Abstract
Purpose – Using Internet Archive’s Wayback Machine, higher education web sites were retrospectively analyzed to study the effects that technological advances in web design have had on accessibility for persons with disabilities.
Design/methodology/approach – A convenience sample of higher education web sites was studied for years 1997-2002. The homepage and pages 1-level down were evaluated. Web accessibility barrier (WAB) and complexity scores were calculated. Repeated measures analysis of variance (ANOVA) was used to determine trends in the data and Pearson’s correlation (r) was computed to evaluate the relationship between accessibility and complexity.
Findings – Higher education web sites become progressively inaccessible as complexity increases.
Research limitations/implications – The WAB score is a proxy of web accessibility. While the WAB score can give an indication of the accessibility of a web site, it cannot differentiate between barriers posing minimal limitations and those posing absolute inaccessibility. A future study is planned to have users with disabilities examine web sites with differing WAB scores to correlate how well the WAB score is gauging accessibility of web sites from the perspective of the user.
Practical implications – Findings from studies such as this can lead to improved guidelines, policies, and overall awareness of web accessibility for persons with disabilities.
Originality/value – There are limited studies that have taken a longitudinal look at the accessibility of web sites and explored the reasons for the trend of decreasing accessibility.
Keywords Higher education, Educational policy, Internet, Disabled people

Background
Since the onset of the world wide web, many new technologies have been developed that introduce new ways of presenting information. These constantly emerging technologies also present ongoing challenges for maintaining web accessibility for people with disabilities. As web page designers have included more of these complex web design components such as images and streaming audio and video, it has become less accessible for many users with disabilities (Amtmann, 2000; Heim, 2000; Bucy et al., 1999).

Having an accessible web page means that the information contained therein is accessible to all, including persons with disabilities. This accessibility may be direct or through the use of assistive technologies, hardware and software that aid a person in accessing the information. For example, blind users may be accessing web pages using a screen reader, a type of assistive technology that translates text displayed on the computer screen into synthesized speech (Amtmann et al., 2000) and physically impaired users might be navigating with a non-traditional input device (Goodwin-Jones, 2001).
Because of the lag in technological advances in assistive technology, as compared to advances in web application technology and design, persons with disabilities have a profound disadvantage when it comes to the opportunities on the web. The US Federal Government acknowledges this disadvantage with the Rehabilitation Act Amendments of 1998. The most pertinent of these amendments for accessibility was to Section 508, setting standards requiring that all electronic and information technology developed or purchased by organizations receiving US Federal funding be accessible by persons with disabilities, except where this would cause an “undue burden”. It applies, though not exclusively, to US Federal or US Federally-funded pages on the internet or the world wide web (Foley and Regan, n.d.; Board, n.d.).

The world wide web consortium (W3C), the standards-setting body for the web, developed the web content accessibility guidelines (WCAG) consisting of 65 checkpoints for use in developing accessible web pages (Chisolm et al., 2001) and evaluating pages for their degree of accessibility (Goodwin-Jones, 2001). The checkpoints are organized into three levels of priority, with corresponding conformance logos that may be placed on the web site to indicate the conformance to a specific level of accessibility. Priority 1 checkpoints must be met to ensure that the page itself is accessible. Priority 2 checkpoints should be met to prevent difficulties in access for some users. Priority 3 checkpoints may be met; otherwise some groups of users may find it somewhat difficult to access information (Goodwin-Jones, 2001; Parmanto and Zeng, 2003).

Mandating that web sites be accessible and following guidelines are alternative policies that can be adopted to make web sites accessible. The US government has taken a middle stance by requiring conformance, but only for US Federal government web sites. One interesting question is whether this works. Previous studies suggest that the US government web sites have low compliance (Stowers, 2002; West, 2001; Hackett et al., 2004). Using a more accurate measurement, we would like to see if this approach works. The second important question is how the government web sites accomplish the compliance. Our initial hypothesis was that the US government web sites achieved compliance by making the web sites bland and unattractive. To evaluate this, we introduce a second measurement: complexity scores.

Our previous study (Zeng and Parmanto, 2004) on web accessibility of consumer health web sites found that government and educational web sites are the two best categories of web sites that are relatively accessible compared to other categories: e-commerce, corporate, community, and portal. In this study we looked at the current level of accessibility for 108 consumer health information web sites and evaluated the relationship between web accessibility and three variables: the category of the web site, the popularity of the web site based on Alexa®’s daily traffic-ranking data (www.alexa.com), and the importance of the web site based on the Google® PageRank (www.google.com).

In general, removal of barriers on a web page is simply a matter of good design but accessible web sites are not only beneficial for those with disabilities. They also benefit users of low-end technology with lower modem speeds, persons utilizing wireless internet connections, and the aging. A web site that is navigable by assistive technology is also accessible by phones and palmtops (Heim, 2000) whose small screens make it difficult and time-consuming to scroll through the information that was designed with the desktop user in mind (Chen et al., 2003).

**Accessibility barriers**

It is important to understand how accessibility for persons with disabilities is affected by introducing complex technologies into web page design. Hypertext markup
language (HTML) is the technology used to create most web sites. While not programmable, it can be augmented with other features that can add complexity to the page and, consequently, are often the barriers to accessibility. In order to make these non-text features readable by some assistive technologies, it is critical to accompany these elements with meaningful text equivalent labels (alternative text), that are accessible by assistive technologies (Parmanto and Zeng, 2003). Alternative text is easily provided by making a simple modification to the HTML of the web page.

Some technologies posing barriers are plug-ins, Java applets, and scripting languages, among others. These technologies most often allow the web site to display multimedia content such as audio and video tracks, which, by their nature, pose barriers to persons with aural and visual impairments. Java applet components are used to create web page effects. Applets cause accessibility problems because many browsers used by persons with disabilities do not support them (Lescher, 2000) and also because they may provide video or audio output. Scripting languages allow a web designer to add dynamic and interactive behavior to a web page. Scripts can be used to change an image on the screen when the user moves his or her cursor over the image (rollover GIFs), presenting difficulties to persons with mobility issues, as they may not have the dexterity for the careful mouse placement that may be required. Tables are multi-dimensional in nature, with layout being an important part of the content. Screen readers may often skip cells that do not contain information, without telling the user that this was done (Amtmann et al., 2000). Since many screen readers read across cells in a table row by row, information may not be reproduced in the order intended, making it impossible for the user to associate content with the corresponding column and row (Pontelli et al., 2002; Goodwin-Jones, 2001).

Accessibility evaluation

A well-known tool for evaluating web site accessibility is Bobby (Zeng and Parmanto, 2004), developed by the Center for Applied Special Technology (CAST) and based on the WCAG and Section 508. Bobby is a software that examines a web page and reports violations of accessibility and provides a rating of either “approved” or “not approved” based on automatically and manually evaluated checkpoints (www.bobby.watchfire.com). If “approved”, the web site may display the “Bobby Approved” icon indicating its compliance with Bobby standards (Rogoff, 2001). Another evaluation method was developed at the University of Pittsburgh. The web accessibility barrier (WAB) score is derived by evaluating 25 of the WCAG checkpoints that can be automatically evaluated. By using checkpoints that can be automatically checked, a large number of web sites can be evaluated consistently. A higher WAB score means more accessibility barriers exist. A lower score means better conformance with WCAG guidelines. A score of zero indicates that the site has no accessibility barriers to persons with disabilities (Parmanto and Zeng, 2003; Zeng and Parmanto, 2004).

Web sites are constantly being altered to incorporate new features and technologies in web development. The Wayback Machine, a service from the Internet Archive (www.archive.org/about/wb_press_kit.php) and Alexa internet allows one to see the web page as it existed at a particular point in time and, by comparing the page at different points in time, the changes that are made to a page. The Internet Archive began archiving the web in 1996 and any web site that is available to the public has the potential to be in the Wayback Machine. Web sites may not be included in the Wayback Machine for various reasons, including: sites that are password-protected, blocked by the webmaster, or otherwise inaccessible to the Archive’s automated systems.
Related work

There have been previous studies evaluating the accessibility of education web sites or evaluating particular departments or school web pages within the educational domain (Spindler, 2002; Sloan et al., 2002; Clyde, 2004; Yu, 2002). The majority of these studies have utilized Bobby in the evaluation process.

A study by Sloan et al. (2002) evaluated 11 UK higher education web sites and found that only samples from two sites met every Priority 1 guideline. One of the most common accessibility barriers was found to be the lack of alternative text for graphical features.

A study of a large sample of college and university library web sites (Spindler, 2002) found that only 42 percent were Bobby approved. Spindler found that most sites used images and that 56 percent failed to provide alternative text for at least some of these images. Another barrier that was commonly found (in 51 percent of the sites studied) was the lack of alternative text for image map hotspots.

Yu (2002) studied four sets of homepages for each of 108 California Community Colleges: the college, library, distance education, and disable student programs and services homepage. Many of the pages evaluated did not receive Bobby approval. Many pages failed approval because a few images lacked alternative text, while some were designed with no accessibility considerations.

There have been a limited number of studies on the accessibility of government web sites. A report (Stowers, 2002) funded by the PricewaterhouseCoopers Endowment for the Business of Government found Section 508 regulations slow to take effect. Again using Bobby, 148 major US Federal web sites were examined for accessibility. Although Federal agencies were required to be Section 508 compliant as of June 2001, only 13.5 percent of the web sites examined met this requirement a year past the deadline (Stowers, 2002). An earlier study conducted by a Brown University researcher found that 37 percent of the US government web sites were accessible (West, 2001).

Methodology

Selection of web sites

The education web sites in the study were all members of the Association of American Universities (AAU, www.aau.edu/aau/aaufact.html). At the time of this study there are 62 members of the AAU. This method for selecting education web sites was chosen since members of AAU are known to be the leading research universities that set standards for academic research and education. Only web sites that had an archived instance for each year, 1997-2002, were used. For convenience, the first archived instance for each year was used for analysis, unless this instance was unable to be used. If there was not an instance for a particular year for a web site this site was not included in the study. By including only web sites that have archived instances for all years being studied, it is possible to analyze trends in individual web sites as well as across the genre. There were a total of 45 education web sites included in the study.

A comparison group of government web sites was also evaluated. Since government web sites are required to comply with accessibility standards, they are a good basis of comparison. The government sample was obtained from www.100topgovernmentsites.com. This is a subset of 100.com, a web site that ranks the top 100 web sites in various categories. A list of the 100 top government web sites was obtained from this site on 15 August 2003. Government web sites included were limited to those ending in the postfix “.gov” from this list of 100. Again, only web sites that had an archived instance for every year were used. There were a total of 22 government web sites included in the study.
Measurement for evaluating accessibility
The accessibility of each archived instance was measured using the WAB score (Parmanto and Zeng, 2003). The homepage and pages 1-level from the homepage (link from the home page to another page of the website) were evaluated. The site-wide score is the average of the WAB scores of all pages evaluated for the site.

The WAB metric was developed with the intentions of overcoming the deficiencies of the current measurements used in web accessibility studies. The current rating system and the so-called “Bobby Approved” measurement reflect an absolute measure of accessibility: if the website has even one violation of a checkpoint it is considered inaccessible. The new metric provides a quantitative score that provides a continuous range of values ranging from perfectly accessible to completely inaccessible. This allows for comparison between websites and assessment of changes in web accessibility over time.

The metric is a proxy indicator of web accessibility and looks at 25 checkpoints that can be automatically evaluated, based on WCAG and the US Access Board’s Electronic and Information Technology Accessibility Standards specifications. The number of violations of the checkpoints is the basis for the score.

The WAB formula is:

$$\text{WAB Score} = \frac{\sum_p \sum_v (\frac{n_v}{N_v}) W_v}{N_p}$$

where $p$ is the total pages of a website; $v$ the total violations of a web page; $n_v$ the number of violations; $N_v$ the number of potential violations; $W_v$ the weight of violations in inverse proportion to WCAG priority level; and $N_p$ the total number of pages checked.

This measure looks at the actual violations of the page and normalizes them against the potential violations. The measure utilizes the WCAG checkpoint priorities, but in reverse. This means a Priority 1 violation weighs three times more than a Priority 3 violation, since Priority 1 violations pose absolute barriers to accessibility. The WAB score for each website is the average score of the pages being evaluated for that website. A higher WAB score means more accessibility barriers exist, while a lower score denotes fewer barriers. A score of zero denotes that the website does not contain any violations and should not present any accessibility barriers to persons with disabilities.

There also exists a threshold between accessible and non-accessible websites. Previous work (Parmanto and Zeng, 2003) indicated the WAB as a novel metric for measuring content accessibility of the web for persons with disabilities. Upon calculating the scores of 1,141 rated websites with “A”, “AA”, and “AAA” conformance levels and 500 random, non-rated websites, it was found that the metric provides a good representation of the website’s accessibility. Scores of the WAB metric provide continuous degrees of accessibility. The average scores of the “AAA”, “AA”, “A”, and non-rated websites are 2.02, 2.74, 4.47, and 10.5, respectively. By doing further analysis, it was found that a score of 5.5 separates accessible and non-accessible websites with a high degree of accuracy (with area under the curve of 0.962 as measured using receiver operating characteristics (ROC) Curve (Egan, 1975).

Measurement for evaluating complexity
To further evaluate reasons for accessibility barriers and determine whether or not government web designers are also incorporating complex design components or
simply maintaining bland sites, we examined the complexity of the web sites. The complexity score was designed to follow a complexity sequence that factors in that some components are more complex than others and pose differing levels of barriers to accessibility. The HTML of the web document is parsed and a value is assigned to each HTML tag. Object tags (e.g. `<OBJECT>` and `</OBJECT>` ) are coded with a value of 100 units since they are the most complex component. Script tags (e.g. `<SCRIPT>` and `</SCRIPT>` ) are coded with a value of 10 units. All other tags (e.g. `<P>`, `<TR>`, `</TR>`), being less complex than object and script tags, are coded with a value of 1 unit. The average of the complexity for all pages evaluated for a web site (including the homepage and 1-level from the homepage) comprises the complexity score for that particular web site.

The complexity score is:

\[
\text{Complexity} = \sum (\text{Tag} \times 1) + \sum (\text{Script} \times 10) + \sum (\text{Object} \times 100)
\]

Statistical methods
Repeated measures analysis of variance (ANOVA) procedures, with time being the within subjects factor, was used to test for linear trends in accessibility and complexity of the web sites studied. Pearson’s correlation was performed to correlate WAB scores and complexity scores without regard to year.

Results
Education web sites
Of the 62 members of the AAU at the time of data gathering, 45 (72.6 percent) were included in the education sample, since the requirement for selection was the presence of an archived instance in the Wayback Machine for each year 1997-2002. WAB scores for education web sites continuously increased over time (Figure 1). Repeated measures ANOVA was computed. Because of evidence that the assumption of sphericity was not met, results using the Greenhouse-Geiser corrections were interpreted and the results

![Figure 1. Mean WAB score for education web sites](image-url)
were significant \( F[5, 220] = 26.257, p < 0.001 \). There is also significant linear trend noted \( F[144] = 50.181, p < 0.001 \). Education web sites were accessible at the beginning of the web’s history, but as time has elapsed they have gotten progressively less accessible for persons with disabilities.

Complexity scores also increased each year from 1997 to 2002 for education web sites (Figure 2). Repeated measures ANOVA was computed. Because of evidence that the assumption of sphericity was not met, results using the Greenhouse-Geiser corrections were interpreted. The results were significant \( F[5, 220] = 16.826, p < 0.001 \). There is also significant linear trend noted \( F[144] = 31.539, p < 0.001 \), indicating that there is a tendency for complexity scores to increase each year.

A Pearson correlation coefficient was computed to evaluate the relationship between WAB and complexity scores education web sites without regard to year. By graphing a box-plot, outliers (18) were identified and removed \( (n = 252) \) and the Pearson’s correlation coefficient is 0.332 \( (p < 0.01) \) (Figure 3), suggesting a low degree of correlation (Franzblau, 1958): as complexity scores increase so do WAB scores. The correlation coefficient is 0.297 prior to the removal of outliers.

Table I shows results of the 25 checkpoints comprising the WAB score, with the rate of violation for education web sites. The rate is derived by dividing the number of actual violations by the number of potential violations. A score of zero means that there were not potential violations of that particular checkpoint, while a score of one denotes violations of every occurrence of the subject of that checkpoint.

Government web sites
As previously mentioned government web sites were compared against the education web sites since government web sites are required to comply with accessibility standards and therefore form a good basis for comparison. Mean WAB scores of government web sites remain fairly unchanged from 1997 to 2002 (Figure 4); the scores of government web sites over the years are close to the accessible line. Repeated measures ANOVA was computed. Because of evidence that the assumption of sphericity was not met, results using the Greenhouse-Geiser corrections were
Evaluating complexity of government web sites shows that complexity increases over time (Figure 5). Repeated measures ANOVA was computed. Because of evidence that the assumption of sphericity was not met, results using the Greenhouse-Geiser corrections were interpreted. The results are significant \( F(5, 105) = 3.758, p < 0.01 \). There is also significant linear trend noted \( F(121) = 9.926, p < 0.005 \), indicating that there is a tendency for complexity scores to increase each year.

A Pearson correlation coefficient was computed to evaluate the relationship between WAB scores and complexity scores of government web sites without regard to year. By graphing a box-plot, outliers (6) were identified and removed \( (n = 126) \). There was no relationship between the two \( (r = 0.14) \) (Franzblau, 1958). Prior to the removal of outliers, Pearson’s correlation coefficient is 0.206.

Of the 25 checkpoints captured and used to determine the WAB score, the priority 1 checkpoints were further analyzed because they pose absolute barriers if violated. The priority 1 checkpoints included in the WAB score are:

1. provide Alt text for images;
2. provide Alt text for applets;
3. provide Alt content for objects;
4. provide Alt text for image-type buttons in forms;
5. provide Alt text for image map hot spots;
6. make Frames reference HTML files; and
7. give Frames a title.

The issues that cause the most accessibility barriers to persons with disabilities for both government and education web sites are not supplying alternative text for images and image map hotspots. Another issue that posed issues in the education web sites, but not the government sites, was not providing titles for frames. If designers would
make the minimal effort to fix these just the two issues posing most barriers (to include alternative text for each image and image map hot spot), their web site would be substantially more accessible. Take for example a 2000 education web site, of which the homepage and 29 pages 1-level down were evaluated, has a mean WAB score of 11.69. If the designer would add alternative text for images and image map areas, the mean WAB score of the web site would decrease to 6.78.

With respect to the complexity of the web sites, government and education web sites are fairly similar in terms of the average number of simple tags per site (Table II). The same is true for the average number of scripts per web site. Education web sites appear to be incorporating slightly more objects into their design. This could be due to many universities including virtual campus tours and other information in multimedia format to inform prospective students.

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Provide alternative text for all images</td>
<td>0.31</td>
<td>0.29</td>
<td>0.43</td>
<td>0.45</td>
<td>0.38</td>
<td>0.29</td>
</tr>
<tr>
<td>1</td>
<td>Provide alternative text for each applet</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0.82</td>
<td>0.68</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>Provide alternative content for each object</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>Provide alternative text for all image-type buttons in forms</td>
<td>0.43</td>
<td>0.50</td>
<td>0.78</td>
<td>0.51</td>
<td>0.39</td>
<td>0.27</td>
</tr>
<tr>
<td>1</td>
<td>Provide alternative text for all image map hot-spots (areas)</td>
<td>0.79</td>
<td>0.74</td>
<td>0.60</td>
<td>0.49</td>
<td>0.42</td>
<td>0.39</td>
</tr>
<tr>
<td>1</td>
<td>Each frame must reference an HTML file</td>
<td>0</td>
<td>0.03</td>
<td>0.05</td>
<td>0.08</td>
<td>0.11</td>
<td>0.16</td>
</tr>
<tr>
<td>1</td>
<td>Give each frame a title</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Use a public text identifier in a DOCTYPE statement</td>
<td>0.88</td>
<td>0.82</td>
<td>0.80</td>
<td>0.77</td>
<td>0.77</td>
<td>0.68</td>
</tr>
<tr>
<td>2</td>
<td>Use relative sizing and positioning (percent values)</td>
<td>0.03</td>
<td>0.08</td>
<td>0.10</td>
<td>0.16</td>
<td>0.21</td>
<td>0.21</td>
</tr>
<tr>
<td>2</td>
<td>Nest headings properly</td>
<td>0.15</td>
<td>0.07</td>
<td>0.06</td>
<td>0.11</td>
<td>0.07</td>
<td>0.07</td>
</tr>
<tr>
<td>2</td>
<td>Provide a NOFRAMES section when using frames</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>Avoid blinking text created with the BLINK element</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Avoid scrolling text created with the MARQUEE element</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Do not cause a page to refresh automatically</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>Do not cause a page to redirect to a new URL</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>Make sure event handlers do not require use of a mouse</td>
<td>0.92</td>
<td>0.95</td>
<td>0.98</td>
<td>0.99</td>
<td>1</td>
<td>0.94</td>
</tr>
<tr>
<td>2</td>
<td>Explicitly associate form controls and their labels with the LABEL element</td>
<td>0.81</td>
<td>0.85</td>
<td>0.83</td>
<td>0.84</td>
<td>0.89</td>
<td>0.92</td>
</tr>
<tr>
<td>2</td>
<td>Create link phrases that make sense when read out of context</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
<td>0.03</td>
<td>0.04</td>
<td>0.03</td>
</tr>
<tr>
<td>2</td>
<td>Do not use the same link phrase more than once when the links point to different URLs</td>
<td>0.08</td>
<td>0.08</td>
<td>0.11</td>
<td>0.11</td>
<td>0.13</td>
<td>0.13</td>
</tr>
<tr>
<td>2</td>
<td>Include a documents TITLE</td>
<td>0.02</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>3</td>
<td>Client-side image map contains a link not presented elsewhere on the page</td>
<td>0.68</td>
<td>0.67</td>
<td>0.62</td>
<td>0.64</td>
<td>0.73</td>
<td>0.74</td>
</tr>
<tr>
<td>3</td>
<td>Identify the language of the text</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0.99</td>
</tr>
<tr>
<td>3</td>
<td>Provide a summary for tables</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0.91</td>
</tr>
<tr>
<td>3</td>
<td>Include default, place-holding characters in edit boxes and text areas</td>
<td>0.68</td>
<td>0.69</td>
<td>0.71</td>
<td>0.73</td>
<td>0.63</td>
<td>0.56</td>
</tr>
<tr>
<td>3</td>
<td>Separate adjacent links with more than white space</td>
<td>0.16</td>
<td>0.18</td>
<td>0.19</td>
<td>0.20</td>
<td>0.26</td>
<td>0.34</td>
</tr>
</tbody>
</table>

Table I. Rate of violations for the 25 checkpoints comprising the WAB score for education web sites 1997-2002
Discussion
There is a concurrent increase in accessibility barriers that coincides with an increase in complexity in the education web site studied. As web designers have increased their use of complex web design components, they have also added barriers to accessibility for persons with disabilities.

Like web sites in the sample of education web sites, the complexity scores of the government web sites in the study also increased. From 1997 to 1999, government web sites are actually more complex than education web sites, but become very similar in
complexity from 2000 to 2002. Government web sites, however, fail to have the concurrent increase in WAB scores that is present in the education web sites and in contrast remain consistently close to the accessibility line, showing that an increase in complexity does not necessarily translate into a decrease in accessibility. These results provide hope that if all web sites take accessibility issues as seriously as government web sites do, the goal of universal web accessibility is one that is attainable.

To illustrate the WAB metric and the difference in WAB score between web sites, take the following example. Figures 6 and 7 show the homepage of the University of Colorado at Boulder in 1997 and in 2002. While some of the changes in the page are visibly apparent, some of the problems posing accessibility issues are not. The WAB score of the 1997 homepage is 4.0 (accessible), while that of the 2002 homepage is 14.11 (inaccessible). The differences that contribute to this increase in WAB score and subsequent decrease in accessibility include:

- The 2002 homepage has six images and one object without alternative text, while the 1997 page has no images lacking alternative text and includes no objects.
- The 2002 page has 35 violations of using absolute sizing rather than relative sizing and positioning. The 1997 page has none.

<table>
<thead>
<tr>
<th></th>
<th>Simple tags</th>
<th>Scripts</th>
<th>Objects</th>
<th>Simple tags</th>
<th>Scripts</th>
<th>Objects</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>1,647.55</td>
<td>20.41</td>
<td>0</td>
<td>1,506.87</td>
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<td>0.5</td>
<td>3,113.91</td>
<td>70.11</td>
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Table II. Average number per site for government and education web sites
The 2002 homepage contains more tables than the 1997 page (14 versus 3) and there are no summaries provided for any of them.

The 2002 page contains seven event handlers that require the use of a mouse, while the 1997 page includes no event handlers.

There are no place holders in edit boxes and text areas located within the 2002 homepage. There are no edit boxes or text areas in the 1997 page.

In the 2002 page there are two occurrences of form controls without the label element, while there are no form controls in the 1997 page.

There are two occurrences in the 2002 page where the same link phrase points the user to different URLs.

**Contributions**

Studies such as this demonstrate where the real problems exist and thus lead to improvements in guidelines for accessible web design. This information can also be useful to engineers of web authoring tools. By incorporating information on what the accessibility issues are and where they lie within the design, as well as including accessibility guidelines into authoring tools, designers would be a step ahead in producing an accessible web site. Another beneficial technology is one similar to Bobby (which gives the designer feedback as to where violations are occurring within the design), in which the designer could run an application that would not only tell them what the violations are and where they occur, but also the WAB score for their site. This would allow the designer to run the application on numerous occasions until the desired WAB score is reached.

By demonstrating the trend of inaccessibility that is occurring on the web, one law and policy implication that may arise from studies, such as this one, is the extension of the Americans with Disabilities Act (ADA) to the internet. Government agencies are proving that these mandates are effective and that web sites can be accessible without
stifling the creativity of web designers. A similar mandate would be beneficial in educational institutions, at the state and local government level, as well as in the private sector as they design intranets for their employees and commercial web sites for their customers and the public.

Most of the higher educational institutions belonging to the AAU receive research funding from federal agencies. Technically, the web sites of the federally funded research are required to be accessible under Section 508 of the Rehabilitation Act Amendments. The fact that the web sites of higher education institutions are increasingly inaccessible indicates a lack of overall awareness of the issue of web accessibility. Government web sites are relatively similar to the education web sites, in regard to increasing complexity, but they have also remained accessible despite the increase. The percentage of education web sites in the study considered to be accessible in 1997 (having a WAB less than 5.5) is 64.4 percent compared to only 15.6 percent in 2002. In contrast, the number of accessible government web sites is 59.2 percent in 1997 and 41 percent in 2002. This may lead one to believe that accessibility standards are having an impact.

Many web designers, especially of non-government web sites, may be inadvertently placing barriers to persons with disabilities simply by using web authoring tools and the latest web technologies. Although they may be providing an aesthetically appealing site for some people, they are unaware of the implications such technology poses to other individuals. Guidelines and policies cannot only bring about adherence to better practices of web page design; they can forge a more widespread awareness of the problem. By proving that these mandates do have an effect on accessibility, more industries will embrace policies similar to Section 508, making WCAG checkpoints common practice and evolving the internet into something that truly is accessible.

Limitations
The authors recognize the limitation that is presented by the WAB score as a proxy of web accessibility. The WAB score can give an indication of the accessibility of or the amount of barriers in a particular web site. It cannot, however, differentiate between a barrier that poses minimal limitation to the user and a barrier that poses absolute inaccessibility. Take as an example a web page that contains only one unlabeled image-type button. The page may have a very low WAB score and appear to be inaccessibile, but if this unlabeled button is a submit button and is required for the user to submit information, the web site would not be functional to a person that could not effectively use the page.

Future study
In the future, the authors plan to pursue a study that would involve users with disabilities in the examination of web sites with low WAB scores (accessible) and high WAB score (inaccessible), to correlate how well the WAB score is gauging accessibility of web sites from the perspective of the actual user.

References


Further reading
IBM (n.d.), available at: www.ibm.com