



Accessibility Guidelines and Standards: Analyzing Stack Overflow Posts

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ABSTRACT

The prevailing strategy for ensuring the accessibility of web applications involves adhering to established accessibility guidelines. Yet, there has been insufficient investigation into the developer’s challenges concerning these guidelines during the development of their applications. In this paper, we aim to elucidate the representation of accessibility challenges within developers’ posts and to discern potential relations to website accessibility guidelines and standards. To achieve this, we collected and labeled 5092 developers’ posts from Stack Overflow (SO) related to web accessibility, adapting the categorization of the most accepted and recognized website accessibility guidelines (WCAG 2.2). The results demonstrate a notable emphasis among developers on the integration of accessibility features into web applications. Our analysis revealed that approximately 60% of the discussions associated with the perceivable guideline predominantly address issues associated with the customization of time-based media and the configuration of screen readers’ accessibility attributes, including focus management.

CCS CONCEPTS

• **Human-centered computing** → **Accessibility in Stack Overflow**.

KEYWORDS

Stack Overflow, Accessibility Guidelines, Web Applications

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1 INTRODUCTION

In today’s software development landscape, the understanding that applications are used by a diverse range of users has raised the importance of accessibility in web applications. In this context, many developers are committed to guaranteeing that their applications are accessible to anyone by following guidelines and employing specialized tools, demonstrating a dedication to inclusivity and fairness in the digital realm, despite the many organizational obstacles [12, 17, 20]. Complying with accessibility standards such as the Web Content Guideline (WCAG), for instance, may be difficult due to the interpretation of specific guidelines and the technical challenges. Understanding the interplay between the efforts invested by software developers to comply with established accessibility guidelines is critical for laying a solid foundation to facilitate the improvement and innovation of tools and methodologies applied in the creation of accessible software, in addition to specific training materials.

Therefore, the purpose of our study is to examine concerns and challenges expressed by developers with respect to the implementation of accessible web applications in order to highlight their potential connection with WCAG’s accessibility guidelines. To achieve such a goal, we analyzed 5092 Stack discussions related to web accessibility posted by developers on Stack Overflow from 2008 to 2022. Stack Overflow is a well-known online forum for programmers and other tech experts, commonly used to get aid for technical problems faced during software development. Our examination was specifically centered on the following research question:

RQ1: How are accessibility issues conveyed in developers’ posts, and what is their relationship to established guidelines and standards for accessibility compliance?

The main contribution of this study is to systematically identify a diverse range of accessibility challenges reported in developers’ posts and highlight potential connections to Web Content Accessibility Guidelines (WCAG 2.2) that may represent common accessibility features (e.g., screen reader and color contrast).

2 RELATED WORK

Stack Overflow (SO) is a vital resource for the software development community, offering a vast collection of questions and answers on a wide variety of development topics. This rich dataset has become a key resource for academic research, with numerous studies utilizing it to explore different scopes of software development, [2, 11, 21, 24, 27], showcasing the platform’s utility in academic research. For instance, a study conducted by Saha et al. [24] analyzed 1139 Stack

Overflow-related commits to identify the programming languages and platforms that programmers frequently discussed.

In recent years, there has been a significant increase in scholarly interest in investigating accessibility issues within mobile and web applications. Researchers have continually sought to identify technological barriers users experience [3, 4, 26] and aspects that contribute to enhancing the accessibility of websites for those with impairments [18, 19]. Numerous research efforts have analyzed the user reviews regarding accessibility on major mobile application platforms [5, 14, 22]. Eler et al. [15] examined user reviews in 701 Google Play Store applications to explore the existence and discourse surrounding accessibility functionalities for mobile devices. Reyes et al. [23] conducted a comprehensive study that analyzed 701 user reviews of the Android platform. Arias et al. [23] analyzed how accessibility issues are described in reviews, aiming to link them with accessibility standards. Similarly, studies such as [5–7, 9, 10] developed models that classify user reviews in mobile applications into pre-defined accessibility criteria. Even though many such studies identified important issues and challenges for the development of accessible products, they have not investigated developers' challenges in making their web or mobile applications accessible.

In this sense, when it comes to the investigation of the developer perspective on implementing accessibility requirements, Vendome et al. [25] examined the accessibility issues discussed by developers regarding Android Apps in Stack Overflow. The author classified 810 Stack Overflow discussions related to accessibility using keyword-based techniques and manual analysis. Their study provides insightful information, but they have not mapped the discussed issues with any accessibility guidelines. While our research shares similarities with their study, it is important to note that we conducted a unique analysis of Stack Overflow discussions specifically focused on web accessibility and with a larger dataset.

3 METHODOLOGY

This section outlines the procedures we follow to obtain a Stack Overflow dataset and extract posts related to web accessibility. We also outline our coding approach.

3.1 Data Collection

Figure 1 shows a summary of our study. We resorted to Stack Exchange Data Explorer to collect posts from Stack Overflow posts[1], which includes a wide range of technical questions and answers related to programming and software development. This study focuses solely on posts related to web accessibility and accessibility guidelines. Hence, we extracted only web-related questions that were tagged with words that included “accessibility” and “WCAG”. The result was a dataset of 8,538 accessibility-related posts.

3.2 Data Labeling

Our approach was organized as a three-step iterative process. First, the authors extensively analyzed the dataset to pinpoint posts linked to web accessibility. Two of the authors analyzed the initial dataset, consisting of 8,538 accessibility-related posts from 2008¹ to 2022. The dataset was split among the researchers so that each post

¹Stack Overflow was introduced in September 2008

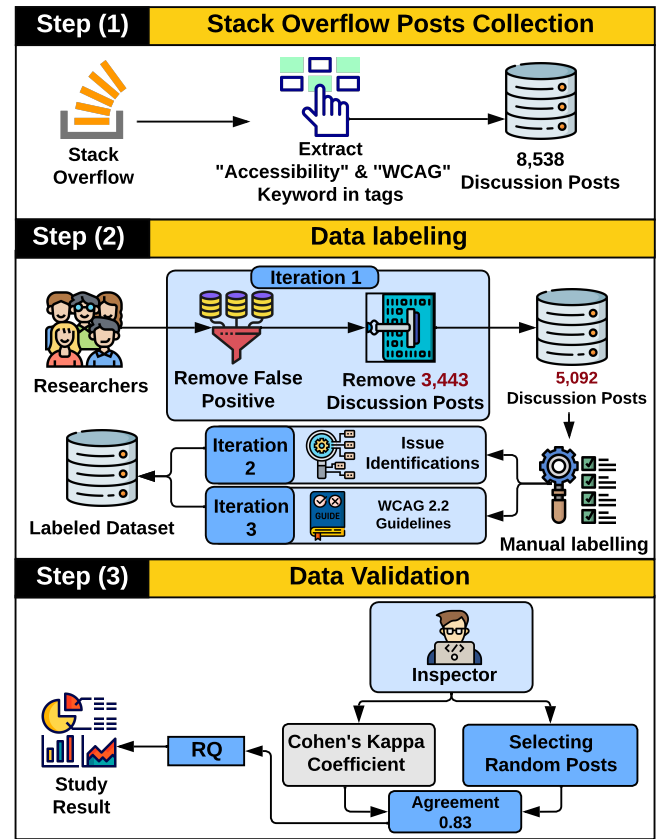


Figure 1: Study overview.

was examined individually twice. Researchers reviewed the collected posts and eliminated those that may potentially yield incorrect results. This includes posts that are mistagged as accessibility-related, such as “network accessibility” and posts related to “mobile accessibility”. Following the removal of false positives, 5,092 posts remained.

In the second iteration, researchers implemented a structured approach to categorize the accessibility issues in each post, focusing on detailed explanations and examples to grasp the core topic fully. The researchers had the flexibility to attach multiple keywords to each post, a measure taken to guarantee that each label was precise and appropriately matched with the relevant content. Researchers discussed their classification process to identify any disagreement that had been found throughout the work.

In the final iteration, the researchers performed the labeling process to categorize web posts according to WCAG 2.2 guidelines. They systematically examined the issue keywords in each post to identify relevant keywords for each guideline. Researchers were permitted to assign posts to one or more guidelines. Additionally, they deliberated on their categorization methodology to detect and address any issues that had arisen. The WCAG 2.2 accessibility guidelines are represented in Table 1 alongside their count for each principle in Table 2.

3.3 Data Validation

In order to verify the accuracy of the coding findings, a third participant, henceforth referred to as an inspector with expertise in accessibility, was recruited to manually assign labels to a subset of posts that had already tagged two researchers to verify the accuracy of coding findings. The objective was to assess the consistency of labels between inspectors. In accordance with the guidance of Aljedaani et al.[8], an equal number of samples from each inspector was selected to determine the level of agreement. A 9% sample (459 out of 5092 posts) was randomly selected from the full dataset. The sample size was estimated using a 95% confidence level and a 6 confidence interval. The research participants carefully examined the retrieved posts, utilizing their extensive knowledge and industry experience to evaluate the content-related labels. Then, Cohen’s Kappa coefficient is used to evaluate the degree of agreement among the inspector and researchers on the assigned categorical classes[13]. We achieved an agreement level of 0.83, which is considered almost excellent, according to Fleiss et al.[16].

Table 1: Guidelines covered by WCAG 2.2.

NO	Principles	Guidelines	Occurrence
1	Perceivable	[1.1] Text Alternatives	74
		[1.2] Time-based Media	1533
		[1.3] Adaptable	560
		[1.4] Distinguishable	887
2	Operable	[2.1] Keyboard Accessible	464
		[2.2] Enough Time	95
		[2.3] Seizures	78
		[2.4] Navigable	858
		[2.5] Input Modalities	257
3	Understandable	[3.1] Readable	30
		[3.2] Predictable	40
		[3.3] Input Assistance	131
4	Robust	[4.1] Compatible	86

4 STUDY RESULTS

This section presents the results of our results. To maintain user privacy, we do not provide a direct link to Stack Overflow posts. Instead, we cite their body text.

RQ: How are accessibility issues conveyed in developers’ posts, and what is their relationship to established guidelines and standards for accessibility compliance?

Result. Table 1 shows the number of Stack Overflow posts associated with accessibility principles and guidelines of WCAG 2.2. These discussions have been cataloged and ranked based on the frequency of their occurrence. By analyzing the issues of all the posts in the dataset, we found that the highest number of issues are associated with the *perceivable* principle, comprising 3054 posts (60% of the dataset), followed by *operable*, with a total of 1752 posts (34%); *understandable*, with a total of 201 posts (4%), and *robust*, with only 86 posts (2%).

As presented in table 1, the Perceivable issues presented in the posts concern four main guidelines: Text Alternatives are determined in developers’ posts with 74 questions to deliver non-text

Table 2: Issues covered by WCAG 2.2. for web app posts.

Principles	Related Issues	Count
Perceivable	1.1.1 Non-text Content	74
	1.2.3 Audio Description or Media Alternative (Prerecorded)	308
	1.2.5 Audio Description (Prerecorded)	255
	1.2.8 Media Alternative (Prerecorded)	885
	1.2.9 Audio-only (Live)	49
	1.2.1 Audio-only and Video-only (Prerec.)	9
	1.3.1 Info and Relationships	318
	1.3.2 Meaningful Sequence	29
	1.3.5 Identify Input Purpose	179
	1.3.6 Identify Purpose	61
	1.4.1 Use of Color	115
	1.4.4 Resize text	91
	1.4.6 Contrast (Enhanced)	74
Operable	1.4.7 Low or No Background Audio	15
	1.4.8 Visual Presentation	492
	1.4.10 Reflow	59
	1.4.13 Content on Hover or Focus	41
	2.1.1 Keyboard	309
	2.1.2 No Keyboard Trap	135
	2.1.4 Character Key Shortcuts	20
	2.2.2 Pause, Stop, Hide	30
	2.2.5 Re-authenticating	65
	2.3.3 Animation from Interactions	78
	2.4.2 Page Titled	31
	2.4.3 Focus Order	371
	2.4.4 Link Purpose (In Context)	154
2.4.6 Headings and Labels	79	
2.4.9 Link Purpose (Link Only)	160	
2.4.10 Section Headings	34	
2.4.13 Focus Not Obscured (Enhanced)	29	
2.5.3 Label in Name	216	
2.5.4 Motion Actuation	7	
2.5.6 Concurrent Input Mechanisms	17	
2.5.7 Dragging Movements	17	
Understandable	3.1.1 Language of Page	14
	3.1.2 Language of Parts	5
	3.1.4 Abbreviations	4
	3.1.6 Pronunciation	7
	3.2.4 Consistent Identification	40
	3.3.1 Error Identification	32
	3.3.3 Error Suggestion	48
3.3.7 Accessible Authentication	51	
Robust	4.1.1 Parsing	5
	4.1.2 Name, Role, Value	78
	4.1.3 Status Messages	3

information in various formats such as voice, symbols, or more straightforward language; Time-based Media presents with 1533 posts to facilitate the availability of time-based and synchronized media incorporating audio/video and interactive media elements for screen reader or other tools; Adaptable guidelines are present in 560 posts where developers are concerned with designing material that possesses the flexibility to be presented in various formats, such as text formatting and simplified layout, while ensuring that neither the information nor the structure is compromised. Finally, 887 issues were found related to Distinguishable guidelines for enhancing the accessibility of web content by implementing measures for characterizing the visual presentation, such as color contrast and text size.

Title: 'Adjust color based on contrast'

☞ Body: "I'd like to incorporate the player's theme colors and use them to generate UI elements. However, I'm running into an issue where not all color themes have colors that provide."

Example 1 : Sample of issue classified under the Perceivable principle.

The operable-related issues are presented in the dataset in 1752 posts. Those posts consider the execution of interactive controls of the web application to possess the capability for users to perceive the presented contents and to take action based on those contents. The Operable issues presented in the posts concern five main guidelines: 464 posts were found about enabling full keyboard functionality, including but not limited to using a keyboard or speech input, designing focus options, and controlling unexpected focus shifts and keyboard traps; 95 posts are related to Enough Time guidelines, where developers are consulted on setting the time limit and the warning message for their web content; 78 posts are associated with Seizures guidelines, in which developers want to avoid contents that are known to cause seizures or physical reactions; 858 posts are linked to ways to help users navigate through the websites; and 257 posts are related to Input Modalities guidelines, in which developers discuss issues to enhance the user experience by implementing a wide range of input methods to facilitate the operation of various functionalities and navigate the web page easily.

Title: 'Tab stop not working for textboxes inside data template'

☞ Body: "I'm writing a really simple name/value editor control where the value is editable - label on the left and property text box on the right. Control works fine, except when the user hits TAB when inside one of the "value" text boxes on the right, the focus shifts from my control to the next control in the hierarchy. I want the focus to go to the next text box in my control so users can just tab between property text boxes. I tried setting "IsTabStop" to true, but it does not seem to work."

Example 2 : Sample of issue categorized under the Operable Principle.

Within the scope of the 'Understandable' principle, we found 201 accessibility posts with issues regarding the functioning of the user interface to enhance the readability and comprehensibility of the text content, ensure that web pages are designed and function consistently and reliably, and assist users in identifying and rectifying errors. The majority of the issues identified were associated with input assistance. The issues involve a collection of methods that developers aim to aid users in comprehending the process of inserting information. These methods include offering clear instructions, an opportunity to verify entered data before submitting it, and assistance notification or error message to the context in which the user can understand the errors.

Title: 'email address suggestions?'

☞ Body: "If a user does not fill out the email address by leaving off the @ or domain - and we do not provide an example of a correct

email address on submit (example@example.com) does this fail the success criterion for WCAG 2.0 3.3.3 regarding error suggestions? It looks like a lot of sites use placeholders to instruct the user on formatting, however, once submitted the user has no clear direction on proper format."

Example 3 : Sample of issue categorized under the Understandable Principle.

Ultimately, a total of 86 accessibility posts related to the Robust principle were discovered, which specifically emphasize sufficient robustness of content to provide consistent interpretation for both present and future user agents and encompass assistive technology. The developers are interested in the implementation of content name roles and values so that all elements have properly nested according to their specifications, as well as implementing the dynamic configuration and regularly updating the content of the user interface.

Title: 'AXWindowMoved (via AXObserver) - continuous updates?'

☞ Body: "Is there any other method available to get continuous updates instead of kAXWindowMovedNotification (accessibility api - listened to via AXObserver) that just sends the notification much later than when dragging started? I need continuous updates if at all possible."

Example 4 : Sample of issue categorized under Robust Principle.

Table 2 shows in detail the frequency of posts considering the specific success criteria within each guideline. Such results can be useful to understand the specific issues developers may be facing to integrate accessibility into their design.

Discussion. While reviewing the questions' details, we noticed that many accessibility tool-related inquiries asked for assistance in resolving challenges unique to the developer's website, such as assigning accessibility elements, changing the font size and languages, or accessing notification accessibility. We also found that a subset of the sampled inquiries on implementing code is generally focused on finding best accessibility practices, which the Stack Overflow community considers an opinion-based issue. The analysis of the developers' issues and connected guidelines reveals a significant trend among web developers, demonstrating a prevalent concern regarding the adherence to accessibility guidelines, specifically in the customization of time-based media, as well as the configuration of screen readers' accessibility attributes, including focus management. However, the majority of developers who submit posts concerning accessibility have been trying to adhere to accessibility guidelines to develop the user interface components in a manner that is perceivable and operable for all users, as well as possess the capability for them to utilize the interface effectively.

5 THREATS TO VALIDITY

This section outlines potential threats to the validity of our findings, which can be Internal, Construct, and External validity.

Internal Validity: The study focuses on developers' challenges raised regarding web applications on Stack Overflow. The dataset was created by extracting and analyzing posts that were tagged with words including "accessibility" or "WCAG". This approach decreased the size of the dataset, which may have excluded terms that are similar or closely related to web accessibility.

Construct Validity: To mitigate any bias, we validated our data by engaging in conversations among annotators to address and reconcile any differences. Furthermore, a detailed assessment was carried out by an accessibility specialist who personally examined a chosen set of posts to guarantee a thorough examination. A comprehensive cross-validation procedure was undertaken among the annotators to guarantee comprehension and agreement.

External Validity: The study relies on Stack Overflow posts, which are written by developers who engage with other developers on the platform. Although the results may not apply to all developers, the challenges and trends discovered in this study are significant for accessibility development and can be valuable to both practitioners and researchers.

6 CONCLUSION

In this study, we analyzed 5,049 Stack Overflow posts to uncover important insights into how developers express accessibility issues and their relationships with accessibility guidelines. Our analysis demonstrated a significant emphasis on the perceivable principle in developer discussions, accounting for 3,054 posts, especially with regard to time-based media. The operable principle followed with 1,752 posts centered on issues associated with focus order, keyboard access, and labels. In contrast, the robust principle received minimal attention with only 86 posts, and understandable, related discussions were slightly higher with 201 posts.

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