Web Accessibility Theory and Practice: An Introduction for University Faculty*

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Abstract

Web accessibility is the practice of making Web sites accessible to all, particularly those with disabilities. As the Internet becomes a central part of post-secondary instruction, it is imperative that instructional Web sites be designed for accessibility to meet the needs of disabled students. The purpose of this article is to introduce Web accessibility to university faculty in theory and practice. With respect to theory, this article first reviews empirical studies, highlights legal mandates related to Web accessibility, overviews the standards related to Web accessibility, and reviews authoring and evaluation tools available for designing accessible Web sites. With respect to practice, the article presents two diaries representing the authors' experiences in making their own Web sites accessible. Finally, based on these experiences, we discuss the implications of faculty efforts to improve Web accessibility.

Keywords: Web design; accessibility; Web accessibility

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Introduction

Research shows that the Web has become a significant part of postsecondary education (Clarke III et al., 2001). The Web provides faculty with resources that support both face-to-face instruction as well as distance learning (Benbunan-Fich et al., 2001; Eastman & Swift, 2001). Lincoln (2001) found that more than 81 percent of university educators reported creating and maintaining individual faculty Web sites. Furthermore, Lincoln's data showed that the amount of material being placed on these faculty Web sites has increased significantly over time. As part of their course work, students are being asked to access individual faculty Web sites to download course syllabi, PowerPoint slides, and assignments, among other materials (Clarke III et al., 2001; McBane 1997).

Many faculty are aware of the Americans with Disabilities Act[1] (ADA), which requires federally funded institutions provide accommodations, and thus equal access, for students with disabilities. These requirements apply to both public and private institutions. Since the passage of the ADA in 1990, additional legislation has emerged with respect to accommodating students with disabilities. Section 508 (explained in depth below) mandates that all federally funded institutions, including universities, must have an accessible Web site. Web accessibility is the practice of making Web sites accessible to people who require more than just traditional Web browsers to access the Internet. In an instructional setting an "accessible Web site" is designed to accommodate a wider set of ways students can access a Web site's content. Many Web sites are designed with visual aesthetics, rather than equal access, as the goal.

As faculty are placing an increasing amount of course-related content on the Web, they are simultaneously expressing concern about the lack of free time and institutional support necessary to stay abreast of new technology for instructional purposes (Lincoln 2001). One technological domain in which faculty members may be behind the curve is in designing accessible Web sites. Section 508 could be interpreted as applying to individual faculty members who are an integral part of such universities. Thus, individual faculty members could be held liable (or responsible)

[1] The full text of this act can be found at http://www.ada.gov/pubs/ada.htm.

for complying with the legal mandates of Web accessibility for the individual Web sites they create and use for instructional purposes.

There is a growing disabled population that exists among postsecondary students. Approximately 35 million Americans and 750 million people in the world suffer from physical, cognitive, or sensory disabilities (Lazzaro, 2001). Data from the U.S. Census Bureau (2005) indicate approximately 40 million Americans have at least one form of disability. More recent estimates from the Institute of Medicine put the American disability population as high as 50 million, and this number is expected to double by 2030 (Zwillich, 2007). Wellner (2000) estimated of the total number of disabled Americans, approximately 40 percent use computers and access the Internet. Arguably, only a portion of disabled people attend postsecondary institutions, but these students are more likely to use computers and access the Internet when compared to the larger disabled population.

The most recent estimates (2003-2004) for the size of the population of post-secondary students with disabilities put the total number of undergraduate students at 2,156,000 out of a total population 19,054,000, and the number of graduate students at 189,000 out of a population of 2,156,000 (Digest of Education Statistics, 2008, table 215). Thus, disabled students represent approximately 11 and 7 percent of the total undergraduate and graduate student populations, respectively. It is important to note the percentage of disabled students attending postsecondary institutions has increased over time. For example, the 1995-96 statistics for the percentage of disabled students in the undergraduate and graduate populations were 5 percent and 3 percent, respectively (Digest of Education Statistics, 1997, table 211).

Because of the substantial number of individual faculty Web sites, several existing legal mandates requiring Universities to accommodate disabled students, and an increasing population of disabled postsecondary students, faculty need to understand the importance of Web accessibility in theory and practice. The structure of this article is as follows:

- Part I: Review the literature on Web accessibility
- Part II: Present the standards related to Web accessibility

- Part III: Overview the authoring/evaluation tools available for designing accessible Web sites
- Part IV: Present the authors' personal experiences in redesigning their Web sites for accessibility
- Part V: Summarize and discuss the implications of our findings

Part I: Literature Review

The literature review is divided into five sections. These sections include: Web accessibility and universal design, barriers to Web accessibility, disabilities and Web accessibility, research in higher Education on Web accessibility, and the legal mandates for Web accessibility.

Web Accessibility and Universal Design

Although the focus of this paper concerns the design of Web sites for the disabled, such a design strategy can be beneficial for all users. Specifically, designing for accessibility is a special instance of universal design. "Universal design is an approach to the design of all products and environments to be as usable as possible by as many people as possible regardless of age, ability, or situation" (http://www.udeducation.org/learn/aboutud.asp#1). Universal design is concerned with creating designs that are visually appealing and yet barrier free at the same time, simultaneously meeting the needs of all users. For example, in contrast to creating a separate Web site that accommodates the visually impaired (e.g., a "text only" version of the site that a screen reader can easily access), a universal approach would create a single solution that is both visually appealing and simultaneously accessible by a screen reader. Achieving universal design is a lofty goal as explained by Schneiderman (2000), who states that it requires support for (1) a wide variety of hardware, software, and network access, (2) diverse user populations that differ on such dimensions as age, disabilities, disabling conditions, and literacy, and (3) gaps in the knowledge of users.

Web accessibility is similar to universal design because it also seeks to improve design so all audiences, especially the disabled, can access the content of a Web site. In this sense this is consistent with the definition of accessibility used in TS 16071 (Gulliksen & Harker, 2004)

discussed in section 4.4. However, accessibility differs from universal design because there are legal and regulatory issues related to accessibility not associated with universal design.
With respect to usability and accessibility, ISO 9241 (see section 4.4) defines usability as "The extent to which a product, service, environment can be used by specified users, to achieve specified goals with effectiveness, efficiency and satisfaction, in a specified context of use" (Gulliksen & Harker, 2004, p. 9). If the phrase "specified users" encompasses the widest possible range of diverse user groups, then usability is related to accessibility. But, usability could be limited to a target market and not necessarily encompass a wider set of users (such as the disabled) if a firm does not consider this group a relevant audience. For example, when usability is considered as a competitive advantage (Wegge & Zimmerman, 2007), a firm may not consider disabled users as part of the relevant audience.

Barriers to Web Accessibility

A limited number of empirical studies have examined various Web sites for barriers to accessibility. Most of these studies show no matter the domain, many Web sites are not designed for accessibility. For example, Loiacono (2004a) conducted a study examining the accessibility of the home pages of 96 non-profit organizations. More than 87 percent of the home pages examined had severe barriers. Romano (2002-2003) evaluated the accessibility of the home pages of the top 250 Fortune 500 companies in 2002. He found severe accessibility barriers in 75 percent of these organizations. Two years later, Loiacono (2004b) evaluated the home pages of Fortune 100 companies. Her results show a large improvement, compared to Romano, in that only 20 percent of the sites exhibited severe barriers. However, despite the improvement in the level of severe barriers among corporate home pages, most of the Web sites examined by Loiacono (2004b) still contained moderate to low level barriers. Typical low level barriers were (1) failure to include alternate tags for images, (2) failure to use relative sizing and positioning, and (3) failure to assure that the functionality of the page is independent of a particular input device. Only six percent of the sites she examined had zero accessibility errors.

Hackett et al. (2005) examined Web site accessibility and its interaction with Web site complexity over time. These authors compared a random sample of general Web sites with a convenience sample of U.S. government Web sites over a five year period (1997-2002). By law,

U.S. government Web sites are required to provide access to electronic and information technology to people with disabilities (referred to as Section 508). Their results indicate that both general and U.S. government Web sites became increasingly complex over time. In other words, both the general Web sites and the U.S. government sites offered increasingly rich content and graphics over time. However, where the two samples differ is with respect to accessibility. The general Web sites became more inaccessible as they increased in complexity; whereas the U.S. government Web sites remained relatively accessible even though they became more complex. Hackett et al's. (2005) study is important because their findings prove that making a Web site more accessible does not mean the site is less rich from a communication standpoint. Furthermore, their study shows when an organization improves accessibility, it does not limit the ability to design a communication-rich Web site.

Disabilities and Web Accessibility

The issue at the heart of Web accessibility is that many Web sites are not designed with equal access in mind. In other words, lack of Web accessibility is more a result of faulty design rather than inadequate technologies. Carter and Markel (2001) estimate that one percent of Web developers take accessibility into account when designing Web pages. When Web sites are designed without concern for users with disabilities, barriers often exist that inhibit access to the content of the site. Common accessibility barriers include: images without alternative text; misleading use of structural elements on a Web page; uncaptioned audio or undescribed video; tables that are difficult to decipher when linearized; and sites with poor color contrast (Carter & Markel, 2001). Similarly, McCormick (2006) argues poorly written code underlying the Web design; poor navigational design; missing headings or titles; and alternative text for images are the most common accessibility errors.

The Center for Disease Control (CDC) identifies four types of disabilities (visual, auditory, cognitive, and motor) that are especially relevant to Web accessibility (see http://www.cdc.gov/ncbddd/disabilities.htm.). Visual disabilities include blindness, color blindness, and low vision (i.e., peripheral constriction or retinal detachment). The latter two make it harder for students to read the information on certain Web sites since dark backgrounds, unusual or small fonts, and unclear images pose problems for people with these two visual

disabilities. Students with audio disabilities such as deafness or a hearing impairment are impacted when Web sites use audio files or low quality recordings. Students with cognitive impairments (also called learning disabilities) include autism, ADHD, and dyslexia as exemplars. Those with cognitive impairments can have difficulty reading text or lack the full ability to identify links within a Web site. Motor impairments include people with cerebral palsy, multiple sclerosis, muscular dystrophy, rheumatoid arthritis, carpal tunnel, broken bones, or other conditions that cause tremors or loss of fine muscle control. Students with a motor disability often have difficulty using their hands to navigate Web sites. Given these limitations, disabled students can use a variety of assistive technologies to gain access to the Web. Representative examples of assistive technologies for each of the four disability types are presented in Table 1.

Miller (2006) gives a specific example related to screen reader software interaction with Web page graphics. "In order to identify these elements to a screen reader, your site must provide ALT text, language that is associated with non-text elements that provides contextual meaning in cases in which users cannot see the graphic" (p. 21-22). Because screen readers only read text and cannot interpret graphic images, the code underlying the Web design should be written with titles, headings, and text captions that are appropriate for each graphic. Goldie (2006) argues that pop-ups without warning and insufficient color contrast are other examples of Web accessibility barriers for users with vision impairments. Similarly, graphics are problematic for deaf users who want to access the Web. The authors explain graphical information is difficult for hearing impaired users because they organize and retrieve knowledge about graphical information in long term memory differently than the hearing enabled. Yet Fajardo et al. (2006) found when they substituted textual links for graphics, both deaf and hearing enabled consumers were better and faster at retrieving information from a Web site. Furthermore, both deaf and hearing enabled consumers reported less confusion while trying to retrieve the information via textual links as opposed to graphics.

TABLE 1: Examples of Assistive Technologies for Various Disabilities*

Visual Disability	Auditory Disability	Cognitive Disability	Motor Disability
Screen magnifiers enlarge a portion of the screen as the user moves about the screen. For straight text, users can magnify on screen by zooming	Telecommunications Device for the Deaf (TDD) provides means to communicate over phone lines using text terminals.	Reading tools and learning disabilities programs include software and hardware designed to make text-based materials more accessible for people who have difficulty with reading. Options can include scanning, reformatting, navigating, or speaking text out loud.	Alternate pointing devices enable users with limited or no arm and hand movement to control mouse movements. Examples include foot operated mice, sip-and-puff systems, trackballs, head-mounted pointing devices, and eye-tracking systems.
Screen reader software present graphics and text as speech	Closed captioning provides text translation of spoken material on video media (e.g., distance learning or video conference).	Screen reader software used for visual disabilities is also effective for people with dyslexia.	On-screen keyboards provide the key functions of physical keyboard and are typically used with alternate pointing devices.
Speech recognition systems allow people to make inputs with their voice rather than by mouse or keyboard.	ShowSounds is a standard that provides visual translation of sound information. It is available in Windows XP and Vista. In Vista it is called "Captions."	Speech recognition software can be used by people who find creating written language difficult.	Predictive dictionaries speed typing by predicting words as the user types them and offer words for the user to choose among.
Speech synthesizers allow users to hear the information they put into the computer	Light signaler alerts the user when the computer is emitting sounds such as indicating a new email message.	Software like spell and grammar checkers, writing organizers, time management, and prompters are useful for processing impairments.	Speech recognition enables users to control user interface or enter text via speech
Refreshable Braille displays provide tactile output of information on the computer screen. Lines from the screen are sent to a device where small rounded plastic or metal pins are raised to form		Office technology such as email, automatic reminders, and timers can be used for people with memory related impairments.	Keyboard enhancements enable single finger operation of multiple key combos, delay onset of key repeat, bouncekey delays, or onset of inadvertent key presses

Braille characters. The user reads the Braille letters with his or her fingers, and then, after a line is read, can refresh the display to read the next line.	(users with tremors).
Braille embossers transfer computer generated text into embossed Braille output using a special printer.	
Talking word processors use speech synthesizers to provide auditory feedback of what is typed.	
Large-print word processors allow users to view everything in large text without added screen enlargement.	

* This material was adapted from the following Web sites:
http://www.birf.info/home/library/assistive/ast-assisttech.html, http://www.microsoft.com/enable/guides/vision.aspx
http://www.microsoft.com/enable/guides/dexterity.aspx
http://www.microsoft.com/enable/at/types.aspx
http://developer.gnome.org/projects/gap/at-types.html

Many academic articles address the more technical, computer science issues on Web accessibility. For example, The Association for Computing Machinery[2] (ACM) sponsors two outlets that address issues related to the application of computing technology to solve disability issues. The first outlet is a special interest group named SIGAccess that has sponsored nine conferences concerning application issues. The second outlet addressing these issues is the journal ACM Transactions on Computer-Human interaction (TOCHI). Additionally, several general reference books are available for Web designers (Clark, 2002; Paciello, 2000; Thatcher et al., 2003; Thatcher et al., 2006), as well as books written to address specific design principles and code for Web accessibility (Budd et al., 2007; Duckett, 2005; Kurniawan & Zaphiris, 2006).

Research in Higher Education on Web Accessibility

Although studies on the accessibility of postsecondary Web sites are limited in number, the research to date suggests many universities, like businesses, lack accessible Web sites. Two studies have examined the Web sites of colleges and universities outside of the United States (where laws with respect to Web accessibility are often stricter; see the Disability Discrimination Act of 1995 discussed by Hackett et al., 2005). In Britain, an examination of 100 university Web sites found 33 percent failed to meet the most basic of accessibility guidelines (Anonymous, 2003). Studies of 350 Web sites from Canadian postsecondary institutions conducted in 2002 found only 19.9 percent were free of severe accessibility errors (Zaparyniuk & Montgomerie, 2005).

Rowland and Smith (1999) present one of the few studies that analyzed a random sample of the home pages of 400 postsecondary institutions within the United States. They found only 22 percent of these sites were free from accessibility errors. Hackett and Parmento (2005) examined a convenience sample of higher education Web sites over a five year period (1997-2002). They found the Web sites of postsecondary institutions have become increasingly complex and inaccessible over time.

Other published studies to date focus on a specific domain. Schmetzke (1999) examined University home pages and the first layer of library pages of the 13 four-year institutions within

[2] ACM is the primary professional organization for computer professionals see http://www.acm.org.

the University of Wisconsin state system. He found 31 percent of the pages had no severe accessibility barriers. Lilly and Van Fleet (2000) found more than half of the library home pages of Yahoo's "America's 100 Most Wired Colleges" did not provide equal access for disabled students. Schmetzke (2001b) examined the top 24 *US News and World Report* ranked schools of library and information science. He analyzed both the university's library home page and the home page of the school of library and information science. Four of the library Web sites were free from accessibility errors while only one of the schools of library and information science sites was error free.

Flowers, Bray, and Algozzine (1999) examined the homepages of 89 special education programs throughout the United States. Twenty seven percent of the sites had no accessibility barriers. Another study analyzed the University home pages of 392 AACSB-Accredited Universities. Approximately 32 percent of these Web sites were free from severe accessibility errors (Gutierrez & Long, 2001-2002). Schmetzke (2001a) studied the accessibility of two sets of distance-education Web sites. The study looked at homepages and pages directly linked to the home page. The first set used 219 Web sites of postsecondary distance education Web sites, and the second set used 12 major national organizations concerned with distance learning. In the first set, 15 percent of the homepages were free of accessibility errors. Of the 3,360 pages linked to the homepages, only 23 percent were free of accessibility errors. In the second set, only one of the 12 home pages was free of accessibility errors and only 18 percent of the linked pages were free of accessibility errors.

Spindler (2002) studied the entry page of the main library Web site of 188 U.S. universities with student enrollments between 5,000 and 10,000. Some form of accessibility barrier appeared on 74 percent of the Web sites. The most prevalent problem was the failure to provide alternate text for images. Hackett and Parmanto (2005) examined Web site accessibility and its interaction with Web site complexity over time (1997-2002). They used a convenience sample of 45 members of the American Association of Universities (AAU) and found "a concurrent increase in accessibility barriers that coincides with an increase in complexity" (p. 290). Since most of the members of the AAU receive funding from federal agencies, these institutions are in violation of Section 508. Hackett and Parmanto (2005) attribute the increase in accessibility

barriers to a lack of awareness of the Web accessibility issue. Finally, at the University of Texas, students were trained to evaluate Web site accessibility and then evaluated the accessibility of 99 instructional Web sites (Lewis et al., 2007). Only Web sites from departments that previously showed interest in accessibility were used in the study. Results indicated only 12 percent of the departmental sites met Section 508 accessibility guidelines.

As a whole, the literature review suggests university homepages are not particularly accessible. Of the 11 samples involving Web sites of U.S. postsecondary institutions, 60 to 90 percent of the sites had some form of accessibility barriers. The authors speculate that individual faculty Web pages are in a similar (or worse) situation. However, this speculation is tempered by the fact that no study to date has explicitly examined the accessibility of the instructional Web sites of individual faculty members.

The Legal Mandates for Web Accessibility

The Americans with Disabilities Act (ADA), passed in 1990, directs organizations that are public entities to make reasonable accommodations for those with disabilities. More specifically, Title II (Section 202) of the ADA requires universities make their facilities, programs, services, and activities accessible to the disabled. The ADA interprets information technology and related communication as part of the aids and services that must be reasonably accommodated for the needs of disabled students. However, because the ADA preceded the Web, the law does not specifically address the design of electronic documents as in the case of Web accessibility.

Since an increasing number of people view the Internet as a public space and part of the programs, services, and activities of universities, many believe the ADA applies to the Web (Johnson et al., 2003). Businesses are certainly grappling with this issue as a number of lawsuits were filed about the Web accessibility of corporate sites. For example, the National Federation of the Blind sued America Online, charging the organization violated the ADA because its software did not accommodate screen readers (Carter & Markel, 2001). The suit was dropped when AOL agreed to make its software accessible. In 2003, the New York state attorney filed suit under the ADA against Priceline.com and Ramada.com, charging that their Web sites were

not accessible and deprived the visually impaired access. The two companies settled out of court in 2004 (Miller, 2006).

In early 2006, the National Federation of the Blind sued Target because its Web site contained barriers for the blind (e.g., screen readers did not detect visual information and check out was impossible without using a mouse) and filed suit accordingly. According to Meyers (2006),

> … the suit argues that Target is violating the California Disabled Persons Act, which guarantees full and equal access for people with disabilities to all public spaces. It also argues that Target is violating the California Unruh Civil Rights Act, because blind patrons have been denied full and equal access to Target.com and have been provided services inferior to non-disabled patrons.

Target tried to get the suit dismissed by arguing accessibility only applies to physical access and does not apply to a firm's Web site. However, in September 2006, a Federal District Court judge ruled a retailer can be sued if their Web site is inaccessible to blind customers (Bangeman, 2006). In October of 2007 the case was certified "as a national class action under the ADA" (Anderson, 2007). This suit was finally settled in October of 2008 when Target agreed to (1) establish a $6 million fund for California claimants and (2) permit the NFB to monitor the accessibility of Target's Web site for three years (Danielson, 2008).

This case is significant because it is another instance where courts have ruled that the ADA applies to a firm's Web site. In addition, since Target's Web site is powered by Amazon.com's technology, some of the accessibility barriers may be related to this technology (e.g., one-click checkout). If this is the case, then other retailers that use Amazon.com's technology may be vulnerable to lawsuits like Target.

Although the authors were unable to find a suit brought against a particular university for a lack of Web accessibility, in 1996 the Department of Justice issued an opinion statement (letter number 204) that directs state and local governments to make all their communications, including those that are electronic (i.e., Internet or Web based), accessible to the disabled (Loiacono, 2004a; Schmetzke, 2001b). Thus, it appears the Department of Justice interprets the ADA as applying at the university level. The U.S. Department of Education also issued

statements requiring statewide compliance in California with the ADA to make Web communications accessible at the collegiate level (Schmetzke, 2001a). Schmetzke (2001a) argues only a handful of universities in the United States have Web accessibility policies, and Rowland (2000) argues most are not effective.

With the exception of the wider interpretation of the ADA presented above, the U.S. Government legislatively addresses Web accessibility only with respect to federally funded programs and services. Section 508 of the Rehabilitation Act Amendments of 1998 requires all electronic information technology purchased by the federal government be usable by all disabled people. The legislation requires any institution that receives federal funding to design and enact guidelines and policies for improving the accessibility of the use of information technology among the disabled (Loiacono, 2004a; Schmetzke, 2001b). The legal mandates of Section 508 are based on a subset of the Web Accessibility Guidelines designed by the World Wide Web Consortium, as discussed below.

Part II: Web Accessibility Standards

The dominant standards for Web accessibility come from the World Wide Web Consortium (W3C).[3] W3C is an international association where member organizations, a full-time staff, and the public work together to develop standards for the Web. The W3C is the premiere organization for setting standards for Web site specifications, guidelines, software, and tools (Hackett et al., 2005). In the 90s, W3C created a sub-group called the Web Accessibility Initiative (WAI). The WAI created the Web Content Accessibility Guidelines (WCAG 1.0) which were replaced with a new version called WCAG 2.0 in December of 2008. Because WCAG 2.0 is relatively new, many authoring and evaluation tools, as well as the legal mandate of Section 508, are still geared to WCAG 1.0. In order to better understand WCAG 2.0, we have presented a summary of both WCAG 1.0 and WCAG 2.0. In addition to the standards from WAI, the International Organization for Standardization (ISO) also has produced standards relative to Web accessibility. In particular, we will discuss ISO 9241 and TS 16071.

[3] The URL for the World Wide Web consortium is http://www.w3.org.

WCAG 1.0

WCAG 1.0 contains 14 guidelines for designing and evaluating an accessible Web site (see Table 2). Each guideline is accompanied by a set of checkpoints that operationally define the guideline from a Web designer's perspective. The checkpoints (67 in total) are also assigned priority levels from one to three.[4] Priority one level checkpoints must be satisfied or one or more disability groups will not be able to access information at the Web site. For example, a text equivalent should be provided for every non-text element (e.g., images, tables, or symbols) used in the Web site. Priority two level checkpoints must be satisfied or one or more disability groups will find it difficult to access information at this Web site. For example, the colors used in the foreground and background should contrast sufficiently so a person with color deficits can read screen images. Priority three must be satisfied or one or more disability groups will find it somewhat difficult to access information at this Web site. For example, the primary language of any document on the site should be identified (e.g., HTML or XHTML).

In addition to the priority levels, three levels of conformance inform Web site visitors about the accessibility of a site:

Conformance Level	Priority Checkpoints Satisfied for All 14 Guidelines
AAA	1, 2, 3
AA	1, 2
A	1

[4] The priority levels for each checkpoint are shown in parentheses in Table 2.

TABLE 2: Guidelines, number, and sample checkpoints for WCAG 1.0[3]

#	Guideline	Number of Checkpoints	Sample Checkpoint with Priority Level
1	Provide equivalent alternatives to auditory and visual content.	5	Provide redundant text links for each active region of a server-side image map. (1)
2	Ensure that text and graphics are understandable when viewed without color.	2	Ensure that all information conveyed with color is also available without color, for example from context or markup. (1)
3	Use markup and style sheets and do so properly.	7	Use relative rather than absolute units in markup language attribute values and style sheet property values. (2)
4	Clarify natural language usage.	3	Specify the expansion of each abbreviation or acronym in a document where it first occurs. (3)
5	Create tables that transform gracefully.	6	Do not use tables for layout unless the table makes sense when linearized. Otherwise, if the table does not make sense, provide an alternative equivalent (which may be a linearized version). (2)
6	Ensure that pages featuring new technologies transform gracefully.	5	Ensure that pages are usable when scripts, applets, or other programmatic objects are turned off or not supported. If this is not possible, provide equivalent information on an alternate accessible page. (1)
7	Ensure user control of time-sensitive content changes.	5	Until user agents provide the ability to stop the refresh, do not create periodically auto-refreshing pages. (2)
8	Ensure direct accessibility of embedded user interfaces.	1	Make programmatic elements such as scripts and applets directly accessible or compatible with assistive technologies. (priority 1 if functionality is important and not presented elsewhere, otherwise priority 2).
9	Design for device-independence.	5	Provide client-side image maps instead of server-side image maps except where the regions cannot be defined with an available geometric shape. (1)
10	Use interim solutions.	5	Until user agents handle empty controls correctly, include default, place holding characters in edit boxes and text areas. (3)
11	Use W3C technologies and guidelines.	4	If, after best efforts, you cannot create an accessible page, provide a link to an alternative page that uses W3C technologies, is accessible, has equivalent information (or functionality), and is updated as often as the inaccessible (original) page. (1)
12	Provide context and orientation information.	4	Describe the purpose of frames and how frames relate to each other if it is not obvious by frame titles alone. (2)
13	Provide clear navigation mechanisms.	10	Provide information about the general layout of a site (e.g., a site map or table of contents). (2)
14	Ensure that documents are clear and simple.	3	Use the clearest and simplest language appropriate for a site's content. (1)

The legal mandates of Section 508 of the Rehabilitation Act are based on a subset of the WCAG 1.0 guidelines (see http://www.section508.gov for more information on Section 508). Recall these guidelines apply to all Web sites related to federally funded programs and services as well as Web sites providing state and local services. Table 3 presents a summary of the Section 508 Web Accessibility Guidelines. Even the full set of WCAG 1.0 guidelines are not an all inclusive solution since they are designed based on typical scenarios for the disabled (Hackett et al., 2005). Thus, Web sites designed with Web accessibility as a goal must still be tested using multiple accessibility tools available in the marketplace.

TABLE 3: A listing of the Section 508 guidelines[5]

Provide alternative text for all images.
Provide alternative text for all image map hot-spots (AREAs).
Explicitly associate form controls and their labels with the LABEL element.
Give each frame a title.
Provide alternative text for each APPLET.
Provide alternative text for all image-type buttons in forms.
Include default, place-holding characters in edit boxes and text areas.
Identify the language of the text.

WCAG 2.0

As mentioned earlier, WCAG 2.0 has replaced WCAG 1.0 and is now the official standard for the WAI and W3C. WCAG 2.0 is built around four principles for making Web content accessible for all: (1) Content must be made available to users in a format they can *perceive* with at least one of their senses (i.e., sight, hearing, touch). (2) Content must be presented in a way users can interact with or *operate* on it with either standard or adaptive devices. (3) Content must be presented in a way users can *understand* or comprehend. (4) Content must be presented using technologies and interfaces *robust* enough to allow for disability access, whether natively or in alternative technologies and interfaces. Together these principles address all areas of

[5] Table 3 was adapted from Loiacono [2004b], http://www.w3c.org, and http://www.section508.gov. Words in all capital letters indicate HTML tags.

accessibility, at least in broad conceptual strokes (http://www.webaim.org/standards/wai/wcag2.php).

The four principles also contain a total of twelve guidelines. Under each guideline, there are a varying number of success criteria. These criteria are designed so they can be tested by a computer program or a human tester. The success criteria are similar to the checkpoints found in WCAG 1.0 (see Table 2). The four principles and 12 guidelines are shown in Table 4.

TABLE 4: WCAG 2.0 principles and guidelines[6]

Principle 1: *Perceivable – Information and user interface components must be perceivable by users.*	
Guideline 1.1	Provide text alternatives for any non-text content so that it can be changed into other forms people need such as large print, Braille, speech, symbols, or simpler language.
Guideline 1.2	Provide synchronized alternatives for multimedia.
Guideline 1.3	Create content that can be presented in different ways (for example spoken aloud, simpler layout, etc.) without losing information or structure.
Guideline 1.4	Make it easier for people with disabilities to see and hear content, including separating foreground from background.
Principle 2: *User interface components and navigation must be operable by users.*	
Guideline 2.1	Make all functionality available from a keyboard.
Guideline 2.2	Provide users with disabilities enough time to read and use content.
Guideline 2.3	Do not create content that is known to cause seizures.
Guideline 2.4	Provide ways to help users with disabilities navigate, find content and determine where they are.
Principle 3: *Understandable – Information and operation of user interface must be understandable by users.*	
Guideline 3.1	Make text content readable and understandable by users.
Guideline 3.2	Make Web pages appear and operate in predictable ways.
Guideline 3.3	Help users avoid and correct mistakes.
Principle 4: *Robust – Content must be robust enough that it can be interpreted reliably by a wide variety of user agents, including assistive technologies.*	
Guideline 4.1	Maximize compatibility with current and future user agents, including assistive technologies.

As an example, the success criteria for guideline 3.1 are listed in Figure 1. In addition, WCAG 2.0 contains specific instructions on how to meet the individual success criteria (these are not

[6] Adapted from http://www.w3.org/TR/2008/CR-WCAG20-20080430.

shown). Each success criterion is assigned one of three levels of conformance: Level A, Level AA, and Level AAA.

FIGURE 1: Success criteria for guideline 3.1.[7]

3.1.1 *Language of Page:* The default human language of each Web page within the content can be programmatically determined. (Level A)

3.1.2 *Language of Parts:* The human language of each passage or phrase in the content can be programmatically determined. (Level AA)

3.1.3 *Unusual Words:* A mechanism is available for identifying specific definitions of words or phrases used in an unusual or restricted way, including idioms and jargon. (Level AA)

3.1.4 *Abbreviations:* A mechanism for finding the expanded form or meaning of abbreviations is available. (Level AA)

3.1.5 *Reading Level:* When text requires reading ability more advanced than the lower secondary education level, supplemental content or an alternate version is available that does not require reading ability more advanced than the lower secondary education level. (Level AAA)

3.1.6 *Pronunciation:* A mechanism is available for identifying specific pronunciation of words where meaning is ambiguous without knowing the pronunciation. (Level AAA)

There are five conformance requirements for WCAG 2.0. These requirements and a brief explanation are displayed in Table 5.

[7] Adapted from http://www.w3.org/TR/2008/CR-WCAG20-20080430/ and http://www.w3.org/TR/WCAG20/.

TABLE 5: The five conformance requirements for WCAG 2.0[8]

Conformance Requirement	Explanation
Conformance Level	One of the following levels of conformance is met in full: All Level A success criteria are satisfied or a conforming alternate version is available. All Level A and Level AA success criteria are satisfied or a conforming alternate Level AA version is available. All Level A, Level AA, Level AAA success criteria are satisfied or a conforming alternate Level AAA version is available.
Full Pages	Conformance is for full Web page(s) only, and cannot be achieved if part of a Web page is excluded.
Complete processes	If a Web page that is part of a process does not conform, then no conformance claim can be made for any Web pages in that process.
Accessibility-Supported technologies only	Only documented accessibility-supported Web technologies are employed to meet success criteria. Any information or functionality implemented in technologies that are not accessibility supported must also be available via technologies that are accessibility supported.
Non-Interference	If technologies that are not accessibility supported are used on a page, or accessibility-supported technologies are used in a non-conforming way, then they do not block the ability of users to access the rest of the page. In addition, the Web page as a whole continues to meet the conformance requirements under all of the following conditions: (1) when any technology that is not accessibility-supported is turned on in a user agent, and (2) when it is turned off in a user agent, and (3) when it is not supported by a user agent.

The W3C also provides a substantial amount of guidance for individuals trying to employ the WCAG 2.0 guidelines. In particular, the Web site http://www.w3.org/TR/WCAG20-TECHS/ provides multiple techniques for employing WCAG 2.0 in the following areas: general, HTML and XHTML, CSS, client side scripting, and server side scripting. Additional techniques in more specialized areas are also available at this same Web site.

[8] Adapted from http://www.w3.org/TR/2008/WD-UNDERSTANDING-WCAG20-20080430/conformance.html#uc-levels-head.

Comparing WCAG 1.0 to WCAG 2.0

A quick comparison between the two versions is shown below:

WCAG 1.0	WCAG 2
---	4 Principles
14 Guidelines	12 Guidelines
67 Checkpoints	61 Success Criteria
3 Priority Levels per Checkpoint	3 Levels per Success Criterion
3 Levels of Conformance	5 Requirements for Conformance

Three major changes between the two versions are described below. A detailed comparison between the two versions is available at http://www.w3.org/TR/2006/WD-WCAG20-20060427/appendixD.html.

The first major change in WCAG 2.0 is to separate general principles from technique. The philosophy of WCAG 2.0 is to put technology specific techniques in separate documents instead of embedding them in the guidelines as was done in WCAG 1.0. For example, WCAG 2.0 has placed technology specific techniques in separate documents to explain how to use HTML, CSS, or scripting to ensure conformance with WCAG 2.0 (for HTML see http://www.w3.org/TR/2005/WD-WCAG20-HTML-TECHS-20051123/).

A second major change is all of the success criteria in WCAG 2.0 are verifiable either by a computer or by human testing (http://www.webaim.org/standards/wai/wcag2.php). Another criticism of WCAG 1.0 was checkpoints could not be verified without ambiguity. With respect to human testing, the idea is each criterion can be tested by several trained human testers and conformance can be verified by a sufficiently high inter-rater reliability (e.g., 80 percent or better).

The third major change is WCAG 2.0 abandoned the priority scheme from WCAG 1.0. The priority scheme in WCAG 1.0 gave the impression some guidelines were not as important as others. However, the importance of the guidelines was highly dependent on the nature of the

disability. For example, some priority 3 items were more important for some disabilities than certain priority 1 items (http://www.webaim.org/standards/wai/wcag2.php).

ISO Standards

The ISO also publishes guidelines related to Web accessibility. The most relevant for this discussion is ISO 9241 (titled Ergonomics of Human System Interaction) which is a collection of 28 parts (System Concepts, 2009). The philosophy behind ISO 9241 differs from the philosophy behind the WCAG guidelines in that the primary tests for accessibility are based on user-based testing with diverse populations of users. In contrast, the WCAG guidelines determine accessibility through combinations of manual inspections by experts or automated evaluations tools that test for specific functionalities (Gulliksen & Harker, 2004).

Another standard named TS 16071 "provides guidance to developers on designing human-computer interfaces which provide a level of accessibility as high as possible" (Gulliksen & Harker, 2004). In contrast to the WCAG guidelines, TS 16071 is not restricted to Web accessibility but covers software used in work, home, and educational settings. Nevertheless, there is a strong relationship between TS 16071 and WCAG 1.0. When TS 16071 was under development, the working group reviewed WCAG 1.0 and determined most guidelines in WCAG 1.0 were standard ergonomic guidelines covered by ISO 9241 or guidelines that should be included in TS 16071. As a result, when TS 16071 is used in conjunction with ISO 9241, most of the WCAG 1.0 guidelines are satisfied (Gulliksen &Harker, 2004).

In the latter part of 2008, TS 16071 became a part of ISO 9241 as ISO 9241-171 (Systemconcepts, 2009). Two additional standards related to accessibility also became a part of ISO 9241 in 2008. These include ISO-9241-20 which provides accessibility guidelines for information/communication technology (ICT) equipment and services, and ISO-9241-151 which provides usability guidelines for user interfaces to the World Wide Web (Systemconcepts, 2009).

Part III: Authoring and Evaluation Tools

Authoring Tools

There are various software and services that Web site developers can use to produce accessible Web content. The WAI group published Authoring Tool Accessibility Guidelines (ATAG) Version 1.0 (http://www.w3.org/TR/ATAG10/), providing checkpoints and conformance levels for software vendors producing this type of tool. ATAG 1.0 was approved in 2000 and is compatible with WCAG 1.0. ATAG 2.0 is still in draft form, and the latest version is described by Richards, Spellman, and Treviranus (2009).

Examples of authoring tools include products for generating HTML or XML code (e.g., Expression Web, or DreamWeaver), applications for saving content to a Web format (e.g., Microsoft Office), video production tools for producing multimedia (e.g., Adobe products such as Acrobat, Reader, Flash or Adobe Photoshop), or courseware tools (e.g., Blackboard or WebCT). Each of these will be discussed below. Other authoring tools can be found at http://www.w3.org/WAI/AU/2002/tools.

Expression Web (the latest version is Expression Web 2) has replaced FrontPage as Microsoft's main Web design tool and is designed to compete with Adobe's Dreamweaver. Early reviews indicate Expression Web is far more compliant with current Web standards than FrontPage and is a viable alternative to Dreamweaver (O'Reilly, 2007).

Dreamweaver has a history of producing both HTML and XHTML code that is compliant with Web standards. In addition, both Dreamweaver and Expression Web have built in evaluation tools that check for compliance with Section 508 and WCAG 1.0. Despite these built-in features, most experts recommend additional testing with other evaluation tools. Furthermore, faculty who post files created by Microsoft Office applications (e.g., PowerPoint, Word, or Excel) can improve the accessibility of these files by visiting the Web sites described in Table 6. These Web sites provide techniques, tutorials, and downloads on how to improve the accessibility of these files with respect to WCAG 1.0. None of the Microsoft sites contain information related to WCAG 2.0.

TABLE 6: Web sites containing information for improving accessibility classified by product

Product	Vendor	URL
Adobe Acrobat	Adobe	https://admin.adobe.acrobat.com/_a295153/p89681357/ http://www.adobe.com/enterprise/accessibility/pdfs/acrobat7_accessibility_faq.pdf http://www.adobe.com/accessibility/products/acrobat/pdf/A9-pdf-accesibility-overview.pdf
Adobe Reader	Adobe	http://www.adobe.com/enterprise/accessibility/readcontent.html http://www.adobe.com/accessibility/508standards.html
Blackboard Learning Systems (Release 7)	Blackboard	http://www.blackboard.com/clientcollateral/accessibility_AS_20071101.pdf http://collaborate.cita.uiuc.edu/blackboard/issues.php http://www.edutools.info/compare.jsp?pj=4&i=556)
Dreamweaver	Adobe	http://www.adobe.com/accessibility/products/dreamweaver/overview.html http://www.webaim.org/techniques/dreamweaver
Excel	Microsoft	http://office.microsoft.com/en-us/excel/HP051984341033.aspx http://www.okdhs.org/library/webmgmt/procguide/docs/bpexcel.htm
Expression Web	Microsoft	http://www.webaim.org/techniques/msew/
Internet Explorer	Microsoft	http://www.microsoft.com/enable/training/ie6 http://www.microsoft.com/enable/products/ie7/
Mozilla	Firefox	http://www.mozilla.org/access/features http://firefox.cita.uiuc.edu/ http://kb.mozillazine.org/Accessibility_features_of_Firefox
Office	Microsoft	http://www.virtual508.com/ http://msdn2.microsoft.com/en-us/library/bb404170.aspx
PowerPoint	Microsoft	http://www.cew.wisc.edu/accessibility/tutorials/pptpublish.htm http://www.cew.wisc.edu/accessibility/tutorials/pptscratch.htm http://www.webaim.org/techniques/powerpoint/
Word	Microsoft	http://www.aptitudemedia.com/resources/access/documents/word.htm http://www.cew.wisc.edu/accessibility/tutorials/MSWordFeatures.htm http://www.webaim.org/techniques/word/

Faculty who post content in Adobe's portable document format (PDF) should be aware of accessibility features in Adobe Acrobat and Adobe Reader. Acrobat is commercial software that enables authors to create documents in the PDF format. There are a number of built-in features in Acrobat that enable authors to make PDF files accessible. For example, Acrobat permits the insertion of tags, similar to HTML tags, in documents. Specifically, Acrobat provides for adding an alternate text tag for images embedded in a PDF document. Additional information is contained at the Web sites described in Table 6.

Adobe Reader is free software that allows users to read PDF files. Reader also contains a number of features designed to make documents more accessible for people with disabilities. For example, Reader enables disabled users to utilize built-in text-to-speech synthesis available in Windows and Mac operating systems. Other features are described at the Web sites in Table 6.

Many faculty use courseware tools, such as Blackboard or WebCT to act as instructional aids on the Web, rather than construct their own Web site. Since Blackboard and WebCT merged in 2006, WebCT is being phased out and Blackboard is now the dominant courseware product in the market place. With respect to accessibility, Blackboard seems to address most of the Section 508 guidelines. Blackboard claims to be compliant with WCAG 1.0 at the AA level. One review (Mohammed, 2006) of Blackboard confirmed compliance with Section 508 guidelines but made no mention of WCAG 1.0.

Evaluation Tools

These tools automate as much as possible the process of evaluating whether a Web site conforms to accessibility guidelines. Evaluation tools serve two functions. There are evaluation tools that automatically judge whether the Web site is in conformance with accessibility guidelines and in some instances make the necessary changes. For example, certain tools will automatically check that audio components of a Web site are tagged appropriately so the hearing impaired will see captions on the screen in lieu of audio. However, automated tools are useful but not always sufficient in completely judging accessibility. Some of the accessibility guidelines must be manually checked. For example, issues such as quality, ease of use, and look and feel that require human judgment must be checked manually. There are also evaluation tools that attempt to do both functions in the sense the tool automates changes necessary for conformance with accessibility guidelines and informs designers where manual checks may be required.

Five features are particularly important when comparing the various authoring and evaluation tools in the marketplace: accessibility guidelines, nature of the assistance, page scope, repair options, and format scope. Which accessibility guidelines are supported is of primary importance (e.g., WCAG 1.0, WCAG 2.0, or Section 508). Some tools provide reports

indicating conformance or non-conformance to specific guidelines (e.g., Section 508), while others provide step-by-step instructions (similar to a Microsoft Wizard) to guide the developer through a series of check points. With respect to the nature of assistance, some tools insert symbols in a page's code to inform the developer of accessibility problems, while others modify the appearance of the Web page. As for page scope, some tools support checking on single pages while others can check on groups of pages or even full Web sites. Some tools offer no repair options (requiring that the designer rewrite the problematic HTML code themselves),while others can change the code of the page, add captions to audio or video content, and/or convert various file types (e.g., PDF) into accessible HTML code. Finally, tools also vary in the number of formats that can be checked for accessibility. For example, tools vary on whether they check HTML, cascading style sheets (CSS), compatibility with Synchronized Multimedia Integration Language (SMIL), different browsers (Mozilla/Firefox, Safari, or Opera), work with integrated design environments (IDE), and/or work with runtime applications (such as Javascript).

The WAI group provides guidelines for selecting authoring and evaluation tools and a brief overview of 115 tools in the marketplace (http://www.w3.org/WAI/ER/tools/complete). Some of these tools are commercial while others are either free or open source software. Of the 115 tools, 41 were listed as commercial. To get some sense of the availability of tools for WCAG 2.0, we visited each of the 41 commercial Web sites. The results showed: 14 sites had explicit statements of support for WCAG 2.0; 17 had no explicit claim of support for WCAG 2.0; and 10 sites could not be reached.

Part IV: Making a Web Site Accessible: The Diaries of Two Faculty Members' Experiences

Carter and Markel (2001) argue that designing an accessible Web site can be done with little effort and relatively few resources. This assumption may be true for an individual with an extensive background, education, and experience in Web design. However, the average faculty member at a typical post-secondary institution may lack such knowledge. Lincoln (2001) found that while marketing faculty are increasingly utilizing the Web for instructional purposes, they are also concerned about the lack of free time and institutional support necessary related to the

utilization of new technology. Thus, the authors sought to individually update the designs of their own Web sites with accessibility as the goal. The authors documented their activities and efforts via personal diaries. These diaries are provided below to shed light on Web accessibility in practice for a typical faculty member at a federally funded institution.

The Marketing Professor

It has been almost ten years since I graduated from my Ph. D. program in marketing. During the first two years of my program, I remember taking a seminar in which we had to write the HTML code to design a Web site. Since that time, I have been active in building and maintaining my own Web site for instructional purposes, but I have done so using the point-and-click format of FrontPage. From a visual standpoint, I was pretty happy with the existing design of my instructional Web site. The site had all of the materials for my three classes linked into the contents. I had appropriate graphics for each of my classes and even posted a picture of myself. Overall, it was a functional, well-organized, visually appealing site. When my co-author and I decided that we were going to revise our individual instructional sites, I was not very excited about the task. I understand Web accessibility in theory, but upgrading specific HTML code seemed like a daunting task. I consider myself a non-technical person.

I realized that I simply do not know enough about HTML to upgrade my site on my own. However, having read articles about Web accessibility, I knew that there were resources I could draw from to upgrade my site. I started by emailing the owner of a local Web accessibility consulting firm that I had invited to speak to my e-commerce course this semester. I asked him if he had ideas for how I should approach the problem. He stated that for a small fee he could probably set me up with some templates that would be accessible. I could then cut and paste the existing material from my site into the template. I was not excited about having to pay for the templates, so I thought I should investigate whether my university had templates that I could use for free.

I emailed the computing services office of my university asking if they had such templates and were familiar with accessibility. A student who works at the help desk emailed me and said that I needed to contact KB in University Relations. Her job is to help coordinate the content and

style of the various University web sites (i.e., the home page of the university and the home page of each academic unit on campus). As part of her job description, she manages the templates and is the sole "Web accessibility expert" on campus. I emailed KB inquiring about the existence of templates and their accessibility. She replied with an email that contained a link to three University templates. It is required that Web page designers across campus use these templates when creating a site that would be linked up with the university's site as a whole. In contrast, individual faculty and student Web sites were located on separate servers from that of the University, and thus these populations were not required to use the templates.

KB explained that the templates were designed by her predecessor and should be accessible. I could simply download the template of my choice and cut/paste my existing content into the new design. She also said that if I need any help beyond that, she would be happy to help, but I would have to complete a formal work request to be approved by my Dean. I visited the Web site that KB directed me to, and it did seem relatively straight forward. The site contained the three templates and some directions on how to customize a few of the features to fit your academic unit. For example, the University logo was running across the top (which could not be changed/modified) and to the right of the logo there was a box where the designer could cut/paste a file that had the name of the academic unit (i.e., College of Business). I reviewed the templates and selected the one that seemed to best fit the layout of my existing Web site. I downloaded the file and saved it to the server where my existing Web site was located. I then opened the file and started to move the material to the template.

After inputting all of my existing material into the new template and saving the file, I felt pretty good. Although the new site no longer contained many of the graphics that I used in the past (e.g., a picture of myself), the text was all there and the final product looked consistent with the overall home page of the University as well as that of the College of Business. In the end, the site was more text-based when compared with the visual design of my previous Web site; however, I felt that this tradeoff was fair given that the new design was consistent with that of the University as a whole.

I decided that it was time to try and upload the file to the Internet and take a look. This is where I found that the template solution to accessibility was not as easy as I originally thought. When I went in to view my new Web site, none of the graphics that were part of the template were there. I was able to see the text that I had typed in, but there were boxes with a red "x" where the graphics should have been located. At this point, I tried to upload the file again and had the same problem. Unable to determine what I did wrong, I walked over to KB's office to get an appointment. She happened to cross paths with me at the front desk and when I told her about my experience, she explained that the templates are designed to draw files from the University server and faculty Web pages located on a separate server, which may be the cause of the problem. She said that she would take a look and fix the problem with the graphics by the time I arrived back to my office.

Within a few minutes, KB had indeed fixed the template so it worked on the faculty server. I was ecstatic! It was now time to test the new site for accessibility. (It should be noted that a Web site must be uploaded for automated tests to work, as the tester has to input a Web address for the evaluation tool to visit and search for accessibility errors.) When speaking to my class this semester, the owner of the Web accessibility consulting firm demonstrated two tools that the students could use to evaluate a Web site for accessibility. Specifically, he showed them how to use Firefox (a search engine) and Cynthia Says (an open-source Web-based tool) to evaluate an individual Web page.

I decided to visit http://www.cynthiasays.com to test the accessibility of my new site. I entered my Web address and selected Section 508 as the standard of comparison. (Recall 508 is the lowest standard but that which federally funded institutions must comply.) I was shocked when the test resulted in several accessibility errors. Another road block! The evaluation report from Cynthia Says listed each Section 508 checkpoint in the left hand column and then marked whether it passed in the right hand column (Yes, No, or N/A). Once I got the information that I had accessibility errors in the new design, I was not quite sure how to proceed. So I printed a formal work request (and got it signed by my Dean) so that I could get KB to help me fix the errors in the HTML code. After she received my request in writing, she called and we reviewed the code together.

Cynthia Says reported the following accessibility errors. I will follow each statement with KB's suggested changes to the HTML code underlying my new Web site.

A. 508 Standards, Section 1194.22, (a) A text equivalent for every non-text element shall be provided (e.g., via "alt", "longdesc", or in element content).

- One of the images in the template (a gold bar under the University logo) did not have an alt tag that described the image. I did a right-click on the gold bar and gave it the name of "gold bar" so an assistive technology would no longer read it as "image1."

B. 508 Standards, Section 1194.22, (l) When pages utilize scripting languages to display content, or to create interface elements, the information provided by the script shall be identified with functional text that can be read by assistive technology.

- I had failed to identify and formally name the content of the site within the HTML code. This was part of the directions that came with the template, but I was unsure how and where to properly insert this information in the code underlying the template. I could not see any problem with skipping this step when previewing the design, but an assistive technology needs to identify a title or name for the site to work properly. KB showed me where to insert the name and content description in the HTML code (which was part of the meta-tags).

C. 508 Standards, Section 1194.22, (m) When a Web page requires that an applet, plug-in or other application be present on the client system to interpret page content, the page must provide a link to a plug-in or applet that complies with §1194.21(a) through (l).

- I had two links that appeared problematic. One of my exam reviews, which was a file linked to the site, was not named properly so I renamed the file and recreated the link.
- One of the links to another Web page had only part of the name highlighted and identified as a link, which also caused an error. I recreated the link making sure that the full filename was highlighted and identified as the link.

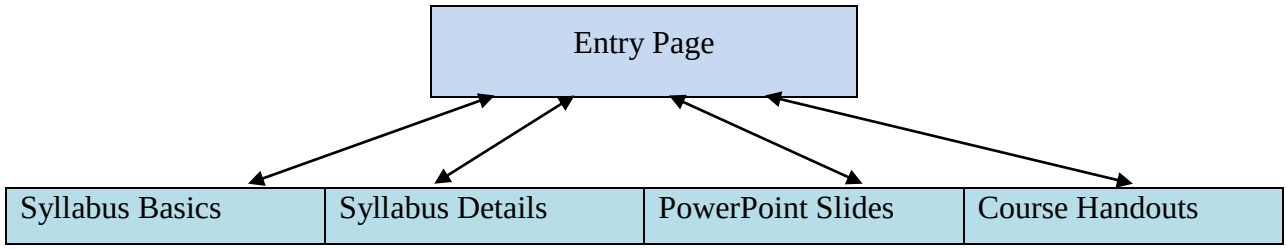
After making these changes, I once again visited http://www.cynthiasays.com and ran the Cynthia Says evaluation tool to test the accessibility of the upgraded site. I passed all of the 508 checkpoints! I also ran a test using the evaluation tool of Bobby (http://webxact.watchfire.com/ : selecting Section 508 as the standard), which again indicated that I had passed all of the 508 checkpoints and was free from accessibility errors at that level. Although I was relieved that I

finally had an accessible Web site, further conversations with my co-author reminded me that my site may still not be completely accessible as the site has only been tested using automated evaluation tools and has never been scrutinized by a disabled human subject.

The Management Information Systems Professor

Since 1998, I have used two Web sites to support my classes where FrontPage was the software for creating the HTML code for these sites. Both Web sites support required Information Systems classes. One class is required of all undergraduate business majors, and the second is required of all MBA students. Figure 2 displays the page linkage structure used at both sites. Each box in Figure 2 represents a page, and the bi-directional arrows indicate users can go back and forth between the Entry Page and any one of the four subordinate pages.

FIGURE 2: Page relationships for my Web sites.



Since FrontPage was not designed to create HTML code compliant with either Section 508 or WCAG 1.0, both Web sites had deficiencies with respect to accessibility for disabled students. For example, images were used without explanatory tags because I was unaware of the impact on vision-impaired users. Tables were also used without adding explanatory material making the tables easier to understand for students using a screen reader. Other features that were problematic for students with disabilities included hit counters, time and date stamps, scrolling marquees, and background music.

The strategy for redesigning the Web sites was to test each Web site's conformance with Section 508 and WCAG 1.0 with three testing tools. Each testing tool produces a report that identifies where and/or how the HTML code does not conform to accessibility guidelines. These reports

would then be used to modify the HTML for each page so that all pages would conform to both Section 508 and WCAG 1.0.

The first testing tool is "Cynthia Says" (see www.contentquality.com from HiSoftware and serves as a free preview for their full-featured testing tool. The second testing tool is called Bobby which is the tool used in several studies cited in the review of literature. During the testing time frame, the Bobby program was owned by Watchfire. Prior to February 2008, Bobby served as a demonstration product for WatchFire's commercial product WebXact (described earlier). In the summer of 2007, IBM acquired Watchfire, and on February 1, 2008 free online testing was discontinued. The paragraphs that follow describe experiences with Bobby during the free testing period. The third testing tool is available from Microsoft's Expression Web. During the time period the Web sites were tested, our university replaced FrontPage with Expression Web. Since Expression Web has a built in tool for testing accessibility, this tool was added to the testing plan. Unlike CS and Bobby, which were free, the Expression Web tool requires a licensed copy of Expression Web.

Testing with Cynthia Says (CS). The entry screen for (CS) is shown in Figure 3. CS enables users to test pages one page at a time by entering the URL for the page as shown in Figure 3. After selecting the page, the user can select to test for conformance for Section 508 or any of the three priority levels for WCAG 1.0. The check boxes below the accessibility report type provide users with options to enhance their reports. The option "Include the source on accessibility failures" provides a numbered line listing of the HTML code from a tested page with failures which was very useful for identifying and correcting errors. The last option enables the user to choose a browser for the testing from among thirty browser options including Internet Explorer up to version 6 and Netscape up to version 6. Internet Explorer version 7.0 and Mozilla were not included.

Two problems repeatedly detected by CS included images without tags to explain the image and scrolling marquees. To correct the first problem, HTML code was modified by adding tags for the images. The second problem was corrected by deleting the code for the scrolling marquees. Once these changes were made, CS validated all pages passed the checklists for Section 508 and

all three priority levels for WCAG 1.0 (see Figure 4). All pages were tested using Internet Explorer 6.0.

FIGURE 3: The entry screen for Cynthia Says content validation tool.

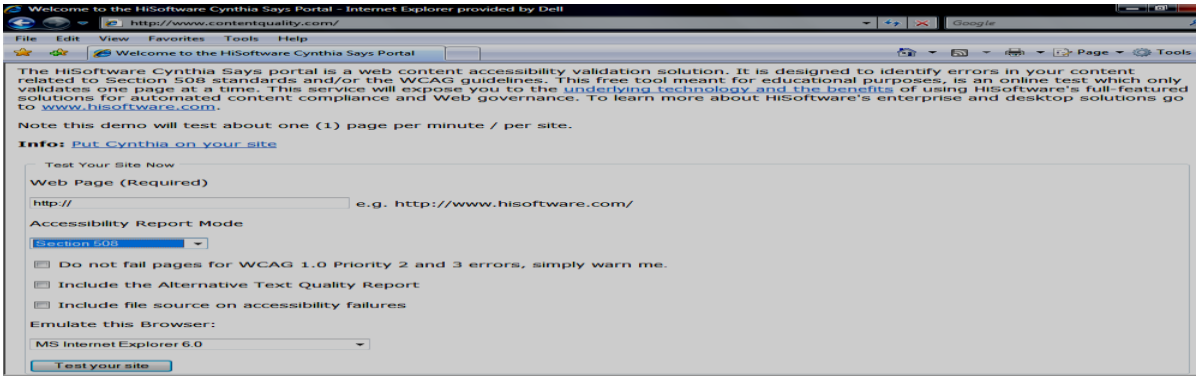


FIGURE 4: Output report from Cynthia Says concerning conformance to WCAG 1.0 priority levels 1, 2, and 3 (Note that N/V means not selected for verification).

Priority 2 Verification Checklist

Checkpoints	Passed		
Priority 2 - Basic	**Yes**	**No**	**Other**
2.2 Ensure that foreground and background color combinations provide sufficient contrast when viewed by someone having color deficits or when viewed on a black and white screen.			N/V
3.1 When an appropriate markup language exists, use markup rather than images to convey information.			N/V
3.2 Create documents that validate to published formal grammars.			N/V
3.3 Use style sheets to control layout and presentation.			N/V
3.4 Use relative rather than absolute units in markup language attribute values and style sheet property values.			N/V
3.5 Use header elements to convey document structure and use them according to specification.			N/V
3.6 Mark up lists and list items properly.			N/V
3.7 Mark up quotations. Do not use quotation markup for formatting effects such as indentation.			N/V
6.5 Ensure that dynamic content is accessible or provide an alternative presentation or page. In addition to the rules specified below, refer to the detail of checkpoints 6.3 / (l),(m) and 1.1 / (a) for locations of elements that apply to this checkpoint.			N/V
7.2 Until user agents allow users to control blinking, avoid causing content to blink (i.e., change presentation at a regular rate, such as turning on and off). To assist with visual verification, we recommend that you refer to the detail of checkpoint 7.1 / (j) for locations of elements that apply to this checkpoint.			N/V
7.4 Until user agents provide the ability to stop the refresh, do not create periodically auto-refreshing pages.			N/V
7.5 Until user agents provide the ability to stop auto-redirect, do not use markup to redirect pages automatically. Instead, configure the server to perform redirects.			N/V

Priority 3 Verification Checklist

Checkpoints	Passed		
Priority 3 - Basic	**Yes**	**No**	**Other**
4.2 Specify the expansion of each abbreviation or acronym in a document where it first occurs.			N/V
4.3 Identify the primary natural language of a document.			N/V
9.4 Create a logical tab order through links, form controls, and objects.			N/V
9.5 Provide keyboard shortcuts to important links (including those in client-side image maps), form controls, and groups of form controls.			N/V
10.5 Until user agents (including assistive technologies) render adjacent links distinctly, include non-link, printable characters (surrounded by spaces) between adjacent links.			N/V
11.3 Provide information so that users may receive documents according to their preferences (e.g., language, content type, etc.)			N/V
13.5 Provide navigation bars to highlight and give access to the navigation mechanism.			N/V
13.6 Group related links, identify the group (for user agents), and, until user agents do so, provide a way to bypass the group.			N/V
13.7 If search functions are provided, enable different types of searches for different skill levels and preferences.			N/V
13.8 Place distinguishing information at the beginning of headings, paragraphs, lists, etc.			N/V
13.9 Provide information about document collections (i.e., documents comprising multiple pages.).			N/V
13.10 Provide a means to skip over multi-line ASCII art.			N/V
14.2 Supplement text with graphic or auditory presentations where they will facilitate comprehension of the page.			N/V
14.3 Create a style of presentation that is consistent across pages.			N/V

Testing with Bobby. Figure 5 shows the entry screen for the Bobby program. As in the CS program, users can test for accessibility for Section 508 or any of the three levels for WCAG. All testing in Bobby used Internet Explorer 7.0. Bobby found five errors not detected by CS on each of the pages: (1) use relative sizing and positioning rather than absolute, (2) identify the language of the text, (3) provide a summary for tables, (4) use a public text identifier in a DOCTYPE statement, and (5) separate adjacent links with more than whitespace. The first two were priority 2 checkpoint errors, and the latter three were priority 3 checkpoint errors. Errors two through five were corrected by inserting corrective statements in the HTML code.

The error concerning "relative sizing and positioning rather than absolute" turned out to be the most difficult. The first strategy used was to modify each instance in the HTML code. This strategy worked for pages with only a few instances of this error, but several pages contained over 100 instances. This problem was solved by changing from FrontPage to Expression Web. While writing this paper, the University replaced FrontPage 2003 with Expression Web as the official Web page development tool. Expression Web contains editing tools that enable users to edit HTML code similar to ways a word processor enables users to edit text. Specifically, the "find and replace" tool in Expression Web fixed the "relative sizing and positioning" problem in short order. Figure 5 displays the entry screen for Bobby and Figure 6 displays a partial report.

FIGURE 5: The entry screen for the Bobby program.

The report screen for Bobby is shown in Figure 6. Errors concern problems that will cause a page to fail accessibility standards. Warnings signify content that should be reviewed because

the content may be a potential accessibility problem. The manual list serves as a reminder list to ensure the designer is aware of requirements imposed by certain standards. Starting in row four of Figure 6, Bobby reports there are (1) repairs required for all three priority levels as indicated by the X's in the first status column. Similarly, manual verifications are noted for all three priority levels as indicated by the exclamation points (!) in the second status column. By the time all testing was done with Bobby, all pages complied with the automatic checkpoints at each of the priority levels (i.e., there were no errors).

FIGURE 6: A partial accessibility report from Bobby (Screen shots were unavailable, since Bobby was no longer free).

X This page **does not comply** with all of the automatic and manual checkpoints of the W3C Web Content Accessibility Guidelines, and **requires repairs and manual verification**.

	Automatic Checkpoints			**Manual checkpoints**		
	Status	**Errors**	**Instances**	**Status**	**Warnings**	**Instances**
Priority 1	X	1	1	!	8	22
Priority 2	X	2	136	!	15	167
Priority 3	X	3	21	!	8	8

X Priority 2 Checkpoints
2 tests, 136 instances on page

Guideline	**Instances**	**Line Numbers**
3.2 Use a public text identifier in a DOCTYPE statement. 3.4 Use relative sizing and positioning, rather than absolute.	135	32, 61, 64, 74, 75, 76, …

! Warnings
15 tests 167 instances on page

Guideline	Instances	Line Numbers
2.2 Check that the foreground and background colors contrast sufficiently with 3.1 Where it's possible to mark up content instead of using images, use a markup	3	23, 546, 650

Testing with Expression Web. Because Expression Web was used instead of FrontPage to resolve errors identified by Bobby, a third testing tool was available. The testing tool in Expression Web tests for accessibility of pages with respect to WCAG 1.0 Priority 1, WCAG 1.0 Priority 2, and Section 508. This tool produces a report as shown in Figure 7. Errors, warnings, and manual checks have the same meaning as in the Bobby report shown in Figure 6. To correct errors identified in Bobby, three pages were totally redesigned using Expression Web. The results of using Expression Web to redesign pages can be seen in the entries of Table 7 where there are zeros in the "# of Warnings" column.

FIGURE 7: A screen shot of an accessibility report from Expression Web.

Line	Issue Type	Checkpoint	Problem Summary
	Manual Check	WCAG 11.4	If you are unable to make an accessible page, create an alternative...
	Manual Check	WCAG 13.2	Web sites and pages should provide semantic information and orien...
	Manual Check	WCAG 13.3	Web sites and pages should provide layout information.
	Manual Check	WCAG 13.4	Use of navigation should be consistent throughout your Web site.
	Manual Check	WCAG 14.1	Use the clearest and simplest language appropriate for this content.
	Manual Check	508, 1194.22(o)	Provide a method for the user to skip these repetitive links.
	Manual Check	508, 1194.22(p)	If a time-based response is required, provide an alert allowing the u...
56	Warning	WCAG 5.1	If this is a data table, please add header rows and/or columns using...
56	Warning	WCAG 5.2	If this is a complex data table identify structure and groupings.
56	Warning	WCAG 5.3	If this table is used for layout, make sure it makes sense when linea...
56	Warning	WCAG 5.4	If this table is used for layout, do not use structural format for visu...
8	Warning	WCAG 6.1	Verify that this document can be read with style sheets turned off.
54	Warning	WCAG 11.2	This line contains a deprecated element.
146	Error	WCAG 13.1	Clearly identify the target of links.
352	Warning		FrontPage Web Components usually do not comply with accessibility...

After correcting the errors identified by Bobby, Table 7 presents a summary of the testing results for the 10 pages that comprise my Web sites. The goal was to have zero errors on all pages. With the exception of the page for Undergraduate/Course Handouts, that goal was achieved. The screen shot for the accessibility report for this page is shown in Figure 7. The error related to WCAG 13.1 is concerned about the text in a hyperlink. According to the guidelines, the text should "clearly identify the target of links." The point of this guideline is to discourage designers from using text like "click here" as the text for a hyperlink. The link in question is to a handout containing examples of well-constructed essay questions from previous exams. The text of the link is "GoodEssayAnswers." However, immediately before the error causing link is a link where the phrase in the hyperlink is "WeakEssayAnswers." The latter link did not trigger an error. This example demonstrates the testing tools make some subjective judgments, and human intervention is sometimes required.

TABLE 7: Summary Results from the Accessibility Reports from Expression Web

Site/Page	# of Errors	# of Warnings
Undergraduate/EntryPage	0	13
Undergraduate/Syllabus Basics	0	0
Undergraduate/Syllabus Details	0	0
Undergraduate/PowerPoints	0	7
Undergraduate/Course Handouts	1	7
Graduate/Entry Page	0	10
Graduate/Syllabus Basics	0	2
Graduate/Syllabus Details	0	0
Graduate/PowerPoints	0	5
Graduate/Course Handouts	0	8

In summary, three testing programs were used to test 10 pages at two different Web sites each containing five pages. The testing was done in the following order: Cynthia Says, Bobby, and Expression Web. The first two testing products tested for Section 508 and all three priority levels. Expression Web tested for Section 508 and priority levels one and two. Cynthia Says and Expression Web used Internet Explorer version 6 while Bobby tested using Internet Explorer version 7. With the exception of one error explained above, all of the pages are free of accessibility errors.

It should be noted the bulk of the effort for this project was carried on during 2008. During this time period, there were four major changes in the environment that impacted the study. First, the authors' university changed from FrontPage to Expression Web. Therefore the authors' also changed the program they used for Web design. This change turned out to be fortuitous because Expression Web has built in facilities for checking whether a page is compliant with WCAG 1.0. Second, the parent company for the Bobby evaluation tool, WebXACT, was purchased by IBM and Bobby ceased to exist. Fortunately, each author's Web site testing was completed before this event. Third, WCAG 2.0 was finally approved and replaced WCAG 1.0 as the standard for Web accessibility. Fourth, Microsoft released an upgrade for Expression Web called Expression Web 2. These environmental factors explain why (a) the authors tested their

sites for compatibility with WCAG 1.0 and (b) why they discussed WCAG 1.0 as well as WCAG 2.0 above.

Part V: Summary and Conclusions

Although individual faculty are likely supportive of Web accessibility as a social cause, there is a significant probability most faculty are either unaware or unable to make the time commitments necessary to design their own instructional sites with Web accessibility as a goal. This conclusion can be drawn from the review of literature where several groups within academe, that should be aware of accessibility issues, maintained Web sites with low levels of accessibility. Furthermore, each of the individual authors of this paper experienced several road blocks in updating the accessibility of their own Web sites. Arguably, the authors were highly motivated to improve accessibility and potentially more skilled in the domain of Web design than a typical faculty member at a given university in the United States. Additionally, given the increasing commitments being placed on faculty with respect to teaching, research, and service, it will be very difficult for even the most skilled faculty members to stay abreast of changing Web design technologies and changing accessibility standards over time.

When comparing the two diaries, several conclusions can be drawn related to Web accessibility efforts generated by individual faculty members. From our experiences in retrofitting their existing sites, designing new pages from scratch using the latest technological tools (e.g., Expression Web or Dreamweaver) is a more efficient way to generate HTML code conforming to Section 508 and WCAG 1.0 guidelines. Nevertheless, there are instances where even these up-to-date tools make subjective judgments that may need to be overridden by humans. Even the most effective mechanical testing methods and what appears to be well-written, accessible HTML code cannot fully account for all potential accessibility issues and thus the true test of a Web site's accessibility should be undertaken by disabled students (see http://www.w3.org/WAI/eval/users.html).

What also can be seen from the diaries is the effort the authors put forth to make their existing Web pages (generated with FrontPage) conform to accessibility requirements was significant. The authors suspect this effort is far beyond what typical faculty members, especially those less

familiar with HTML code, would be willing to invest in a project that is not directly related to teaching, research, or service. Retrofitting existing Web pages is costly with respect to time, expertise, and effort.

Universities may need to find ways to assist faculty in improving the accessibility of their Web sites. One solution, identified by the marketing professor, is that the university may provide accessible templates in which faculty can cut and paste in existing code. However, as shown in the diary, even that solution was not a clean, easy implementation. Universities may also want to consider providing Web content management systems which automatically conform to Section 508 Web accessibility standards and then require faculty to use them for their instructional needs. However, that type of system potentially reduces the individual faculty member's autonomy with respect to the design (and potentially content) of his/her Web site. A third solution may be that faculty should rely less on the Web and more on course management software such as WebCT and Blackboard. Blackboard has purchased WebCT so over time there may only be one product from this merger. These tools claim to be accessible. However, people using WebCT version 4.x should be aware this product conforms to Section 508 but does not conform to all priority levels of WCAG 1.0. Furthermore, there are some tools in WebCT that are not accessible, such as Whiteboard and Chat (Rehberg et al., 2004).

The diaries also shed light on the variation that occurs with testing a Web site for accessibility, which raises something of a Pandora's Box for individual faculty members who are not particularly familiar with Web accessibility. For example, the MIS Professor's diary shows different testing tools yield different results. His pages conformed to accessibility guidelines using Cynthia Says but did not conform when tested using Bobby. Furthermore, testing for different browsers and multiple versions of the same browser adds another level of complexity to the testing regimen. Although WCAG 2.0 has been finalized since December 2008, many of the support tools are still geared to WCAG 1.0. Typical faculty may not be aware of the new standards nor have the time and/or skills necessary to make the changes required to conform to WCAG 2.0.

As the review of literature indicates, many experts believe Web pages used for instructional purposes are subject to federal accessibility standards. This appears to include Web pages developed by individual faculty members. Experts also maintain "academic freedom" will not be a defensible justification for an inaccessible Web site. For example, a faculty member might argue that he/she has no more of an obligation to design a Web site for accessibility than to use a particular teaching strategy. The counter argument would be if the Web site is available to all students, then there must be an accommodation for disabled students who cannot access the Web site content so that the university is in compliance with the ADA (http://www.washington.edu/accessit/webpslegal.html). Typically, an accommodation would be made through the university's facilities for students with disabilities, again suggesting universities need to provide support for individual faculty members with respect to Web accessibility.

This study points to a need for universities to start developing and implementing university-wide Web accessibility policies that also contain plans to support individual faculty efforts to improve their existing instructional Web sites. It appears universities cannot afford the potential cost of ignoring Web accessibility. Recall that in the private sector, AOL, Target, Priceline and Ramada were sued because their Web sites were not accessible to the visually impaired. AOL and Target were sued by the National Federation of the Blind. Priceline and Ramada were sued by the State of New York. Most likely these organizations were sued because they did little or nothing to improve the accessibility of their sites. It would be far better for universities to proactively address the need for Web accessibility before they become embroiled in disability litigation. Two positive steps universities could take include: (1) Develop a comprehensive Web accessibility policy that provides guidance for all staff and faculty involved in Web design. (2) Establish training and support facilities so all university employees involved in Web design have access to uniform guidelines regarding the design of accessible Web sites.

In conclusion, this study suggests several important directions for future research. There has been no formal survey of faculty Web pages and faculty awareness related to Web accessibility published to date. This type of data would inform universities about the need for creating policies and providing support to faculty who need to improve the accessibility of their

instructional Web pages. In addition, there has been no study to date that has examined university policies with respect to Web accessibility. If there are no effective policies in place, then there may be little incentive, and certainly less direction provided, for faculty to pursue such activities. Finally, a study of the awareness and importance of Web accessibility to university administrators and employees in university computing service departments would also yield useful information on university activities related to Web accessibility.

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