Web Design Requirements for Improved Web Accessibility for the Blind

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Abstract. Considerable research has been done on how to make e-learning systems accessible. But Learners in electronic and hybrid learning environments utilize many Web based systems beyond what the instructor and institution provides and can control such as search engines, news portals and research databases. This paper presents Web design requirements that can improve the accessibility of such websites for PWDs particularly the blind. The requirements were derived from both theoretical and quantitative data gathered from both literature and a case study. It was observed that graphical user interfaces, non-linear navigation, forms, tables, images, lack of key board support, non-standard document formats and acronyms and abbreviations hinder Web accessibility for the blind. Therefore in order to improve Web accessibility for the blind, the following requirements were suggested; a text only version of the website or a combination of design considerations namely: text alternatives for visual elements, meaningful content structure in the source code, skip navigation link(s), orientation during navigation, ensure (tables, frames and forms) are accessible if any is used, test the website with keyboard only access, use or convert documents into standard formats and expand abbreviations and acronyms the first time they appear on a page. Meeting the given requirements in the Web development process improves Web accessibility for all blind Web users including those engaged in hybrid learning.

Keywords: Web Accessibility, Requirements, Blind, Hybrid Learning, E-learning

1 Introduction

With the Web, People with Disabilities (PWDs) can undertake a number of tasks that would otherwise be difficult or impossible. Learners with visual, audio, cognitive, learning and physical disabilities can take all or most of the courses in the comfort of their homes. They can access course content online, interact with the instructor, participate in online discussions with classmates, research on the subject, buy books/ software and read news including that related to class modules. However this is only

possible when designers of such systems consider their special access needs. Considerable research has been done on how to make e-learning systems accessible [1], [2], [3], [4]. This has resulted into systems like VisiCAST [5], SMILE [6] and the EVIDENT [7] which are trying to address the need for accessible learning materials for PWDs. But learners utilize many other Web systems during their learning experience beyond what the instructor and institution provide and can control. They use search engines and research databases for additional study material, buy books/software online, access news portals for articles on class modules and may need to interact with classmates and other learner groups on social networking sites like Facebook [8]. Besides educational needs, the Web offers opportunities for all PWDs to do more things themselves without external support. They can shop, read news and pay their bills online among other things.

This paper provides Web design requirements that can improve accessibility of websites such as search engines, e-commerce sites, news and general portals for PWDs particularly the blind. The requirements are based on both theoretical and quantitative data gathered from literature and a case study involving blind and sighted Web users on sample websites. Meeting the given requirements in the Web development process improves Web accessibility for blind Web users such as those engaged in hybrid learning. Other than PWDs, accessible websites offer other benefits to other users and owners namely: better page download speed, easier to use for all, easier maintenance and upgrade and better visibility for search engine indexing [10]. The remainder of the paper has methods, results, discussion of the results, Web accessibility requirements for the blind, conclusion and future work.

2 Methods

The objective of this work was to establish the Web accessibility requirements of blind Web users. This was achieved by reviewing the major guidelines, policies and published literature on Web accessibility for PWDs particularly the blind and a case study involving blind and sighted Web users. The case study was used to verify if the requirements given in the guidelines and literature were correct, complete or otherwise. The case study involved blind and sighted Web users who performed tasks on five sample websites covering common Web applications: search engines, news portals, e-commerce and a tourism portal. Each website had one or more of the features reported in literature to hamper accessibility for the blind. Features not found in the sample websites or that could not be sufficiently assessed using the sample websites were tested by the researchers using Job Accessibility with Speech (JAWS) 8.0 screen reader. A website designed to be accessible to PWDs was included in the sample to compare its usability with others. Only participants with intermediate web usage skills and above were involved in order to minimize expertise related other than visual disability related problems with the tasks. The tasks and associated questions made participants interact with the website features reported to affect Web accessibility such as graphical user interfaces (GUIs), forms and tables.

Participants were required to open sample websites, perform specified tasks, give feedback about the results and any problems encountered. The questionnaire was e-

mailed to 10 participants on 1st July 2007 to be returned by 30th July 2007. Five of the participants were university students and the rest were working class. We fell short of our target sample of 20 blind Web users because blind people that could use the Web in Uganda were found limited. During the time of the assessment, we checked the sample websites in the morning and afternoon to ensure the features referred to in the tasks were available and functioning as required. Five sighted Web users were also assessed on the sample websites using the same tasks and questions to compare the experience of the two groups. The next section presents results of the review of the major guidelines, policies and research efforts followed by the results from the case study.

3 Review of Guidelines, and Policies and other Literature

The guidelines reviewed included Web Content Accessibility Guidelines (WCAG) 1.0 and its successor WCAG 2.0 draft, Americans with Disabilities Act (ADA) 1990, Section 508 of the US Rehabilitation Act, Australian Disability Discrimination Act (ADDA) and National Institute on Aging (NIA) Guidelines. The review revealed that only WCAG 2.0 draft mentions which guidelines benefit the blind. But it is still a draft under review hence not stable. WCAG 1.0 contains all key points for Web Accessibility [10], [11] and most of the other guidelines are comparable to it. But WCAG 1.0's guidelines are general and not specific to different types of disabilities. NIA only covers low vision. The academic literature revealed that some sites only try to comply with the guidelines without understanding the needs underlying Web accessibility [12]. This results into supposedly compliant websites that are neither accessible nor usable to PWDs. Suggestions on WHAT could make Web applications accessible based on user experience could supplement existing guidelines. Other important findings from the literature were that: there is low accessibility despite the increasing number of PWDs [13], [14], [12], [15], [16], [11] the focus of many Web developers is often limited to meeting standards and regulations at the expense of the human interaction aspects [17], [10] but also there are significant efforts towards enhancing Web accessibility for PWDs such as those in [11], [19], [20].

Also from the literature, a number of Web application features that hamper Web accessibility for the blind were reported namely: graphical user interfaces (GUIs) [13], [11], [20]; non-linear navigation approach for the Web environment [10], [18], [12]; visual elements [22], [13], [11]; tables [23], [13], [21], [11]; forms [13], [24], [17]; frames [24]; lack of keyboard support [23], [24], [11]; lack of orientation [10], [22], [10]; non-standard document formats [23], [13], [11]; and abbreviations and acronyms [24]. In order to verify whether these features are indeed a problem and if there were any other problems, we carried out a case study on actual blind and sighted Web users. The next section presents the results obtained.

4 Results

4.1 Web Accessibility Experience of Blind Web Users on the Sample Websites

The sample websites covered common Web applications used by my many groups including hybrid learning students: search engine, news portal, e-commerce and a general portal. Each of the websites had one or more of the features reported to hamper accessibility for the blind. Participants were required to use a screen reader to open the website, perform the given task that was related to the feature of interest and answer given questions. The questions covered: if the user was able to perform the task, how long it took to access a given information item, what happened in cases where the task could not be successfully executed and any problems faced while performing the task.

The features tested on each websites were as follows:

- A simple form on **Google** (www.google.com) used for its search functionality. The task was to search and read about the theme of the 2007 Common Wealth Heads of Government Meeting (CHOGM 2007) *which was due to take place in Kampala, Uganda from 23rd to 25th November 2007 and preparations were in high gear involving almost every citizen*.
- A detailed form on **Amazon (www.amazon.com)** used for ordering goods. The task was to search for any book of interest, order for one up to submission of shipping address.
- Tables (layout) and images on New Vision (www.newvision.co.ug). The task was to open the national link on the home page and read the first story.
- Flash on **About Uganda** (www.aboutuganda.com). The task was to open the home page, listen to its contents.
- Images on the designed to be accessible **British Broadcasting Corporation (BBC)** (www.bbc.co.uk). The task was to open the News link on the home page and read the first story. The interest was to find out if images on this website were accessible to the blind in comparison to the images on the New Vision.

The questionnaire was administered to 10 blind Web users in Kampala, the capital city of Uganda out of which 8 responded (80%).

Figure 1 and Tables 1 and 2 present the time taken to access a given information item on each website and a summary of the quantitative and qualitative results respectively. ‘NA’ in Table 1 means that a particular question did not apply to that website and ‘Nil’ in Table 2 means that there was no problem for that task.

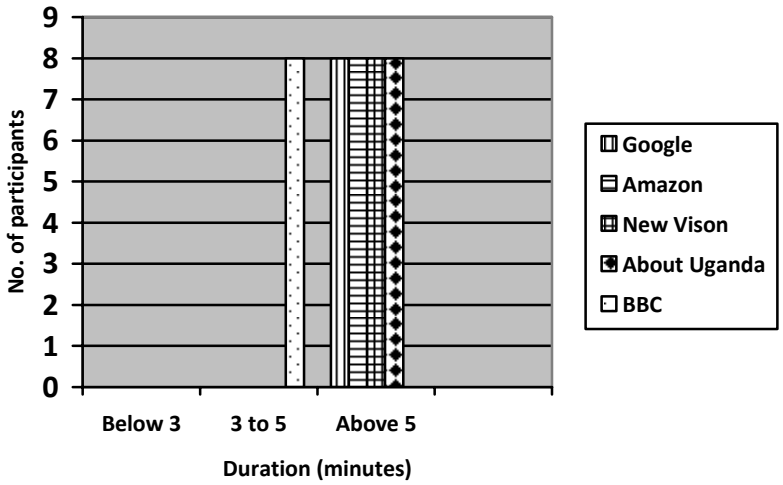

Fig. 1. Time taken by the Blind to access a given Information Item on Sample Websites

Table 1. Quantitative Results about the Experience of Blind Web users

Question	**Google**		**Amazon**		**New Vision**		**About Uganda**		**BBC**	
	Yes	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**
Found Required information item	8	0	7	1	8	0	8	0	8	0
Could use info item obtained to perform given task	0	8	0	7	8	0	8	0	8	0
Understood content in text form	NA	NA	NA	NA	8	0	NA	NA	8	0
Understood content in image form	NA	NA	NA	NA	0	8	NA	NA	8	0

4.2 Web Accessibility Experience of Sighted Web users on Sample Websites

The sample websites were also tested on 5 sighted users on similar tasks to compare the experience of the two groups. All the 5 (100%) responded.

They all took less than three minutes to access a given information item on all the websites, performed the tasks successfully and understood the content in text as well as image form. However, two of them faced problems with the task on the Amazon website. A first time online shopper did not find guidance on how to shop, the second participant was sensitive about submitting a functioning e-mail address. Other complaints on Amazon were: too much **c**lutter, difficulty finding the shopping cart and the need to scroll to read content. Other than Amazon, participants also

complained of many flash images on 'About Uganda' that made page loading slow. The next section discusses the results obtained from both groups.

Table 2. Summary of the Qualitative Results about the Web Accessibility Experience of Blind Web users

What happened?	**Couldn't get info Item Required**	**Couldn't use info obtained to perform given Task**	**Couldn't Understand Text**	**Couldn't Understand Images**	**Any other Problems**
Google	Nil	Could get to list of links but screen reader could not read results (8)	NA	Nil	Nil
Amazon	Failed to open homepage(1)	Couldn't get info on how to proceed after getting search results(7)	Nil	NA	Not able to order book of interest due to lack of relevant cues (8)
New Vision	Nil	Nil	Nil	-Screen reader kept silent on certain sections (5) -Got vague messages 'out of field'(3)	Difficulty tracing headlines (4)
About Uganda	Nil	Nil	Nil	Nil	Nil
BBC	Nil	Nil	Nil	Nil	Difficulty determining which story came first (6)

5 Discussion of Results

5.1 Time Taken to Access Required Information Items

All the blind users took above 5 minutes to access a given information item on all websites except BBC where they took 3 to 5 minutes. The sighted took less than three minutes on all the websites. Four of the five websites had graphical intensive user Interfaces (UI), a feature that affects accessibility for PWDs [13]. Only BBC had a text intensive interface and a text only version. The results confirmed the fact that Graphical User Interfaces (GUI) affect Web accessibility for the blind. Less GUI

interfaces improve access speed for the blind as evidenced on the BBC. Moreover this does not affect access speed for the sighted as evidenced by the same duration taken by sighted users on both BBC and the other websites.

5.2 Execution of the Tasks on each Website

- **Forms on Google and Amazon**: The search function was successful for both the blind and sighted on both websites but all the blind were not able to use the obtained results to perform the required tasks. The sighted had no problem using the results on Google probably because they use the mouse rather than the keyboard but two were not successful with the task on Amazon, a problem they related to the poor usability of the website. The problem on Google was not the form based search function but the format of the results which could not be navigated with a keyboard and opened by the screen reader. Web designers should ensure that results from search forms are accessible for such functions to be useful to PWDs. Interestingly, Amazon had a link to an accessible version of the website on the home page but all the blind participants never realized so. Thus Web designers need to test such links with relevant assistive technologies to be sure they are accessible as required.
- **Tables on New Vision**: All the blind users were able to get the news link of interest that was presented with other website items in a table based layout. But they found it difficult to trace the headlines. The sighted users had no problem with the task. Therefore using tables for layout makes accessibility of web pages difficult for the blind.
- **Images on New Vision and BBC:** The blind did not recognize images on New Vision but did so, on the BBC where the screen reader read out alternative textual descriptions and the users understood what the images were about. The sighted users had no problem on both websites. Therefore images on general audience websites also pose accessibility problems to the blind.
- **Flash on About Uganda:** All the blind and sighted participants were able to understand the content of interest that was primarily presented in flash. This was made possible because the content in flash had alternative text describing the flash images. All web pages with flash should emulate this practice. However one sighted user complained that the flash images made the site slow. Such users especially those with slow internet links can benefit from designs with out flash just like the blind where flash can be avoided.
- **Orientation during navigation:** Orientation is the user's understanding of their current location, and their own movements and their grasp of their current navigation context [11]. Sighted users had better orientation on all the sample websites given the less time taken to identify the required information item. On Amazon, all the blind and one sighted participant failed to get cues on how to order hence addressing this problem benefits both groups. On New vision, the blind had problems tracing the headlines. Interestingly, two blind participants also found it difficult to determine which news story came first on BBC. One of them said, "I only had to guess which story came first". This is a revelation that even websites

designed to be accessible can still have some problems for PWDs hence further research to identify such issues and possible solutions is desirable.

- **Frames:** All the websites surveyed did not use frames. We failed to get one with frames to include in the sample.
- **Lack of keyboard support:** All the sample websites supported use of the keyboard for input tasks and navigation. This was tested using JAWS 8.0 screen reader and navigating the websites with the keyboard. In addition, no participant reported a keyboard related problem.
- **Non-standard document formats e.g. PDF:** This was not tested on the participants but New Vision had images of scanned text documents. Such documents pose the same problems as images without alternative text. This was verified and confirmed by the researchers using JAWS 8.0 screen reader.
- **Acronyms and abbreviations:** Using JAWS 8.0 screen reader, we tested an MS word document with acronyms and abbreviations. The screen reader read the acronyms and abbreviations as one word, which makes the user unable to decipher them. Hence acronyms and abbreviations that are not expanded cannot be understood by users of assistive technologies such as screen readers.

5.3 Other issues from the assessment other than the features tested in the case study:

- Pop ups disorient blind users when they pop up in a page.
- Images without alternative text is the biggest problem for the blind.
- On websites with many images, the blind use sighted guides which interferes with their privacy.
- Lack of information on the page download progress frustrates the blind especially on slow links
- Designers in Uganda are ignorant about the diversity of their clientele
- There is limited effort by internet cafes in Uganda to install screen readers.

In the next section, we present suggestions on WHAT needs to be done in order to address the difficulties faced by blind Web users.

6 Web Accessibility Requirements for the Blind

This section discusses Web design considerations that can address the difficulties faced by blind Web users on websites such as those covered in the case study.

6.1 Provide a Text only Version of Entire Website

Assistive technologies used by the blind such as screen readers have plain interfaces that sequentially verbalize Web content in the order it is structured in the source code [12], [21]. This makes it difficult for the blind to identify and use information items on graphical intensive websites compared to sighted users as was evidenced on the 4

out of the 5 websites. It took all the blind users more than 5 minutes to access a given information item on the graphical intensive websites and 3 to 5 minutes on the text intensive BBC. The sighted took less than 3 minutes on all the websites to perform the same tasks. Therefore a text only version of the entire website can improve the access speed for blind users.

6.2 Apply a Combination of Web Design Considerations

Other than a text only version, Web accessibility for the blind can be improved with out having two website versions by applying a combination of Web design considerations as follows:

- **Provide Text Alternative for every Visual Element:** Web content conveyed using visual elements with out alternative text excludes persons who are blind from accessing such information because screen readers cannot interpret such content [14], [12] and as was established on the New Vision website. Web designers should provide a text alternative for every visual element and avoid elements that cannot be presented in this form [24], [12]. Screen readers can adapt text into audio formats for the blind users to access. The common method of achieving this is to use the 'alt' attribute of the 'IMG' tag which allows for a short textual description of information contained in an image. For complex images such as charts and graphs, the 'D-link' attribute to link to a file or page with a detailed description of the image is recommended and preferred over the 'Longdesc' attribute. The latter is not widely supported by screen readers [18]. Images that do not convey important information should have null 'alt' text. Designers should ensure that the alternative content conveys the same function or purpose as the image, for it to be useful to the blind [24], [12]. Alternative text can also be useful to people without disabilities e.g. those using handheld devices with small screens and limited graphics capabilities and increases usability for all users [18].
- **Structure Content Meaningfully in the Source Code:** This is possible through use of markup such as HTML's structural tags like heading (<H1>, <H2>…), Paragraph <P> to describe the document structure [12]. Markup embeds information structure and relationships among page elements into content of a document thereby adding a layer of meaning to the website document structure. This enhances the capacity of screen readers and voice browsers to read and interpret Web documents to blind users. They can easily find, skip or go back to content items given the logical presentation [21]. Markup can also provide additional functionality to the user such as document overview using heading tags. However, mark up should be used for the intended function for it to yield accessible applications.
- **Provide Skip Navigation Links:** Traditionally, Web pages are written in Hypertext Markup Language (HTML) whose documents are presented in a non-linear form. But screen readers present information sequentially using a text-to-speech (TTS) engine. Hence the blind have to go through all the clutter such as adverts and repeated navigation on each page. From the case study, a content item that took less than 3 minutes to locate by sighted users, took more than 5 minutes to reach using the screen reader. Even on BBC, it took blind users more time than

the sighted (3 to 5 minutes and less than 3 minutes for the sighted). Skip navigation links [18] enable users of screen readers to skip repeated or peripheral content and go straight to the main content. This saves time and improves usability for the blind. More over the link(s) can be made invisible by using an invisible image link so as not to affect the visual layout [13].

- **Provide for Orientation during Navigation:** To improve orientation for the blind, Web designers should mark up different sections of Web pages with predefined semantics such as main, heading, navigation and adverts [21]. This makes it possible for them to navigate to different sections of the website including the ability to skip certain sections. In addition, some screen readers like Home Page Reader (HPR) support heading navigation mode with the 'ALT' + 1 command and using the arrow keys to move from current, previous and next headings [18]. Other suggestions include: put main content after the title followed by navigation for table layouts; provide clear 'alt' text on each area of the client side image map; provide redundant text links for all hot spots of server-side image maps. Asakawa [12] proposes fragmentation e.g. the XML fragmentation recommendation (XFrag) for the benefit of both blind and users of small screen devices.
- **Create Accessible Tables:** Tables on the Web are used for layout and data presentation. The former is however discouraged in favor of cascading style sheets (CSS). For those that still insist on using tables for layout, Thatcher et al., [17] advises that they should put content after the title instead of left navigation and put navigation in the right column after main content. Alternatively since tables are read a row at a time, if main content can be the only content in row two and navigation menu in row three, then content can be read first. On the other hand, data tables can be either simple or complex. A table is simple if the column headers for any given data cell is in the same column as the cell and the row headers for any given data cell is in the same row as the cell [17], [24]. To create accessible simple tables, designers should identify table headers in the first row and first column or use the table header <TH> element or scope attribute. Complex data tables are tables with two or more logical levels of row or column headers. They can be made accessible by associating heading information with the data cell using the ‘id’ attribute of the <TH> element [18].
- **Create Accessible Frames or Provide Alternative Content:** To design accessible frames, frame elements should have meaningful titles and name attributes and all frame pages must have meaningful titles. Some assistive technologies such as Lynx and JAWS depend on the name attribute of the frames. Others such as Window-Eyes and Home Page Reader use the title element on the actual frame pages [17]. Frame title and name attributes should explain the role of the frame in the frame set, e.g. navigation or title. Alternatively, designers can provide alternative content with out frames [21], [23].
- **Create accessible forms:** To make form based content accessible to blind Web users, Web designers should explicitly and programmatically associate form labels with their controls e.g. place text information for text entry fields and combo boxes to the left (or above) the control and put the prompt for a checkbox or radio button to the right of the object. When the prompt is programmatically connected to the <input> element, all the screen readers make the correct announcement [17]. The alternative approaches are to place titles in the <input> elements that identify the

purpose of the control, to use the <label> element to associate the correct text prompts with each form control with the 'for' attribute and to use the <FIELDSET> and <LEGEND> tags to structure complex forms so that they are clearer and simpler to understand. For forms used for search functionality, designers should ensure that results from the search are accessible e.g. with the keyboard and screen reader.

- **Test the application with Keyboard only Access:** The blind Web users rely on keyboards as their primary input device. To be sure that all parts of a Web application are usable with the keyboard, designers should test the application with keyboard only access.
- **Use or convert documents into available standard formats:** Web designers should use or convert documents into available standard formats such as those recommended by W3C [23].
- **Expand Abbreviations and Acronyms:** Designers should expand abbreviations and acronyms the first time they appear on a page. This will enable users of screen readers to get their full meaning hence making them understandable to them [23].

7 Conclusion and Future Work

We have presented Web design requirements that can improve Web accessibility for PWDs particularly the blind like blind hybrid Learners. The requirements are derived from both theoretical and quantitative data gathered from both literature and a case study. It was observed that graphical user interfaces, non-linear navigation, forms, tables, images, lack of key board support, non-standard document formats, acronyms and abbreviations hinder Web accessibility for the blind. In order to address the challenges faced, we suggest a text only version of the website or a combination of Web design considerations namely: text alternatives for visual elements, structure content meaningfully in the source code, skip navigation link(s), orientation during navigation, accessible (tables, frames and forms), test the website with keyboard only access, use or convert documents into standard formats and expand abbreviations and acronyms the first time they appear on a page. Meeting the given requirements in the Web development process improves Web accessibility for all blind Web users including those engaged in hybrid learning. In future, we plan to carry out the same case study in another country to compare results and infer a wider perspective.

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