), and using relevant technological tools during the development process (Mean = 6.20). These are followed by enforcing applicable laws and regulations (Mean = 5.89), restructuring the WCAG (Mean = 5.37), introducing new phases in the development process to specifically address the accessibility requirements (Mean = 5.31) and integrating users with disabilities in the development process in various roles (Mean = 5.29).

B. Key correlations to web accessibility

Pearson correlations helped identify significant associations between the accessibility of the web applications routinely developed and the variables under study. Results in Table 2 show very strong correlations to following formal accessibility guidelines ($Rho = .812$), being familiar with the WCAG ($Rho = .685$), applying the WCAG ($Rho = .797$) and, to a lesser degree, to reporting manual testing using tools and metrics as an effective evaluation method ($Rho = .535$). The other significant correlations are to identifying the lack of accessibility consideration in the development process ($Rho = .439$) and of accessibility awareness among IT professionals ($Rho = .360$) as contributing to accessibility barriers, and

TABLE 1: DESCRIPTIVE STATISTICS FOR THE VARIABLES UNDER STUDY

Items	Mean	St. dev.
1. Accessibility standard: I follow formal web accessibility guidelines/ standards in my line of work	5.09	1.78
2. Accessibility standard: I am familiar with the Web Content Accessibility Guidelines (WCAG)	5.60	1.59
3. Accessibility standard: I apply the Web Content Accessibility Guidelines (WCAG) in my line of work	5.37	1.57
4. Web accessibility: The web applications we develop are easy to interact with for all users, including those with disabilities	5.14	1.16
5. Web accessibility: The web applications we develop are easy to navigate for all users, including those with disabilities	5.20	1.05
6. Web accessibility: The web applications we develop are easy to understand for all users, including those with disabilities	5.26	1.06
7. Web accessibility: The applications we develop are compatible with assistive technologies (e.g., screen reading etc.)	4.91	1.31
8. Effective method for assessing accessibility of web applications: Manual testing using tools or accessibility metrics	5.63	1.14
9. Effective method for assessing accessibility of web applications: Automated testing using tools	5.26	1.44
10. Effective method for assessing accessibility of web applications: Relying on the evaluation by users with disabilities	5.03	1.68
11. Accessibility barriers in web application development: Lack of accessibility awareness	6.77	0.49
12. Accessibility barriers in web application development: Lack of accessibility training	6.63	0.69
13. Accessibility barriers in web application development: Lack of accessibility knowledge	6.54	0.78
14. Accessibility barriers in web application development: Lack of accessibility consideration in the development process	6.54	0.74
15. Accessibility barriers in web application development: Lack of familiarity with assistive technologies	5.60	1.21
16. Accessibility barriers in web application development: The complexity of accessibility guidelines	5.29	1.40
17. Accessibility barriers in web application development: Limited integration of people with disabilities into the project	5.06	1.43
18. Accessibility barriers in web application development: Limitations of testing tools	4.91	1.29
19. Accessibility barriers in web application development: The difficulty to implement accessibility requirements	4.91	1.59
20. Accessibility barriers in web application development: Cost constraint	4.69	1.69
21. Accessibility barriers in web application development: Time constraint	4.66	1.83
22. Consequence of non-compliance with accessibility requirements: Usability challenges	6.40	0.65
23. Consequence of non-compliance with accessibility requirements: Negative impact on end-user satisfaction	6.20	0.75
24. Consequence of non-compliance with accessibility requirements: Risk of legal complications for organizations	5.74	1.14
25. Enhancing the accessibility of web applications: Increasing accessibility awareness among all stakeholders	6.54	0.74
26. Enhancing the accessibility of web applications: Increasing the number of accessibility specialists in the project	6.40	0.69
27. Enhancing the accessibility of web applications: Using relevant technological tools during software development	6.20	1.02
28. Enhancing the accessibility of web applications: Strictly enforcing applicable laws and regulations	5.89	1.10
29. Enhancing the accessibility of web applications: Restructuring the WCAG	5.37	1.06
30. Enhancing the accessibility of web applications: Adding steps in the development process to address accessibility	5.31	1.36
31. Enhancing the accessibility of web applications: Integrating users with disabilities in the development process	5.29	1.52

reporting increasing the number of accessibility specialists in the development process as an effective solution to enhance web accessibility ($Rho = .362$). Findings finally show significant correlations to identifying risk of legal complications for organizations ($Rho = .488$) and usability challenges ($Rho = .473$) as consequences for building web applications that do not meet appropriate accessibility requirements.

TABLE 2: SIGNIFICANT CORRELATIONS TO WEB ACCESSIBILITY

	Pearson Rho
Following formal guidelines	.812 (2-tailed sig. < .001)
Being familiar with the WCAG	.685 (2-tailed sig. < .001)
Applying the WCAG	.797 (2-tailed sig. < .001)
Manual testing as an effective method	.535 (2-tailed sig. < .001)
Lack of consideration as a barrier	.439 (2-tailed sig. = .008)
Lack of awareness as a barrier	.360 (2-tailed sig. = .034)
More specialists as a solution	.362 (2-tailed sig. = .032)
Risk of legal issues as a consequence	.488 (2-tailed sig. = .003)
Usability challenges as a consequence	.473 (2-tailed sig. = .004)

C. Knowledge required for web accessibility

Although the analyzed postings refer to various relevant job titles, the findings summarized in Table 3 show that IT professionals responsible, in their respective positions, for effectively managing accessibility requirements in application development projects are very often required to have a working knowledge of formal

accessibility guidelines (96.7%), of evaluation methods and testing tools (86.7%), of web development languages and tools (85%) and of assistive technologies (73.3%). They are also expected to have a working knowledge of user interface design principles (43.3%) and of software development methodologies (33.3%). Finally, various relevant certifications that validate IT professionals' working knowledge of accessibility standards, best practices, tools, and technologies can be required (30%).

TABLE 3: KEY KNOWLEDGE REQUIRED FOR WEB ACCESSIBILITY

	Frequencies (N=60)
Formal accessibility frameworks	58 (96.7%)
Evaluation methods and testing tools	52 (86.7%)
Web development languages and tools	51 (85%)
Assistive technologies	40 (73.3%)
User interface design principles	26 (43.3%)
Software development methodologies	20 (33.3%)
Accessibility-related certifications	18 (30%)

V. DISCUSSION

This study builds a map that integrates the key themes covered by research on web accessibility in application development projects, analyzes the related industry practices and helps identify some critical aspects linked to an effective management of accessibility requirements.

First, accessibility requirements management is improved when IT professionals involved in web application development projects are familiar with the WCAG (or a related framework) and they apply its guidelines in their line of work. Clearly, those professionals help develop applications with improved accessibility, which explains why employers, very often, require that candidates have a working knowledge of the WCAG (or a related standard) and sometime require a certification that validates that ability. Furthermore, those IT professionals tend to be more aware of the problems caused by lack of accessibility consideration in the development process, of the insufficient number of accessibility specialists in that process and of the usability challenges and possible legal issues linked to building web applications that do not meet applicable accessibility requirements. Being aware of such problems is a first step towards solving them.

Accessibility requirements management is also improved when IT professionals involved in web application development projects are able to effectively assess whether an application meets the WCAG (or a related standard) relevant requirements. This assessment is a fundamental step in the development of web applications and this study shows the importance of effective manual testing using tools and metrics and its strong correlation to building web applications with improved accessibility. It shows also that a working knowledge of evaluation methods and testing tools is, overall, the second most required working knowledge (after that of accessibility standards) for IT professionals expected to develop accessible applications.

Finally, applying the WCAG (or a related standard) has the potential to gradually promote other best practices or avoid pitfalls captured in the research map and further improve web accessibility.

VI. CONCLUSION

The purpose of this study was to build a map that integrates the key logically linked themes covered by research on web accessibility and then to investigate the industry practice related to each theme and the abilities web accessibility typically requires. Findings show that a better management of accessibility requirements in web application development projects starts with IT professionals who have a working knowledge of accessibility standards and effective testing methods and apply that knowledge in their line of work.

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