Behavioral Sciences and the Law
Behav. Sci. Law **21**: 27–49 (2003)
Published online 8 January 2003 in Wiley InterScience (www.interscience.wiley.com). DOI: 10.1002/bsl.521

Electronic Doors to Education: Study of High School Website Accessibility in Iowa

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The Americans with Disabilities Act (ADA), and Sections 504 and 508 of the Rehabilitation Act, prohibit discrimination against people with disabilities in all aspects of daily life, including education, work, and access to places of public accommodations. Increasingly, these antidiscrimination laws are used by persons with disabilities to ensure equal access to e-commerce, and to private and public Internet websites. To help assess the impact of the antidiscrimination mandate for educational communities, this study examined 157 website home pages of Iowa public high schools (52% of high schools in Iowa) in terms of their electronic accessibility for persons with disabilities. We predicted that accessibility problems would limit students and others in obtaining information from the web pages as well as limiting ability to navigate to other web pages.

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The program of research described herein is supported, in part, by grants to Dr. Blanck from National Institute on Disability and Rehabilitation Research (NIDRR), U.S. Department of Education projects (i) "Technology for independence: A community-based resource center," #H133A021801, (ii) "IT Works," #H133A011803; (iii) The Rehabilitation Research and Training Center on Workforce Investment and Employment Policy for People with Disabilities, #H133B980042-99; and by The Great Plains ADA and IT Center, and the University of Iowa College of Law Foundation. The views herein reflect only those of the authors and not of any funding agency or any other entity. Many colleagues provided valuable suggestions on this article including Heather Ritchie, Helen Schartz and James Schmeling. For additional information on the resources and policy briefs referenced by the LHPDC, or to direct correspondence, see www.its.uiowa.edu/law.

Contract/grant sponsor: National Institute on Disability and Rehabilitation Research (NIDRR), U.S. Department of Education.
Contract/grant numbers: H133A021801; H133A011803; H133B980042-99.
Contract/grant sponsors: The Great Plains ADA and IT Center; University of Iowa College of Law Foundation.

Findings show that although many web pages examined included information in accessible formats, none of the home pages met World Wide Web Consortium (W3C) standards for accessibility. The most frequent accessibility problem was lack of alternative text (ALT tags) for graphics. Technical sophistication built into pages was found to reduce accessibility. Implications are discussed for schools and educational institutions, and for laws, policies, and procedures on website accessibility.

INTRODUCTION

Public and private schools increasingly use their websites to offer information—schedules, contacts for school personnel, course projects, and materials—to students, families, teachers, and staff. A diverse segment of local communities also relies on information from school websites.

At the same time, legislation such as the Individuals with Disabilities Education Act (IDEA), the Rehabilitation Act of 1973 (Rehab Act), and the Americans with Disabilities Act of 1990 (ADA) has enabled many students with disabilities to enroll in public (and private) schools. Some estimates are that one-fifth of the American population have disabilities (National Council on Disability, 1998; McNeil, 2001) and that one in 12 school-age children have some disability (Cohn, 2002). Recent studies (for a review, see Slatin, 2002) have found that these users with disabilities are three times less likely to use the Web for routine tasks, as compared with similarly experienced peers without disabilities. The trends suggest, therefore, that unequal access to web-based information may disproportionately hinder persons with disabilities, at school, work, and home.

This article examines the technological accessibility of 157 high school websites throughout Iowa. The sample represents slightly more than half (52%) of all public high schools in Iowa and all (100%) that had operational websites from December, 2001, to May, 2002, the period of study. The first part of this article explores the laws that govern accessibility of public school websites. The next part describes the concept of Web accessibility and the barriers that people with different disabilities face when websites are not accessible. The method of study and the findings of the investigation follow. The final part discusses implications of the findings for students with disabilities, school officials, and Web developers.

WEB ACCESSIBILITY AND EMERGING LAW

Public schools are required to provide equal access to educational materials and experiences, to the extent feasible. Title II of the ADA, for instance, requires that "no qualified individual with a disability shall, by reason of such disability, be excluded from participation in or be denied the benefits of the services, programs, or activities of a public entity" (ADA, 1990).

The equal access requirement increasingly has come to include developing and maintaining school websites in technologically accessible formats for students and others with disabilities (Blanck & Sandler, 2000).[1] Students with disabilities who cannot access school website information often are denied the benefits of this type of information when the information, services, programs, and activities are not provided to them in alternative formats (e.g. Braille, video description, and so on).

Enacted in 1990, before the emergence of the Internet, the ADA does not explicitly mandate Internet access. The issue of whether private websites are subject to the antidiscrimination provisions of Title III of the ADA (the law's public accommodation provisions) has been the subject of recent litigation (e.g., see National Federation of the Blind v. America Online, Inc., 1999; Access Now, Inc., v. Southwest Airlines, Co., 2002).

The U.S. Department of Education and Department of Justice, agencies charged with enforcing the ADA, have interpreted its Titles II and III to apply to websites, relying on the requirement for "effective communication" between individuals with disabilities and public entities (see Cardenas, 1997; Patrick, 1996; Waddell, 1998). In a 1996 letter to Senator Tom Harkin, Deval L. Patrick, former U.S. Department of Justice, Assistant Secretary for Civil Rights, explained that "the issue is not whether the student with the disability is merely provided access, but the issue is rather the extent to which the communication is actually as effective as that provided to others."

Like the ADA, Section 504 of the Rehabilitation Act of 1973 prohibits discrimination on the basis of disability by organizations that receive money from the federal government, such as public schools. Failure to provide information in effective formats, for instance website information in accessible formats, may be a form of discrimination under the Rehabilitation Act.

As mentioned, the Individuals with Disabilities Education Act of 1997 (IDEA), formerly the Education for All Handicapped Children Act, requires that schools provide students with disabilities an equivalent, appropriate education. When educational materials or activities such as library services, distance-learning courses, homework assignments, and Internet research are provided through the web, these services would be subject to Section 504 and IDEA to the extent that they must be communicated effectively to students and others with disabilities.

In many cases, the ADA, Section 504, and IDEA encourage that accommodations to enhance equal access to school programs and services include minimal assistive technology (AT), such as pencil grips and large print materials.[2] Schools often are not required to purchase expensive screen reading software or other

[1]Others have provided additional reasons for constructing websites that are accessible to people with disabilities. For example, see the World Wide Web Consortium's business case for accessibility at http://www.w3.org/WAI/bcase/benefits.html, much of which is applicable in this context.

[2]The bulk of assistive devices (AT) are common materials and methods, and educators often do not think of them as assistive technology. After all, "assistive technology is any item . . . whether acquired commercially . . . modified, or customized, that is used to increase, maintain, or improve the functional capabilities of individuals with disabilities (29 U.S.C. § 2202(2)). Such items include but are not limited to pencil or tool grips, color coding, picture diagrams, notebook dividers, calculators, tape recorders, checklists, large print materials, math manipulatives, adapted eating utensils, and nonskid surfaces. See generally Berven & Blanck (1998); Cook & Hussey (2002, pp. 450–460); *General modifications for classroom teachers* (n.d.); *Material modifications* (n.d.); Schwab Learning, (n.d.); Weinstein (n.d.); *Accommodations & modifications for students with disabilities in vocational education and adult general education (2002)*.

technology-based solutions for individual students and parents, where a less costly alternative is available or where their purchase would pose an undue financial or administrative hardship. Nevertheless, increasingly students with disabilities obtain and use their own AT (Blanck, Schur, Kruse, Schwochau, & Song, 2003). Therefore, it will be important for school websites to be designed to engage these technological accommodations, such as electronic screen readers.

The 1998 revisions to the Rehabilitation Act provide in Section 508 that all federal electronic information technology (IT) goods and services procurement must comply with specific and established accessibility standards (29 U.S.C. § 794d). Although the 508 standards do not apply to states use and procurement of technology, the requirements apply to federal purchases and establish minimum accessibility requirements to be met by commercial developers who sell to the government. When these products become more popular, they will serve as *de facto* industry standards. Several states in fact have passed their versions of Section 508, requiring state purchases of information technology (IT) goods and services to be accessible (see, e.g., Mo. Rev. Stat. § 191.863, 2000; Ky. Rev. Stat. Ann. § 61.984, 2001).

ACCESS AND BARRIERS TO INFORMATION ON THE WEB

Individuals with disabilities face different challenges in accessing electronic information. For individuals with visual impairments (and others to a lesser extent), the formidable barrier is the visually based *graphical user interface* (GUI). The GUI is the underlying structure for most modern computer operating systems such as Windows. Computer users interact with the GUI by using a mouse to click on objects they view on a computer screen. The GUI creates access problems for people with visual limitations who cannot see the objects on the screen or individuals with limited mobility who cannot easily manipulate the mouse (see National Council on Disability, 1996).

Browser software, such as Internet Explorer and Netscape, employs the user interface that is available in the particular computer's operating system. Programs that run in Windows use the Windows GUI, and those on the Macintosh use the Macintosh GUI. Since the Web was designed primarily as a graphical medium, browsers capable of displaying information will display web pages in graphical ways. However, other browsers, for a variety of reasons including disability, display Web information in text-only formats.

Some text-based browsers, such as Lynx, were designed for text-only display, whereas other browsers are restricted by their operating system, for instance, as found on text-based personal digital assistants (e.g. Palm Pilots) or cell phones. Moreover, browsers display information based on internal standards, such as hypertext markup language (HTML) specifications. However, because of changing technologies and specifications, as well as different interpretations of standards by browser developers, display of information varies across browsers, and among different versions of the same browser.

Software and hardware accommodations have been developed to control the GUI and allow users to access information from a GUI-based computer. Individuals who are blind or have limited vision use various screen reader software that converts text displayed on a computer monitor to speech.[3] Others use screen magnifiers, which enlarge areas of the computer display to make them easier to view. Individuals with limited vision or color blindness use high contrast settings, which convert colors to black and white.

Nevertheless, individuals with disabilities who use special computer software and hardware confront a variety of barriers in accessing the Web. Graphical objects, such as photographs or icons, present a barrier to Web access for people with visual disabilities who are not able to see the graphics. To address this problem, Web developers add brief text descriptions known as *ALT tags* to graphics. Screen reader software then converts the text to speech, allowing users to hear the description of what is on the screen when they cannot see it.

Individuals who do not use specialized computer software or hardware face other barriers to Web access. Small text or graphics may be difficult to read. Certain color combinations or low color contrast on web pages may be inaccessible for individuals with colorblindness. Small, clickable icons or pages that require numerous clicks on the scroll bar may be difficult to negotiate for people who have trouble using the mouse (e.g., individuals with dexterity, arthritic, or other conditions).

Online movies, when not closed captioned, also may be inaccessible to individuals with hearing impairments. Flashing graphics have been shown to precipitate seizures for some individuals with epilepsy. Pages that are unorganized, cluttered, or distracting, such as ones with continuous animations or sounds, may not be effective for conveying information to people with attention deficit disorder or learning disabilities.[4]

WEB DESIGN CONSIDERATIONS

An important step in communicating nontext electronic information on the Web is the use of ALT tags, which are bits of HTML that describe a nontext object in a Web browser. For example, a web page with a U.S. flag might contain an ALT tag, "United States flag." A visual web browser would display the image of the U.S. flag. When a screen reader reaches the graphic, it would convert the words "United States flag" into speech, and the user would hear the ALT tag description of the graphic.

Another accessibility strategy enables individuals with dexterity limitations to use the keyboard instead of a mouse. Using visual browsers, people negotiate a web page with the mouse, scrolling down the page by clicking on the scroll bar and clicking on hyperlinks, images, or text that directs users to other pages when clicked. As an alternative to the mouse, people use the tab and enter keys on the keyboard to access parts of Web pages. The tab key is used to advance through hyperlinks on a page,

[3] A simulation of a screen reader is found at the Web Accessibility in Mind (WebAIM) site (http://www.webaim.org). Many screen readers allow free downloading of demonstration versions, such as JAWS (http://www.freedomscientific.com/), HAL (http://www.dolphinuk.co.uk/), Window-Eyes (http://www.gwmicro.com/), and outSPOKEN (http://www.alva-bv.nl/).

[4] For descriptions on how websites present barriers to people with disabilities, see, e.g., Burgstahler (2002), Hinn (1999), and Wunder (2000). See also the Web Accessibility in Mind (WebAIM) website, http://www.webaim.org/, which has a variety of introductory materials on user experiences.

and the enter key to "click" on the hyperlink. However, advanced programming techniques (e.g., using Java or JavaScript technologies) may interfere with the tab key's ability to locate hyperlinks.

To address many of these barriers, a wide range of information has been generated by the disability community and the Web development community on the importance of and procedures for accessible website development.[5] In particular, the Web Accessibility Initiative (WAI) is a focus of the World Wide Web Constortium (W3C), an international consortium of governments, corporations, and researchers. The W3C sets the primary standards for Web use and development, developing standards for technologies such as HTML. In 1999, the WAI published the *Web Content Accessibility Guidelines*, which identify barriers in Web technology for people with disabilities and offer accessibility guidelines to Web developers, designers, and producers of authoring programs (World Wide Web Consortium, 1999).

Among other recommendations, the WAI *Accessibility Guidelines* stress the importance of separating content from presentation. The content that the Web designer or developer provides should be separated from the presentation, i.e., how the content is communicated and displayed. For example, the content may be statistical information about the popularity of a product. This statistical information could be presented using a table, a bar graph, or simple written text. The developer is encouraged to use available technologies to allow the information to be displayed based on the needs of the user. A sighted user may prefer a graphical display of the information on a browser capable of showing the bar graph, whereas a person using a screen reader may prefer the information in text or table format.

Besides providing user choice, separating content from presentation allows the designer to optimize the content to the browser and the platform. It also allows the user to obtain full content regardless of the software and medium. Web pages may be viewed by a variety of browser software, including different versions of Internet Explorer and Netscape Navigator, on different platforms, such as Windows and Macintosh computers, as well as personal digital assistants and cell phones. Accordingly, web pages will not look the same on different browsers. Effective Web design addresses these presentation issues to the benefit of users.

School websites, like any other, are used by a diverse population of students, teachers, school staff and administrators, parents, and people from the community. To accommodate the needs of this diverse group, web pages need to be designed to provide information in an accessible format. A public school Web home page should include information about the school—such as location, personnel, and contact information, hyperlinks to pages that provide more information related to the school, and perhaps a picture of the school. The purpose of the present study is to begin the systematic assessment of the accessibility of school websites for people with disabilities, initially through a study of sites throughout Iowa high schools.

[5]Note in particular works by the National Council on Disability (especially National Council on Disability, 1998; 2001), Cynthia Waddell, and the Web Accessibility Initiative (www.w3c.org/wai).

METHOD OF STUDY

Materials

The study assessed 159 home pages from websites of public high schools in Iowa. Two pages were removed from the sample because they could not be coded reliably using the researchers' protocols or using automatic accessibility checkers (see Bobby below), leaving 157 home pages in the sample.

The pages studied include all the public Iowa high school websites identified between December 28, 2001, and May 21, 2002. They represent slightly more than half (52%) of public high schools in Iowa. High school websites were identified from multiple sources: the Web-based Iowa Area Education Agency (AEA) state map, Iowa's school district websites, Qwest's online white pages, Iowa Public Television's Iowa Distance Learning Database, and the School Report Express website provided by Realtor.com.

The study focused on high school website home pages, rather than all web pages for a school, for several reasons. First, it was assumed that Web developers would enhance home pages to make them presentable to the public. Second, if a home page is not accessible, the rest of the site probably is not accessible to people with disabilities. A recent study of 400 postsecondary distance-education institutions found that only 4% of second-tier pages were accessible, compared with 22% of home pages (Rowland and Smith study, 1999, as cited by Rowland, 2000).

Coding Protocols

The high school home pages were coded for important accessibility features or barriers. Five graduate students at the University of Iowa, including team members with disabilities, coded the pages. Over a period of one month, coders received training on the common barriers to Web access and how to use a variety of techniques to uncover and count specific characteristics or objects on web pages, such as ALT tags, tables, or clickable hyperlinks. In addition, an online software application, developed by the team, counted ALT tags, hyperlinks to other web pages, tables, graphics, and third-party applications. This application increased the speed and reliability of the coding process.

The coding protocols were developed using an interactive, iterative process whereby the coders reviewed and resolved coding issues on 20 sites selected to test specific coding issues. During this process, coders refined ways to count discrete elements of web pages, such as number of hyperlinks, tables, and images. In addition, protocols were refined to increase reliability in rubrics that categorized more subjective areas, such as sensible reading order, accessibility of color and color contrast, use of tables for content or display, and use and accessibility of graphics.

In developing the research protocols, the team considered the following issues: WAI *Web Accessibility Guidelines*, the needs of people with disabilities for accessing Web information, the dynamics and limitations of using technology in the public schools, and the information needs of the public schools.

The coding of the school home pages was organized, therefore, into five areas:

(i) feedback from the Bobby accessibility checker, which provides automatic feedback on web pages based on the WAI *Web Accessibility Guidelines*,
(ii) feedback from the WAVE accessibility tool, an alternative to Bobby, useful for determining number of tables and reading order of text on web pages,
(iii) a manual count of web page features, including number of ALT tags, hyperlinks to other web pages, text-only hyperlinks, tables, graphics, connection with the district, and use of JavaScript,
(iv) design for visual accessibility, including use of color and contrast, and importance of graphics for accessing content, and
(v) a count of the use of third-party applications and animations, indicating relative sophistication of page design.

Bobby

Bobby is an online accessibility checker developed by the Center for Applied Special Technology (“Bobby WorldWide”). Bobby is one of the most efficient and well known software tools to alert developers and users of potential barriers in the design of web pages.[6] Using the online version, developers enter the address of the page to be tested, and Bobby then returns an accessibility report.

The Bobby accessibility report incorporates the three levels of priorities described in the WAI *Web Accessibility Guidelines*. Priority 1 errors are “showstoppers”—barriers that prevent some people from access to information altogether. For example, a graphic object on a page without a text, label, or audio description (usually a description is located in the ALT tag) prevents individuals who cannot see the object from knowing the object’s content and purpose.

Priority 2 errors produce significant barriers for access to information but do not prevent access entirely. For example, pages that automatically create a new browser window without notifying the user may be confusing and create problems when the user wants to return to the original browser window, though the information in both windows may be otherwise accessible.

Priority 3 errors create somewhat less difficulty for users in accessing information. Users with disabilities access information without significant barriers but do not have parity with others in terms of efficiency and effectiveness using the Web. For example, pages that do not contain menu bars may seem unorganized to some individuals and may be difficult to navigate if the pages are large and require several clicks of the mouse or keyboard to page through (World Wide Web Consortium, 1999). Based on the Bobby accessibility report, each home page in this study was coded as passed or not passed on each of the three accessibility priorities (“Bobby WorldWide”). Under each priority, all Bobby feedback was tabulated.

Although widely used, Bobby has some limitations. For each priority, Bobby performs three levels of checks. The first level is an automatic check, based on objective measures of a web page, such as the presence of one ALT tag for each graphic. Passing this level results in a pass for the priority. However, the second and

[6]Other good accessibility checkers exist besides Bobby and the WAVE. These include LIFT (http://www.usablenet.com/) and A-Prompt (http://aprompt.snow.utoronto.ca/). Other checkers, such as the Macromedia Accessibility extension, are used by developers during development but not on “live” web pages.

third levels are "User Checks," which prompt developers to evaluate the web pages for accessibility issues using human judgment. Second level feedback is based on characteristics of a page, where third level feedback messages are general reminders that appear on every page evaluated. These user checks are not included in Bobby's determination of whether the page has passed or failed a priority.

Bobby assesses only objective components of a web page. According to Bobby's own instructions, users of Bobby should evaluate pages carefully at all levels before accepting Bobby's pass/fail assessment.[7] It does not evaluate scripting or programmatic aspects of a web page. Thus, pages that pass Bobby may not be truly accessible. In addition, Bobby does not distinguish between important content and superfluous decoration (Rowland, 2000). For these reasons, other measures of accessibility were used in this study.

WAVE

The WAVE ("WAVE 2.01") is another online accessibility checker. It was used to supplement the Bobby report, assessing tables, finding graphics for manual counting, and determining reading order of text on web pages, information not available from Bobby.

Manual Counts

In addition to Bobby and the WAVE, coders manually counted (i) the number of ALT tags, (ii) hyperlinks, (iii) text-based hyperlinks, (iv) tables, and (v) graphics. The numbers of ALT tags, hyperlinks, tables, and graphics were counted using the Web-based application developed for this study; then coders verified the counts manually. Text-based hyperlinks usually are visible on web pages, so were counted manually.

Visual Accessibility

Websites were coded for appropriateness of (i) color and contrast, and (ii) use of graphics. Color and contrast were rated using a four-point scale: good, acceptable, questionable, and poor. Color and contrast were considered good if the foreground and background consisted of a combination of black or dark blue against white or light yellow, or vice versa. To be coded as "acceptable" the pages used variations of colors (green, gray, orange, red, or purple), darkness (hue), and color saturation paired with a foreground or background using one of the high contrast colors in the good rating (black, dark blue, white, or light yellow).

Pages coded as "questionable" used combinations of high, medium, and low contrast foreground or background colors paired with medium to low contrast colors. Pages coded as "poor" used foreground and background colors with little contrast between them (see Hess, 2000; Rigden, 1999; Wolfmaier, 1999). Good and acceptable ratings were considered accessible. For example, predominantly

[7]See http: //bobby.watchfire.com/bobby/html/en/readreport.jsp.

dark red text on a dark green background would have been considered poor color contrast, whereas a small, light orange clipart image on a dark blue background might have little or no impact on lowering a rating.

Graphics were categorized as one of the following:

(i) graphics used for navigation,
(ii) graphics that convey meaningful or essential content, or
(iii) other graphics (low content).

Any graphics used as hyperlinks were considered to be navigation. Non-navigational graphics (categories (ii) and (iii)) were then coded as either "essential content" or "low content." In general, if a graphic was representational, it was coded as essential content.

Third-Party Applications

Web pages were coded for whether they used third-party applications, particularly Flash, QuickTime, Real Player, Microsoft Media Player, and Java applets. Third-party applications, such as Macromedia Flash and QuickTime, are not evaluated by accessibility checkers such as Bobby and the WAVE. The presence of a third-party application may render an otherwise accessible web page inaccessible, even though the page passes Bobby.

Animations

Animations, such as GIF animations, that were not developed for use with a third-party application, were counted separately from third-party applications. Animations present themselves to accessibility checkers like static graphic images but have unique issues that affect accessibility, such as creating distractions. Web animations are a series of images that display one after the other. Animations may appear as movement, an object changing size, gradual changes in color, or other continuous change that occurs.

Animations were distinguished from simple, user-initiated changes, such as rollovers. Rollovers, which occur when the user moves the mouse cursor over an object that causes the object to change, were not considered animations because the user has control over the change from one static effect to another. In contrast, users might initiate an animation, but at some point the user does not have control over the changes that occur.

Other Coding Issues

Initial coding revealed that many high school websites were similar in design to their district pages. This finding suggested that a developer at the school district level (or possibly the AEA, which provide support to Iowa schools) may have responsibility for creating websites or Web templates. Home pages were coded as connected or not connected to a school district. A site was coded as connected to a district if (i) the home page contained a hyperlink to the district site, and (ii) the district site had the same appearance (i.e. similar color scheme, hyperlinks, borders, headings, and graphics). Pages that lacked these two criteria were not coded as connected to the district.

Sites were coded as either using or not using JavaScript. Changes occur in a page, such as popup menus or rollovers, based on the location of the mouse cursor. These features usually are created using JavaScript, a kind of programming implemented through the browsing software.

Inter-Rater Reliability

Four student research assistants coded the web pages for this study. Twenty pages (12%) were coded by all four students as a group. The 20 pages were selected on the basis of some potentially arguable feature, such as the use of certain color combinations, the use of a third-party plug-in, the use of frames, or the use of a large number of tables.

Throughout the group coding, the coding protocols were refined. After 20 pages, the group had reached roughly 100% agreement on the fields that required simple counts (e.g. number of tables, number of graphics) and between 60 and 70% agreement on the judgment fields (e.g. reading order makes sense, acceptable use of color). Subsequently, each coder independently coded approximately 35 web pages.

FINDINGS

Bobby Scores

Only 7.6% (12) of the 157 Iowa high school home pages passed Bobby priority 1. A manual check of pages that passed priority 1, however, revealed that three of these pages contained graphics without ALT tags, although Bobby did not flag them. Including these three pages, the vast majority (94.3%) of the home pages had information (at least in the form of graphics without alternative text) hidden to some people with disabilities.

The most common priority 1 error identified using objective measures by Bobby was the failure to include ALT tags for graphics (see Figure 1). This error should result in failing Bobby priority 1. The majority of the 157 pages in the sample (140 or 89.2%) revealed a Bobby ALT tag error message (not including the three mentioned above that passed priority 1). Errors included missing ALT tags from regular graphics as well as graphics used for buttons and image maps (pictures that have different clickable regions).

The only other priority 1 error message from Bobby that would result in failing the automatic check for the priority is missing titles for each frame on a web page. Bobby found that only 14(8.9%) of school home pages had this error. If all alternative text required by Bobby were repaired in these high school web pages, 91.1% would pass priority 1 for the Bobby automatic check.

Only 1.9% (three) of the 157 home pages passed Bobby priority 2 (see Figure 2). The common priority 2 errors were the following: (i) pages did not allow the text and

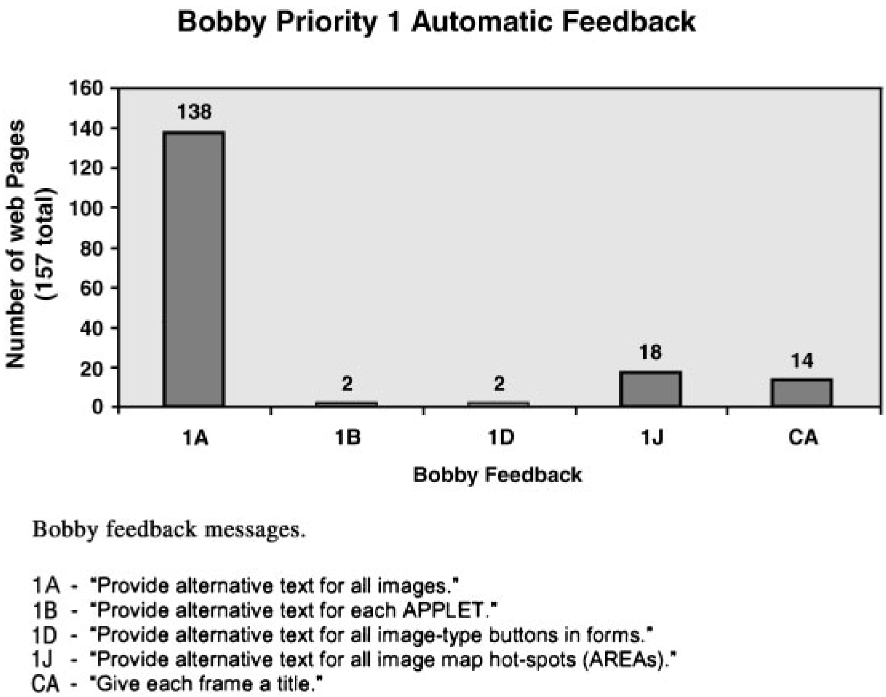

Figure 1. Bobby priority 1 automatic feedback messages per school Web page.

page layout to adjust to the size of the browser window, and instead "locked down" the sizes of elements on a page by specifying absolute values (pixels) rather than percentages of the total size (e.g. width of the browser window); and (ii) pages did not specify the "DOCTYPE" parameter, which tells the browser how to interpret the markup language in a web page. Of the 157 pages, 126(80.3%) had the layout adjustment error and 125(79.6%) did not specify the document type.

If developers corrected the two major priority 2 errors for home pages studied, the number of Bobby automatic checks that would pass would increase to 62.4% (98). The third most frequent priority 2 error (27 pages) was use of a completely mouse-reliant feature, such as a rollover that creates a popup menu. Other errors discovered by Bobby include a variety of issues, most of which refer to structuring a web page to provide information to a user with disabilities. For example, since some accessible browsers do not support frames, providing a way for a user to access the information without using frames is important.

None of the home pages studied passed Bobby priority 3. One priority 3 error was common to all, the failure to identify the natural language of the text (see Figure 3). Although tables frequently were used on the web pages (130), accessibility problems with tables were common; only 1.5% (two) of the home pages that used tables did not produce table errors on Bobby.

One home page passed both Bobby priority 1 and priority 2 automatic checks. This page used a relatively simple design, mostly with text displayed in one table. It did contain one graphic, a picture of the school, which included an ALT tag. Although the page passed Bobby's priority 1 automatic check, technically it did not

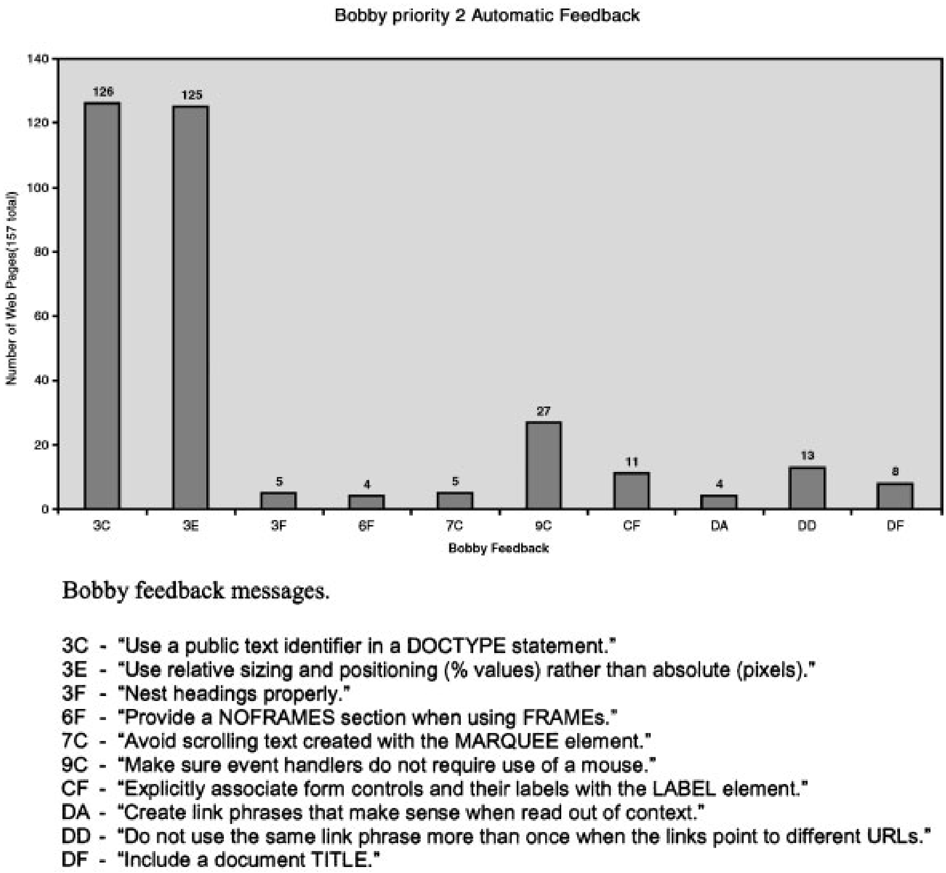

Figure 2. Bobby priority 2 automatic feedback messages per school Web page.

pass the priority because the ALT tag provided only the name of the file where the graphic was stored, "central2.jpg," which is not an accessibility feature, as opposed to a description of the graphic, e.g., "picture of the school."

WAVE Assessment

The WAVE report was used to investigate table designs. Tables were classified according to their uses: format, content, or mixed use. Tables in which the information in each cell could be read in any order, where formatting was predominantly for visual effect, such as placing graphics and text side by side, were coded as "for format." When the information in tables needed to be read to provide meaning, such as in calendars, the tables were coded as "for content."

"For content" tables often required row or column headers, and the cells of the table had to be read in a certain order. This type of information often may be displayed in a linear way. Mixed-use tables contained information where the order was important (content) and it was important that the information be displayed

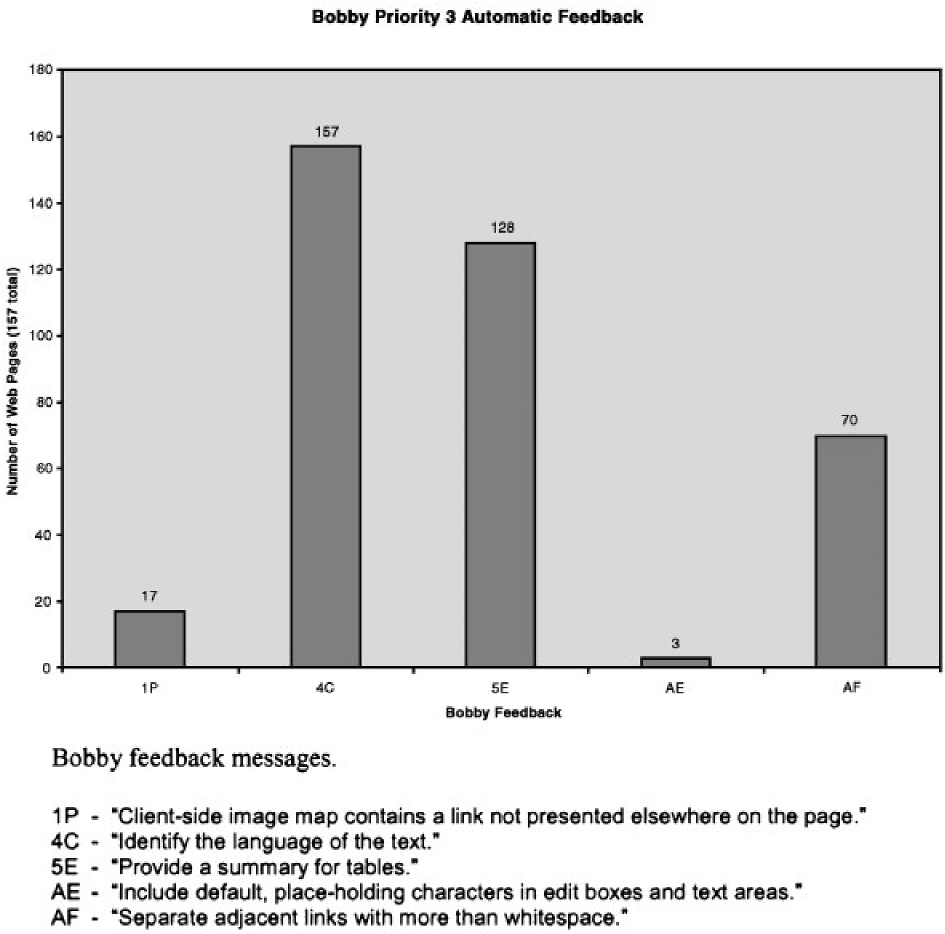

Figure 3. Bobby priority 3 automatic feedback messages per school Web page.

(formatted) in a two-dimensional way. An example of mixed-use tables is a graphic that has been divided into several rectangles and put together, puzzle-like, on the page to form one image. The most common use of tables was for format. Two-thirds of the pages (66.7%, 106) used at least one table in this way. Fewer, 24.5% (39), used at least one table for content, and 26.4% (42) of pages had mixed use tables.

The WAVE report was used also to determine the order in which a text-based browser or screen reader would "read" the tables on a web page. Reading order was categorized as "makes sense overall," "somewhat confusing," or "doesn't make sense." The category was determined by coders using a rubric, which evaluated effort required to understand information on the page based on the WAVE's reading order. Of the 130 pages that used tables, 73.1% (95) were categorized as "makes sense overall," 16.9% (22) were "somewhat confusing," and 6.9% (nine) did not make sense when read using the WAVE reading order.

Manual Counts

Many of the pages that used graphics did not provide any ALT tags. Of the 150 pages that contained graphics, almost two-thirds (61.3% or 92) did not use ALT tags at all. Only 7.3% (11) had ALT tags for every graphic, and 31.3% (47) used some ALT tags but not for every graphic. The number of graphics on each home page ranged from 0 to 66, with a mean of 8.52. Over 40% (65) of home pages used more than five graphics.

Many graphics were used for navigation. Across all sites, 62.4% (98) used graphics for navigation, with as many as 19 graphics used for navigation on a single page. Out of these 98 pages that used graphics for navigation, 90(57.3% of all sites) were missing ALT tags, according to Bobby. Many sites, 87.9% (138), used at least one graphic for content, with as many as 31 content graphics on one page. Low-content graphics were used on 26.1% (41) of home pages.

For all pages reviewed, the mean number of hyperlinks was 18.08. The mean number of text-based hyperlinks was 15.36. The difference between these, 2.72, is the mean number of graphical hyperlinks, which would require ALT tags.

Visual Accessibility

For the 157 web pages reviewed, approximately one-fourth (24.2%, 38) were coded as having "good" color/contrast, and 35.7% (56) as having "acceptable" color contrast. Therefore, 59.9% of the home pages probably will not present color- or contrast-related problems for users. An additional 29.3% (46) were rated "questionable," where some problems may be present for some users. The remaining 10.8% (17) were rated as "poor."

Third-Party Application Assessment

Only 5.7% (nine) of home pages used third-party applications. Five used Flash, two used Java, and two used QuickTime. No pages used Windows Media Player or Real Player; these applications are more expensive to develop for and deliver on the Web.

Animation Assessment

Only 17.2% (27) of home pages used animations. About half of these pages (15) used more than one animation. Some of the animations performed once and then stopped. Most animations ran continuously until the user exited the page.

Association with District

Almost half (47%, 74) of the home pages were coded as associated with their district site. Considering the stringent criteria for inclusion, this number may underestimate the number of school district-associated websites. At least one web page was discovered to have similar content and structure but was not coded as connected because it did not have a hyperlink to the district site.

Use of JavaScript

Almost one-third (50, 31.8%) of the pages used JavaScript. Use of JavaScript was often as simple as to generate rollovers. However, some pages used JavaScript to create more complex interactions, such as to create popup menus or to modify the display of the page based on the individual browser capabilities.

The use of JavaScript was the cause of excluding the two pages from the sample, as mentioned above. Because of the way these pages used JavaScript, Bobby and WAVE feedback, the internal application, and manual counts were inconsistent. On one page, WAVE would not even produce feedback. Further, it was not clear that even manual counts would be consistent for these pages across different platforms, such as Windows or Macintosh, or different browsers, such as Internet Explorer versus Netscape.

DISCUSSION

The emergence of the disability civil rights movement, along with passage of the ADA, Sections 504 and 508, and other antidiscrimination laws, has coincided with a wave of technological advances that enhance the inclusion and equal participation in society of persons with disabilities (Blanck, 2000; Blanck & Schartz, 2001). Technology and Web accessibility are tools that enable equal participation by a broader pool of students and parents with and without disabilities in educational activities.

This article has examined the accessibility of web home pages for about half of Iowa's public high schools. The trend in our findings suggests that people with certain disabilities will have difficulty accessing electronic information on Iowa's high school websites. The majority of websites in the sample contain basic school information, such as contact information, and much of this information will probably be accessible. However, because most websites (92.4%) did not pass Bobby priority 1, some users will miss information because it is not accessible.

For some pages, the fix is easy. The majority (94.2%) of the home pages sampled in this study rely on graphics for conveying important information to users and navigating to other pages on the website. Yet, only 7.3% of pages with graphics had ALT tags for every graphic. The remaining 139 pages were missing ALT tags—information that would describe graphics using screen reader software—on at least one graphic. Of the 98 sites that used graphics for navigation, 90 had missing ALT tags. Although many navigation graphics were appropriately tagged with descriptive text, some were not. Thus, some site visitors will have difficulty navigating beyond the web home page to reach substantive information. This is most critical where entry to the rest of the website relies on navigation through graphic images.

What accessibility checkers generally are not able to address—and this study did not target—is whether the ALT tags used for graphics are appropriate. Some web authoring tools automatically create ALT tags when graphics are placed within pages. If the developer does not specify the text, then a file name such as ''central2.jpg'' may be used as the text alternative. Since many file names are meaningless or misleading, accessibility is not necessarily improved with the addition of ALT tags. Thus developers should be educated in how to create meaningful accessibility features, as well as how to read results knowledgebly from accessibility checkers.

Accessible Website Design

Many times, *disability* is less a function of people's inability to perform certain tasks than it is a function of flaws in the design of the environment (see Slatin, 2002, for a recent example). People would not be considered "disabled" if they could not open a door that requires one hundred pounds of force, even though a few people in the population would be able to open that door. Instead, the design of the door would be questioned. But what is the "appropriate" or normal level of strength needed to open a door? And how many people are going to be excluded from the inside by a particular door design? At what point are those excluded people who are unable to open the heavy door labeled *disabled*?

When heavy doors may be opened with the push of a button, assuming appropriate design and location of the button, most everyone will have universal access to the room. In the same way, designing for electronic website accessibility is good design that benefits all users with and without disabilities (Blanck, 1994).

Information in electronic form (like the easy open electric door) is potentially more accessible than any other media form. Barriers to communication of electronic formats are overcome when computers transform information, making it accessible in real time with various perceptual modalities. Text is converted to speech with screen readers. People who cannot see words on a screen hear them without the assistance of another person. Words that start as audio recordings are converted (with varying levels of accuracy) to text by the computer for those who cannot hear the words. These types of technological strategy (or accommodation) are available widely and are relatively inexpensive.[8]

The rapid advances in technology should not be discouraging to developers. On the contrary, to make Internet Web sites accessible, developers should consider two basic points:

(i) people with disabilities who are experienced using the Web typically work out their own accommodations that allow them access to information, when the information is accessible (Ritchie & Blanck, 2003) and
(ii) meaningful information on a website can be made accessible if the site is designed with accessibility in mind.

Of course, to design accessible websites, designers must understand what is effective for people with different disabilities. Two accessibility features are easy to implement but frequently were missing on the web pages sampled in this study. First, all nontext information should have an available text alternative, usually ALT tags, to describe nontext information using text. In this study, the 89.2% of web

[8]See Cantor (1996). Voice recognition systems, for example, once cost $20,000 but now may be found for less than $500. Many adaptive technologies, such as screen magnifiers and onscreen keyboards, are included in new versions of operating systems, such as Windows. Further, some predict that computer-based products in general will be fully accessible in a few years (Moulton, Huyler, Hertz, & Levenson, 2000).

pages that contained at least one missing ALT tag left a gap, so some individuals were left to wonder about the information conveyed or the purpose of the graphic without description.

Second, action on the website should be possible using the keyboard as well as the mouse. Since much keyboard activity is built into browsers, developers should strive to avoid undermining this functionality in design. Since many accessible browsers allow users to skip from hyperlink to hyperlink using the keyboard, leaving out ALT tags for graphics used for navigation (57.3% of sites using graphics for navigation were also missing ALT tags) or using the same text for hyperlinks to different pages (e.g., "click here") leaves keyboard users perplexed.

In addition, use of scripting languages, such as JavaScript, or third-party applications can limit keyboard functionality, if the developer is not careful. Of the nearly one-third of the pages in the study that used JavaScript, most used scripting for mouse-related activity, such as rollovers and popup menus, which had no benefit to keyboard users.

We did not expect the Iowa high school web pages sampled on average to be technically complex because of limits on expertise, time, and resources of public schools. However, for those technologically sophisticated web pages (with "bells and whistles"), we found that sophistication tended to reduce accessibility.

For example, less sophisticated clickable text that hyperlinks to other pages is probably the most accessible way to provide site navigation. On the other hand, a more sophisticated way to provide navigation is to use an image map, a large graphic divided into clickable regions that hyperlink to site pages. To create accessible image maps, developers must remember to use ALT text not only for the overall graphic, but also for the individual clickable areas. Otherwise, individuals using screen readers have no understanding of the purpose of the clickable areas. Bobby revealed such errors in 17(10.8%) of the home pages in this sample.

Although JavaScript does not inherently reduce accessibility, its effects may be difficult to determine. During initial coding in this study, many of the effects of JavaScript were hidden from coders until most of the pages had been coded and the team focused on resolving discrepancies. The research team then discovered that automatic web page checkers, such as Bobby, the WAVE, and the researchers' own internal application, produced assessment errors on many pages that used JavaScript. Ultimately, two pages were excluded from the study because of the unreliability of the data produced by the JavaScript-driven pages. Future studies should examine more thoroughly the effects of JavaScript on accessibility.

This study also has highlighted that automatic accessibility checkers (such as Bobby) do not always recognize accessibility problems. This is because most accessibility issues ultimately rely on human judgment, such as appropriate wording in text descriptions. Automatic accessibility checkers should not be used without an informed developer making decisions about how content is delivered. This is especially true for pages that use JavaScript and third-party applications,[9] because these technologies are not informed by industry standards and testing for accessibility as HTML has been through the WAI *Guidelines*.

[9]Recently, Bobby has been purchased by a for-profit corporation (Watchfire). It is to be seen how much development will go toward making the application reliable on a wider range of technologies. However, each new standard and Web technology complicates a software applications' ability to check for accessibility.

The present findings do not argue against sophistication in web page design and construction. Indeed, educated use of sophistication is valuable. For example, rollovers—usually created with JavaScript—are beneficial and improve accessibility on web pages to help people recognize when the mouse cursor is over a hyperlink. However, attention to accessibility, such as use of ALT tags and appropriate text size, should occur. Similarly, popup menus created with JavaScript help organize information and make pages more efficient for some users, but use of such menus should not lock out users who are restricted to or prefer to control the browser with the keyboard.

Accessibility Training

Problems of technological accessibility often stem from a lack of information about the barriers individuals with disabilities face in navigating the Web and the ways to eliminate or reduce these barriers. Unfortunately, web page accessibility often is left out of most HTML or Web design and development training (National Council on Disability, 1998).[10]

One web page from a midsize Iowa high school represents an example where more information would significantly enhance the page. The page looks like a paper publication, using a justified column of text and graphics that simulate page boundaries. It has a total of 39 graphics, most of which are used as spacers and serve as placeholders for blank space on the page. Only 11 ALT tags are used, but these are all meaningful ALT tags provided for every meaningful graphic, such as hyperlinks. This approach represents a good effort at best use for ALT tags.

Unfortunately, an individual browsing this page with a screen reader will learn, through the screen reader, that the page has an additional 28 graphics that neither have a description nor an explicitly described function, leaving the individual wondering what he or she is missing. A simple technique using ALT tags cues the screen reader to skip over these meaningless graphics entirely, eliminating the confusion for the user. In this example, the developer may have knowledge of accessible development, but not enough to provide a seamless experience for users with disabilities.

One obvious solution to the lack of information is to provide training in developing accessible websites. In Iowa, the Area Educational Agencies (AEAs) provide technical assistance to the public schools to improve education, and, therefore, are a good first step. Our findings suggest that Iowa high schools and school districts have a close connection in Web development (at least 47% in this study). Personnel who have Web expertise at the AEA or district level may be targeted for training in Web accessibility. The training may be disseminated effectively from the AEA or the district to administrators, teachers, Web developers, and students (with or without disabilities) interested in technology by changing templates they provide and/or offering guidance on their use.

Training school personnel in accessibility may result in students—future Web developers—being exposed to the ideas of accessible Web design by teachers who teach Web development in the schools and who are trained in accessibility by their

[10]Lack of resources, such as time and money, are cited as a major reason for lack of accessibility in web pages, as well as other products.

colleagues in the district (cf. Blanck, Ritchie, Schmeling, & Klein, 2003; Ritchie & Blanck, 2003, both this issue—discussing disability advocacy development by training Centers for Independent Living in Web accessibility).

Self-training in accessibility is another solution. Distance learning courses and other sources of information are available on the Web and in print.[11] The findings in this study illustrate that improvements in accessibility may be discovered in current web pages by focusing on simple techniques, such as the use of text alternatives. In most cases, adding ALT tags to the web pages sampled would have increased their accessibility dramatically. Passing the Bobby priority 1 automatic check would have increased from 7.6 to 91.1%.

On a societal level, and in our knowledge-based society, secondary schools must consider proactive approaches to Web accessibility. Development of a school or district policy on Web accessibility provides standards that local Web developers may learn and follow. A policy for Web accessibility, possibly as part of a broader policy on accessibility to IT in the educational setting, also provides a starting place for accommodations for students (and parents) where individual needs are not being met. It also paves the way for advancement by more and more young adults with disabilities from high school to college, and then into IT jobs (Schartz, Schartz, & Blanck, 2002).

The act of formulating technology policy must involve a variety of stakeholders in the process, facilitate communication among invested parties, and educate stakeholders and their families in the promise of accessibility. Thus, a policy should be distributed widely among those who develop or alter Web pages or, in a general IT sense, disseminate information.

With increasing frequency, Web accessibility policies may be found for schools by searching "school accessibility policy" in a Web search engine, such as Google. The state of Connecticut publishes its policy at http://www.cmac.state.ct.us/access/policies/accesspolicy40.html. A more general approach to creating accessibility policy is described by Waddell (1998) and WebAIM (2002).

Education of Web developers and integration of accessibility into the early design and development of websites is crucial. The cost of integrating accessibility into the original design is far less than retrofitting the site once it has been deployed (Blanck & Sandler, 2000). Many developers with experience in accessible design suggest that most of the cost of accessibility lies in the initial training of the Web developers, resulting in better Web design (See The Applicability of the Americans with Disabilities Act, 2000; Ramiriz, 2001).[12]

Lastly, the present investigation did not examine in detail how JavaScript, a relatively common Web technology, used by nearly one-third of the sites in the

[11]For example, courses may be found at Equal Access for Software and Information (EASI) at http://www.rit.edu/~easi/; Information Technology Technical Assistance and Training Center (ITTATC) at http://www.ittatc.org/; Web Accessibility in Mind (WebAIM) at http://www.webaim.org/; and The Trace Center, University of Wisconsin—Madison at http://www.trace.wisc.edu/, to name a few. For readings, see Clark (2002); Foley & Regan (2002); Paciello (2000); Thatcher et al. (2002); and World Wide Web Consortium (2002).

[12]Estimates for increased costs for retrofitting a site range from no cost to up to four times the initial cost of the site. Advocates argue that savings from increased traffic and reduced need for producing accessible materials, such as Braille or audiotape versions, offset costs of making a website accessible (for examples, see Waddell, 1999). Other estimates range from 10 to 40% of the original costs, depending on the complexity of the site and the needs to be accomplished.

study, affected accessibility or how it was used on the sites sampled. JavaScript frequently complicated the coding of pages. Future research will need to evaluate the use of JavaScript, how it affects Web accessibility, and how it affects feedback from accessibility checkers. Research also should explore how accessibility is affected by third-party applications and emerging technologies, such as XML, to enhance knowledge of accessibility strategies with these technologies, as well as ways that facilitate efficient accessibility checking for developers.

Effective Web design leads to accessible content. Web designers and developers must understand and evaluate the range of people, with and without disabilities, using their sites. Education and support of the designers and developers is one key to unlocking the door to accessible web pages.

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