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# Web Accessibility of the Higher Education Institute Websites Based on the World Wide Web Consortium and Section 508 of the Rehabilitation Act

Web Accessibility of the Higher Education Institute Websites Based on the World Wide Web Consortium and Section 508 of the Rehabilitation Act

A dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy in Rehabilitation

by

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## Abstract

The problem observed in this study is the low level of compliance of higher education website accessibility with Section 508 of the Rehabilitation Act of 1973. The literature supports the non-compliance of websites with the federal policy in general. Studies were performed to analyze the accessibility of fifty-four sample web pages using automated testing via auto-validation tools and using manual testing via assistive technology, followed by a comparative analysis of the findings of the auto validation tools. The auto-validation tools utilized on the sample web pages were comprised of three W3C validation tools. The results showed that two-thirds of the websites failed Priority 1 validation, while one hundred percent of the websites failed to meet the Priority 2 and Priority 3 validation. In addition, three web pages were tested against Section 508 guidelines. The result of the manual testing by assistive technology confirmed that all three websites failed to meet the minimum requirement of federal policy. Moreover, a comparative analysis between the validations of the W3C tools showed that significant differences existed between the findings of each auto-validation tool.

The findings of this study implied that passing the evaluations of auto validation tools is not enough to ensure accessible websites to individuals with disabilities. It is important to utilize assistive tools to determine web accessibility as it appears to individuals with disabilities. Recommendations were made for improvements such as encouraging universities to provide training for website managers and implementing the mandatory use of screen-readers as a validation tool.

**Acknowledgements**

I would like to thank Dr. Brent Williams for his encouragement, assistance and support. His never-ending patience helped me get through this project.

I'm also grateful for the loving support of my husband Dr. Sarwar Alam and thankful for my daughter Annika Tabassum and son Ghaleeb Hakim for growing up so wise as to not let me feel guilty for spending so much time away from them as I worked on this project.

## Dedication

I would like to dedicate this project to my grandmother Begum Aasma Khatun, and my mother-in-law Umme  Elahi Begum, whom I have lost along the way.

## Table of Contents

Chapter 1: Introduction

- Introduction to the Problem…….……1
- Understanding Accessibility issues…….……3
- Problem Statement …….……..…..8
- Significance of the Study…….9
- Definition of Terms…….10
- Research Questions……..18
- Outline of Dissertation…….19

Chapter 2: Literature Review

- Introduction…….…… 20
- Historical Background……..……20
- Web Accessibility Guidelines and Tools……..……..…..24
- Assistive Technology Solutions……..…..…..…..27
- Research on Web Accessibility…….…..…….…..31
- Research on Web Complexity and The Use of Assistive Devices…….……..35

Chapter 3: Methodology

- Introduction…….……..42
- Research Design…….43
- Sample Selection…….……..44
- Instrumentation…….……..….44
- Data Collection Procedure…….……49
- Data Analysis Procedure……55

Chapter 4: Results of the Study

- Introduction……..…..……..57
- Descriptive Demographics…….……57
- Results of the Testing of the Research Hypotheses…….…….…….63
- Using Assistive Tool and Section 508 Checklist……..…..….……71
- Summary…….……74

Chapter 5: Summary, Conclusions and Implications

- Summary of the Study…….……77
  - Statement of the problem…….77
  - Statement of the procedure……..78
  - The specific research hypothesis…….…….81
- Summary of Key Findings……81
- Conclusion……..…..……84
- Implications…….….…….85

Chapter 6: Limitations and Suggested Further Research

- Limitations…….….……..89
- Suggested Further Research……..……90

References……..……....93

Appendix A: 54 Benchmark Institutions of University of Arkansas……...103

Appendix B: Accessibility Errors…….…….105

Appendix C: Shortcut Keys for NVDA Screen Reader……108

Appendix D: Checklist - The Section 508……109

## List of Figures


- Figure 2.1 Common computer interface “widgets” contain graphical cues ……....….30
- Figure 3.1 Choosing the Section 508 as the principal rubric to scan a website for accessibility issues ……..……..…….50
- Figure 3.2 An illustration of an online auto validator site …….……...52
- Figure 3.3 An illustration of a web page after piloting an online Functional Accessibility Evaluator analysis……...…….52
- Figure 3.4 Number of errors found by three auto validators - home page of a website…53
- Figure 4.1 Priority 1 checkpoint……60
- Figure 4.2 Priority 2 checkpoint……61
- Figure 4.3 Priority 3 checkpoint……62

## List of Tables


- Table 2.1 Section 508 Guidelines - WCAG Guidelines……..25
- Table 4.1 Number of errors found by three auto validation tools in one university…...59
- Table 4.2 Result of Priority 1 errors checkpoints…….…...59
- Table 4.3 Priority 1- findings of evaluation tools.....64
    - 4.3.a. Priority 1- findings of two evaluation tools - Eval Access and ETRE ….64
    - 4.3.b. Priority 1- findings of two evaluation tools - Eval Access and HERA2.1 Beta……..…….64
    - 4.3.c. Priority 1- findings of two evaluation tools - ETRE and HERA 2.1 Beta …..65
- Table 4.4 Priority 2 - findings of evaluation tools
    - 4.4.a. Priority 2 - findings of three evaluation tools ……. ……...…..….66
    - 4.4.b. Priority 2 - finding of two evaluation tools; Eval Access and HERA 2.1 Beta.....66
    - 4.4.c. Priority 2 - findings of two evaluation tools; Eval Access and ETRE …….……..…....67
    - 4.4.d. Priority 2 - findings of two evaluation tools; ETRE and HERA 2.1 Beta…….….67
- Table 4.5 Priority 3 - findings of evaluation tools
    - 4.5.a. Priority 3 - findings of three evaluation tools ……...68
    - 4.5.b. Priority 3 - findings of two evaluation tools; Eval Access and ETRE …..68
    - 4.5.c. Priority 3 - findings of two evaluation tools; Eval Access and HERA 2.1 Beta……...69

- 4.5.d. Priority 3 - findings of two evaluation tools; ETRE and HERA 2.1 Beta ……..69

- Table 4.6 Summary of the findings of evaluation tools……...70
- Table 4.7 Summary of the findings of assistive tool NVDA ……..74

# Chapter 1: Introduction

## Introduction to the Problem

This study focuses on the problem of web accessibility issues and the practice of Section 508 and Web Content Accessibility Guidelines in the context of the use of accessibility automation tools and assistive technologies, encompassing the population of four thousand U.S. universities. The research analyses will be based on the WCAG (World Wide Web Consortium [W3C], 2007a, 2007b, & 2007c) and legal standards of U.S. Sections 504 and 508 of the Rehabilitation Act - Americans with Disabilities Act (U.S. Department of Justice, 1990, 2007a, 2007b). The home pages of the institutes of higher education will be analyzed and evaluated.

The World-Wide Web (W3) was developed to be a pool of human knowledge which would allow collaborators in remote sites to share their ideas and all aspects of a common project (Wardrip-Fruin & Montfort, 2003). The term Web Accessibility means that people with disabilities can perceive, understand, navigate, and interact with and contribute to the web (W3.org). Since the emergence of the web in 1994, the need for the web resources to be accessible to people with disabilities has always been of vital importance. Governmental regulations such as Section 508, a rising rate of visual disabilities in the U.S. population, and greater dependence on the Internet have increased the need to produce accessible websites (W3.org). The Web offers one of the best opportunities yet to deliver information inclusively of people with many kinds of disabilities, yet there remains a high percentage of web based information that is inaccessible to disabled users, a situation which makes it difficult for people with disabilities to fully participate in the "digital economy" (Fraser, 2000).

World Wide Web has become a key source of information in the years since its inception and in less than a decade, it has made a huge impact on the way we live by rapidly spreading into

all areas of society (Mancini, Zedda, & Barbarado, 2005). According to Mancini (2005), from news to distance learning, from government services to education, web based information seems to be extremely important in the education field as a source of communication. Despite the widespread availability of web-based information resources, it is difficult for those who rely on assistive technologies to access and utilize this communication tool. In 1998, Section 508 mandated that U.S. public agencies and organizations are required to provide information in an accessible manner (U.S. Department of Justice, 1990, 2007b).

Web resources follow the guidelines that are compliant with the Americans with Disabilities Act (ADA), Public Law 102-569, Section 508 of the Rehabilitation Act (Waddell, 1998), the Assistive Technology Act of 1998 (S.2432); and Section 255 of the Telecommunications Act. The ADA Rehabilitation Act is the principal legislation that is facilitating the trend toward mandatory accessible web design. The WCAG (Web Content Accessibility Guidelines) published Web Accessibility Initiative Guidelines which were initiated by the World Wide Web Consortium (W3C) with the intention of ensuring that the World Wide Web maintained an infrastructure that allowed technologies with which all users can access its content. Adherence to these web accessibility guidelines ensures that web-based materials are "universally" accessible (Reagan, 1997). According to Reagan (1997), this voluntary set of guidelines was developed with the concept of universal design in mind, incorporating various levels of accessibility priorities and multiple levels of conformance. The Web Accessibility Initiative is responsible for making web formats compatible with assistive technologies, without sacrificing visual appeal or higher end features and functionality (Waddell, 1998).

The current study will focus primarily on higher education websites to study their accessibility in relation to Section 508 of the Rehabilitation Act. The literature review revealed

that website compliance has not greatly improved nor has it worsened among many public and educational websites for a variety of reasons (Spindler, 2002; Takata, Nakamura, & Seki, 2004; Yu, 2002). In addition, the literature had evolved in recommending means beyond the automated verification tools for solely testing web accessibility, for example, assistive tools (e.g., JAWS) and people with disabilities to navigate the website to help determine issues and levels of compliance (Byerley & Chambers, 2003 Lazar, Hackett & Parmanto, 2005). However, many accessibility solutions described in this document may contribute to "universal design" by benefiting non-disabled users as well as individual with disabilities. For example, support for speech output not only benefits blind users, but also Web users whose eyes are busy with other tasks, while captions for audio not only benefit deaf users, but also increase the efficiency of indexing and searching for audio content on websites.

For the purpose of the present study, a sample of 54 higher education institutions that are listed as the University of Arkansas' benchmark institutes will be selected. A list of these 54 institutes can be found in Appendix A.

**Understanding Accessibility Issues**

According to W3C, WAI (Web Accessibility Initiatives) develops guidelines for accessibility of websites, browsers, and authoring tools, in order to make it easier for people with disabilities to use the web. Given the web's increasingly important role in society, access to the Web is vital for people with disabilities (W3C, http://www.w3.org/WAI/EO/Drafts/PWD-Use-Web/ ).

Ability to perform certain tasks can vary from person to person, and over time, for different people with the same type of disability. People can have combinations of different disabilities, and combinations of varying levels of severity. Disability can be defined as the

condition of being unable to perform as a consequence of physical or mental unfitness; 'reading disability'; 'hearing impairment' (http://wordnetweb.princeton.edu/perl/webwn?s=disability ). From web accessibility point of view, this study adopts the World Health Organization definition of 'disability';

> 'Disabilities is an umbrella term, covering impairments, activity limitations, and participation restrictions. An impairment is a problem in body function or structure; an activity limitation is a difficulty encountered by an individual in executing a task or action; while a participation restriction is a problem experienced by an individual in involvement in life situations.' (http://www.who.int/topics/disabilities/en/)
>
> 'Thus disability is a complex phenomenon, reflecting an interaction between features of a person's body and features of the society in which he or she lives.' (http://en.wikipedia.org/wiki/Disability)

People with disability may have limitations of sensory, physical or cognitive functioning which can affect their access to the web. These limitations may include injury-related and aging-related conditions, and can be temporary or chronic. According to W3C, the number and severity of limitations tend to increase as people age, and may include changes in vision, hearing, memory, or motor function; aging-related conditions can be accommodated on the web by the same accessibility solutions used to accommodate people with disabilities. As explained in the W3C website, sometimes different disabilities require similar accommodations; for instance, someone who is blind and someone who cannot use his or her hands both require full keyboard equivalents for mouse commands in browsers and authoring tools, since they both have difficulty using a mouse but can use assistive technologies to activate commands supported by a standard keyboard interface.

Web accessibility issues may vary across different types of barriers that someone with that disability may encounter on the web. For the purpose of understanding those barriers, a number of disability types which appear to be most affected by the inaccessibility of the web, have been discussed.

A person with low vision may have difficulties accessing a website. The American Academy of Ophthalmology (http://www.aao.org/aao/ ) defines low vision as "If ordinary eyeglasses, contact lenses or intraocular lens implants don't give you clear vision, you are said to have low vision, whether your visual impairment is mild or severe, low vision generally means that your vision does not meet your needs." To be able to access a site, a person with low vision may use screen readers and his/her keyboard rather than a mouse. To provide keyboard-based navigation, it is helpful to have text equivalents for all meaningful visual images. Screen readers can jump from one link to the other, so "click here" is not very useful with the context in the link (W3C). In addition, links that are part of JavaScript can be confusing a since screen reader may not read these links.

A general practice of webmasters is to use tables to place content, since it is the easy way to create complex structures for pages and it is the traditional way of placing complex graphics. Amtmann, Johnson, and Cook (2000) recommended not utilizing tables at all unless it is understandable when reading the page from left to right. However, interpreting the content within a table cell, as with a screen reader, can be very difficult. Items in table cells which appear to be next to each other when viewed visually may actually be separated by other cells within the code. Items may be read out by the screen reader in a very disjointed format. A considerable number of table cells may need to be navigated to get to relevant pieces of content giving the blind user a very frustrating and difficult experience of the website. According to W3C, where

tables are used they should be clearly labeled with column and row headings, care needs to be taken with merged cells and complex tables should have good descriptions. People who are color blind or who have low vision may not be able to see content unless there is high contrast between background and foreground colors. When information is presented by color alone, those who are color blind may miss that information as various colors appear identical to them.

Magnification of a page can be done in most standard browsers provided the website has the capacity to allow this. According to W3C, the design of the website should allow for elements to change size and still be presentable. Magnification aids might reformat the location, change the contrast, or distort the size and fonts of the text and objects on the web page. Large areas of space may cause a problem with magnification. The area of space becomes larger so the user has to scroll for longer and may miss valuable information. Many website uses mouse over effects. Alternatives are required for a person who is not using a mouse. Multiple frames divide one single page in multiple pages, which may cause confusion since the whole picture may not be seen.

There are many types of low vision (also known as "partially sighted"): poor acuity (vision that is not sharp), tunnel vision (seeing only the middle of the visual field), central field loss (seeing only the edges of the visual field), and clouded vision. To use the web, some people with low vision use extra-large monitors, and increase the size of system fonts and images. Others use screen magnifiers or screen enhancement software. Some individuals use specific combinations of text and background colors, such as a 24-point bright yellow font on a black background, or choose certain typefaces that are especially legible for their particular vision requirements. Individuals with low vision may encounter multiple barriers on the web, for examples, web pages with absolute font sizes that do not enlarge, web pages that are difficult to

navigate when enlarged, web pages or images on web pages that have poor contrast, and whose contrast cannot be easily changed through user override of author style sheets and text presented as images, which prevents wrapping to the next line when enlarged.

Individuals who are deaf or hard of hearing usually rely on the visual representations of auditory information. Deafness may involve a substantial impairment of hearing in one or both ears. To use the web, many people who are deaf rely on captions for audio content. They may need to turn on the captions on an audio file as they browse a page or rely on supplemental images to highlight context (W3C). Examples of barriers that people who are deaf may encounter on the web can include: lack of captions or transcripts of audio on the web, including webcasts, lack of content-related images in pages full of text, which can slow comprehension for people whose first language may be a sign language instead of a written/spoken language, lack of clear and simple language requirements for voice input on websites (W3C).

Individuals with visual and auditory perceptual disabilities, including dyslexia, or learning disabilities, and dyscalculia may have difficulty processing language or numbers. They may have difficulty processing spoken language when heard. They may also have difficulty with spatial orientation. To use the web, people with visual and auditory perceptual disabilities may rely on getting information through several modalities at the same time. For instance, someone who has difficulty reading may use a screen reader plus synthesized speech to facilitate comprehension, while someone with an auditory processing disability may use captions to help understand an audio track. The examples of barriers that people with visual and auditory perceptual disabilities may encounter on the web can include lack of alternative text that can be converted to audio to supplement visuals, the lack of captions for audio, etc.

Individuals with attention deficit disorder may have difficulty focusing on information. To use the web, an individual with an attention deficit disorder may need to turn off animations on a site in order to be able to focus on the site's content. For example, distracting visual or audio elements that cannot easily be turned off may indicate a lack of clear and consistent organization of websites.

Individuals with mobility disabilities have physical impairments that substantially limit movement and fine motor controls. They may use a keyboard, but only strike one key at a time. Website accessibility should make the website more compatible with voice input and control technologies.

Individuals with cognitive or learning disabilities, such as dyslexia and short-term memory deficit, need more general solutions, which include providing a consistent design and using simplified language. Graphics may assist their understanding. People with cognitive or learning disabilities can also benefit from both an audio file and a transcript of a video. By simultaneously viewing the text and hearing it read aloud, they can take advantage of both auditory and visual skills to better understand the material.

**Problem Statement**

The U.S. Department of Education, National Center for Education Statistics (2006) indicated that eleven percent of undergraduates reported having a disability in 2003-2004. Among students reporting a disability, 25% reported an orthopedic condition, 22 % reported mental illness or depression, and 17 % reported health impairment. Individuals with different disabilities have different access barriers related to educational use of the Internet. University websites accessibility failure rates are consistent across all sectors, preventing or making difficult Internet access for those web users with disabilities (Hackett & Parmanto, 2005;

Spindler, 2002; Yu, 2002). Although a number of assistive technologies such as screen readers have been available to assist people with disabilities in navigating the WWW, websites must still be programmed and designed so these assistive tools can interpret the content of the sites for the end-users with disabilities (West & Miller, 2006). If a deaf individual encounters an audio file and the file is not captioned or a transcript does not exist on the site, then that individual cannot profit from the content. Sites with frames and tables tend to confuse text-reading programs that read from left to right, ignoring the layout. According to King, Thatcher, Bronstad and Easton (2005), the automatic checkers are helpful in educating the webmaster, but they are not sufficient in and of themselves to determine Section 508 or WCAG compliance. For example, automated checkers cannot check all points for accessibility, such as JavaScript, or web page content that is generated by a script.

King et al. (2005) suggested two solutions for providing accessibility: one, provide a text only version of the site and two provide contact information and web accessibility policy information for users with disabilities to report a problem. Byerley and Chambers (2003) suggested that webmasters, along with assistive technologies should utilize users with disabilities to navigate their sites. This study is aiming to suggest alternative ways to improve web accessibility. For this purpose, 54 benchmark university websites index pages (main page) were selected to examine accessibility based on criteria of the World Wide Web Consortium and Section 508 of the Rehabilitation Act.

**Significance of the Study**

It is important that all university students be able to access web-based content regardless of their disability or what technology they are using. As Olive (2009) mentioned in his dissertation, the unanswerable question is how many potential students have the universities lost

because of accessibility issues. In this context, the purpose of this research is to further understand problems of web accessibility, specifically addressing higher education Section 508 nonconformance affecting web users with visual disabilities. The present research will attempt to provide an accurate depiction of the levels of accessibility of university sites in the terms of compliance with the Section 508 standards. This research would have value to the 54 million Americans with disabilities, as it may help to facilitate improvements in the accessibility of higher education institutes.

Section 508 of the Rehabilitation Act has been followed since 1998, and even after more than a decade, many universities and other entities that must abide by Section 508 have still not ensured accessible web page designs (Spindler, 2002; Yu, 2002). It is important to promote the use of assistive tools other than using just automatic verification web accessibility checkers, such as Eval Access (HCI, 2006), ETRE (etre, 2005), and Hera 2.1 Beta (Sidar, 2005). The study will provide a more detailed analysis of the levels of web accessibility with the use of NVDA for manual checks. The study sought to identify the success rate of Section 508 compliance and levels and issues of web accessibility of the higher education home pages of fifty four benchmark universities. From the combination of the literature and the resource of various studies' survey questionnaires and tools, this research will analyze and evaluate certain factors that may be contributing to the accessibility compliance issues. In completing this study, the research has the goals of assisting in furthering knowledge regarding web accessibility and hopefully identifying an enhanced means of improved web accessibility.

**Definition of Terms**

*Accessibility specific to the Internet (i.e., Web Accessibility).* According to the World Wide Web Consortium (W3C), which is a group of information technology leaders and

organizations known internationally that created the Web Content Accessibility Guidelines (WCAG), web accessibility means that people with disabilities can perceive, understand, navigate, and interact with the web. Web accessibility encompasses all disabilities that affect access to the web, including visual, auditory, and physical, speech, cognitive, and neurological disabilities. Millions of people have disabilities that affect their use of the web. Currently, most websites and web software have accessibility barriers that make it difficult or impossible for many people with disabilities to use the Internet. As more accessible websites and software become available, people with disabilities are able to use and contribute to the web more effectively. Web accessibility also benefits people without disabilities; for example, a key principle of web accessibility is designing websites and software that are sufficiently flexible to meet different user needs, preferences, and situations. This flexibility also benefits people without disabilities in certain situations, such as those using a slow Internet connection, individuals with "temporary disabilities" such as a broken arm, and people with changing abilities due to aging. (W3C, 2007a, Introduction, paras. 1-4)

*AChecker™*. One of many online automatic verification tools that can check for Section 508 and WCAG accessibility compliance and other usability measures of websites. AChecker™ was created by the University of Toronto (Adaptive Technology Resource Centre, 2008).

*A-Prompt™*. One of many desktop automatic verification tools that can check for Section 508 and WCAG accessibility compliance and other usability measures of websites. A-Prompt™ was created by the University of Toronto (Adaptive Technology Resource Centre, 2008).

*Americans with Disabilities Act (ADA).* The ADA is the U.S. law created to assist the lives of American citizens who have disabilities to provide a clear and comprehensive national mandate for the elimination of discrimination against individuals with disabilities; to provide

clear, strong, consistent, enforceable standards addressing discrimination against individuals with disabilities; to ensure that the Federal Government plays a central role in enforcing the standards established in this chapter on behalf of individuals with disabilities; and, to invoke the sweep of congressional authority, including the power to enforce the fourteenth amendment and to regulate commerce, in order to address the major areas of discrimination faced day-to-day by people with disabilities. (U.S. Department of Justice, 1990, Purpose)

*Assistive/Adaptive Technologies*: Technology can provide the means for a blind or partially sighted person to overcome barriers such as the need to read print, use a computer, take notes and communicate both on pager and electronically. Text and video magnifiers, electronic readers, Optical Character Recognition software, speech output systems and electronic Braille devices are all designed to provide a solution for a particular individual. These computer-related aids and equipment are commonly known as "assistive", "adaptive", "access", or "enabling" technology.

*Baby Boomer Generation (or Baby Boomers).* Americans born in the year ranging from 1946 to 1964. This age range vary by definition based on source and country origin, and this large population segment is being increasingly supported as seen through legislation (Association for American Retired Persons [AARP], 2008) and business entities. "Although the first wave of baby boomers turned 60 in 2006, they are a viable, dynamic consumer group that will continue to evolve for many years to come — requiring boomer-targeted marketing strategies to be equally dynamic and insightful" (Immersion Active, 2008, para. 7).

*Bobby (or WebXACT).* Formerly, a leading online automatic verification tool that could check for Section 508 and WCAG accessibility compliance (Zeng & Parmanto, 2004), which no

longer exists online or available in its desktop version and had transformed to WebXACT (Watchfire, 2008).

*CSS.* Cascading Style Sheet defines how HTML elements are to be displayed. Styles of a website are normally saved as an external .css file. External style sheets enable changing the appearance and layout of all the pages in a website, just by editing a single file (W3schools.com).

*Disability*. Disability is defined below per the U.S. Department of Justice definition: The term disability means, with respect to an individual (A) a physical or mental impairment that substantially limits one or more of the major life activities of such individual; (B) a record of such an impairment; or (C) being regarded as having such impairment. (U.S. Department of Justice, 1990, Disability, Sec.12102).

*E-learning*. Instruction delivered by CD-ROM, Internet, or intranet with the following features: (a) Includes content relevant to the learning objective; (b) Uses instructional methods such as examples and practice to help learning; (c) Uses media elements such as words and pictures to deliver the content and methods; (d) May be instructor-led (synchronous e-learning) or designed for self-paced individual study (asynchronous e-learning); (e) Builds new knowledge and skills linked to individual learning goals or to improved organizational performance (Clark & Mayer, 2008, p. 10).

*E-mail.* E-mail is "a means or system for transmitting messages electronically (as between computers on a network); messages sent and received electronically through an e-mail system" (Merriam-Webster, 2009b).

*Functional Accessibility Evaluator*. An automation tool to check web accessibility, developed by University of Illinois at Urbana/Champaign, 25 November 2005. The Functional

Accessibility Evaluator analyzes web resources for markup that is consistent with the use of HTML best practices for development of functionally accessible web resources and resources that support interoperability. This automation tool generates reports, in-page feedback, and, page transformation information. It is a free open source software to check website accessibility in compliance with Section 508.

*Home page.* A home page is "the page typically encountered first at a World Wide website that usually contains links to the other pages of the site" (Merriam-Webster, 2009c). In the context of this research, "home page" is used to define the portal entryway to a website that helps the web user initially access and navigate the entire website.

*HTML*. HTML (Hypertext Markup Language) is the set of markup symbols or codes inserted in a file intended for display on a World Wide Web browser page. The markup tells the web browser how to display a web page's words and images for the user. Each individual markup code is referred to as an element. Some elements come in pairs that indicate when some display effect is to begin and when it is to end.

*IS/IT/MIS.* Information systems (IS), information technology (IS), and management information systems (MIS) are considered analogous for the context of this research study.

*iPhone.* An iPhone (by Apple) is a multi-functional mobile device that includes music download and Internet capabilities plus many types of application processes (Apple, 2009).

*JAWS™*. JAWS is produced by Freedom Scientific; the acronym stands for Jobs Access With Speech. It is a leading assistive technology for the blind and is called a screen reader wherein a computerized voice tells the blind navigator what appears on the computer monitor as well as the tasks and activities that are being completed by the user (Microsoft, 2007). Available at www.freedomscientific.com .

*JavaScript*. JavaScript is an implementation of the client side scripting language standard and is typically used to enable programmatic access to computational objects within a host environment. It can be characterized as a prototype-based object-oriented scripting language that is dynamic, weakly typed and has first-class functions (Wikipedia, http://en.wikipedia.org/wiki/JavaScript ).

*Kelvin*$^{TM}$. A Web crawler program that computes Web pages and websites on Web Accessibility Barrier (WAB) and Complexity Scores developed by University of Pittsburgh researchers (Parmanto & Zeng, 2005).

*LIFT.* A leading online automatic verification tool that can check for Section 508 and WCAG accessibility compliance (UsableNet, 2007).

*PDA.* A personal digital assistant (pda) that is "a small hand-held device equipped with a microprocessor that is used especially for storing and organizing personal information (as addresses and schedules)" (Merriam-Webster, 2009d).

*Phishing*. Phishing is "a scam by which an e-mail user is duped into revealing personal or confidential information which the scammer can use illicitly" (Merriam-Webster, 2009e).

*Section 504 of the Rehabilitation Act*. U.S. Section 504 was enacted in 1973 and prohibits excluding or denying a person from employment and/or programs and services by an agency receiving federal funds. This act declares that discrimination by Federal agencies or others receiving federal funding for reasons of disability is illegal. (U.S. Department of Justice, 2007a)

*Section 508 of the Rehabilitation Act.* In 1998, Congress amended the Rehabilitation Act to require Federal agencies to make their electronic and information technology accessible to people with disabilities. On August 7, 1998, President Clinton signed in to law the Rehabilitation Act Amendments of 1998 which cover access to federally funded programs and services. The

law strengthens Section 508 of the Rehabilitation Act and requires access to electronic and information technology provided by the Federal government. The law applies to all Federal agencies when they develop, procure, maintain, or use electronic and information technology. Federal agencies must ensure that this technology is accessible to employees and members of the public with disabilities to the extent it does not pose an "undue burden." Section 508 speaks to various means for disseminating information, including computers, software, and electronic office equipment. It applies to, but is not solely focused on, Federal pages on the Internet (http://www.access-board.gov/sec508/guide/act.htm). Inaccessible technology interferes with an individual's ability to obtain and use information quickly and easily. Section 508 was enacted to eliminate barriers in information technology, to make available new opportunities for people with disabilities, and to encourage development of technologies that will help achieve these goals. Under Section 508 (29 U.S.C. '794d), agencies must give disabled employees and members of the public access to information that is comparable to the access available to others. (Section 508, 2007)

*Universal Design*. Universal design is a concept that derived from the disabilities and civil rights movements. With the demographics of a larger population segment with disabilities, people living longer, and increases in disabilities due to aging, the concepts creating universal design in the physical world has now transcended into the virtual world. (Center for Universal Design, 2007; Thompson, 2005)

*Webmaster*. In the context of this research study, the term webmaster may refer to a webmaster, web author, web editor, web developer, web designer, or person with another title but who is responsible for the website or home page.

*World Wide Web Consortium (W3C).* The World Wide Web Consortium (W3C) is an international consortium where member organizations, a full-time staff, and the public work together to develop web standards. W3C's mission is: To lead the World Wide Web to its full potential by developing protocols and guidelines that ensure long-term growth for the web. (W3C, 2007c)

*WAB and Complexity Scoring*. A scoring method called Web Accessibility Barrier (WAB) and Complexity was developed and utilized by researchers of the University of Pittsburgh: Hackett and Parmanto (2005), Hackett et al. (2005), Parmanto and Zeng (2005), and Zeng and Parmanto (2004). This scoring can assist in understanding the use of high technologies in websites that make them more complex and can affect levels of web accessibility. A web crawler program called Kelvin$^{TM}$ was developed to automatically compute these scores (Hackett & Parmanto, 2005).

*WAVE*. WAVE or WebAIM is an online automation tool to check web accessibility. This tool exposes errors and highlights content where accessibility considerations require human judgment; for example, WAVE exposes alt text so a human evaluator can determine whether it is appropriate for the image. This tool is an open source and free software and works across major browsers, Internet Explorer, Mozilla/Firefox, Netscape.

*Web Access Initiative (WAI).* WAI is an international group formed from the World Wide Web Consortium (W3C) and is comprised of website developers, researchers, and organizations to standardize guidelines to assist in developing accessible websites (W3C, 2007a).

*Web Content Accessibility Guidelines (WCAG).* WCAG address Section 508 guidelines, providing more encompassing and restrictive guidelines in terms of web accessibility. WCAG 1.0 was used in this report. WCAG 2.0 was recently completed. WCAG are accepted as an

international set of guidelines for accessibility and usability. “The Web Content Accessibility Guidelines (WCAG) explain how to make web content accessible to people with disabilities. Web ‘content’ generally refers to the information in a web page or web application, including text, images, forms, sounds, and such.” (W3C, 2007b)

*WebXACT (or Bobby).* This was a leading online automatic verification tool that could check for Section 508 and WCAG accessibility compliance (Zeng & Parmanto, 2004) and that no longer exists online. WebXACT was formerly known as Bobby, which had both a desktop and online version (Watchfire, 2008).

*Web Usability*: Web usability generally refers to the experience the user has when reading and interacting with a website, whether using assistive technology or a standard computer set up.

*XHTML*: Extensible Hypertext Markup Language. XHTML is a family of current and future document types and modules that reproduce, subset, and extend HTML 4. XHTML family document types are XML-based, and ultimately are designed to work in conjunction with XML-based user agents.

*XML*: XML stands for extensible Markup Language. XML is designed to transport and store data.

**Research Questions**

The research study will attempt to answer the following questions:

1. What percentage of university websites home pages comply with the three compliance level guidelines set forth by Section 508? Compare the accessibility checkpoints through Eval Access, ETRE, and, HERA 2.1 Beta.

2. Are there any differences among the findings of the three Auto Validation Tools within the group?
3. Are there any differences between the findings of Assistive Technology and Auto Validation Tools?

**Outline of Dissertation**

Following the introduction and overview presented in this chapter, Chapter 2 presents the literature review of the study, detailing the historical and current issues that create the environment around this research. Chapter 3 details all specific components of the methodology of research in this project. Chapter 4 explores the process and findings of the expert testing. Automated testing tools and their relation to this study are also examined and included in Chapter 4. Chapter 5 evaluates the hypothesis and identifies the key themes in data and examining Section 508 standards in light of the data. Chapter 6 concludes the dissertation with recommendations and proposed best practices for website accessibility evaluation.

# Chapter 2: Literature Review

## Introduction

This chapter is categorized into sections elaborating on the literature regarding web accessibility in university websites and practice of Section 508. The first section addresses the historical issues that have led to the current understanding of accessibility, the development of laws related to website accessibility and the legal environment regarding web accessibility. The second section analyzes the literature evaluating the guidelines of web accessibility and the use of assistive tools. The third section presents the organizational aspects of implementing Section 508 compliance. The fourth section presents literature evaluating web accessibility issues. The final section attempts to gather information on available studies on web complexity and the use of assistive devices.

### *Historical Background*

The Rehabilitation Act of 1973 was updated in 1998 and "Section 508" states that electronic information technology should be accessible to individuals with disabilities. This Rehabilitation Act has a background that includes events from the nation's discrimination history. Demonstrating bias against or simply ignoring the existence of individuals with disabilities can be traced back to the earliest recorded human history (Jaeger & Bowman, 2005). Stiker (1999) mentioned that in the course of human history, no society has committed itself to treating the physical, cognitive, the emotional disabilities as normal parts of the natural human condition. In 1914, a study of the laws revealed that 38 states out of 49 states and territories and the District of Columbia had laws prohibiting marriage for individuals with disabilities and violation would result in imprisonment (Smith, Wilkinson, & Wagoner, 1914). The first major disability rights law, Section 504 of the Rehabilitation Act of 1973 (29 U.S.C.A. § 701 et seq),

also demonstrated a complex mixture of stereotyping and sympathy, apprehension and accommodation (Rebell, 1986).

According to Rebell (1986), despite the passage of disability rights laws, fear of handicapped, ignorance of their abilities, and attempt to exclude them remain common contemporary realities. The ADA, Americans with Disabilities Act (42 U.S.C.A. § 12101 et seq) had limited success due to limited enforcement by the federal government in the equal access to new information and communication technologies (Hignite, 2000; Kruse & Hale, 2003; Kruse & Schur, 2003; Lee, 2003).

The Americans with Disabilities Act of 1990 (ADA) prohibits discrimination against persons with disabilities, stating "no qualified individual with a disability shall … be excluded from participation in or be denied the benefits of the services, programs, or activities of a public entity" (42 U.S.C.A. § 12132). In 1990 the ADA did not directly address the issues related to the World Wide Web, as "cyberspace belonged to the realm of science and fiction" (Bick, 2000).

The ADA extended the rights provided to PWD via Title V of the rehabilitation act of 1973. The rehabilitation act only covered the federal government and those entities receiving funds from the federal government. The ADA would also apply to privately owned businesses and public programs not receiving funds from the federal government (Mountain State Centers for Independent Living). It would seem to be the comprehensive civil rights bill sought for so long by Justin Dart and other ADA supporters.

In 1996, the Office of Civil Rights (OCR) examined the ADA's definition of effective communication based on a complaint filed by a student involving a university that failed to provide accessible Internet access (Paciello, M. G., 2000). According to Paciello (2000), the OCR settlement stated that:

> 'The issue is not whether the student with 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. Title II [of the Americans with Disability Act of 1990] also strongly affirms the importance role that computer technology is expected to play as an auxiliary aid by which communication is made effective for persons with disabilities.'

Title I of the ADA prohibits employers having 15 or more employees from discriminating against a qualified individual with a disability because of the disability in such aspects of employment as hiring, job training, promotion, and the discharge process (Rubin & Roessler, 2001). Title II of the ADA has two subtitles, Subtitle A and Subtitle B. According to Rubin and Roessler (2001), subtitle A extends the Section 504 of the Rehabilitation Act of 1973 prohibition of discrimination on the basis of disability in the programs and activities of state and local governments receiving federal financial assistance to all activities of state and local governments including those not receiving federal funds. Title III of the ADA prohibits discrimination on the basis of disability that would prevent PWD from having the full and equal enjoyment of the goods, services, facilities, privileges, advantages, or accommodations of private entities that are places of public accommodation, commercial facilities, as well as private entities offering examination and courses related to applications, licensing, certification or credentials for secondary or post-secondary education, professional, or trade purposes (ADA Technical Assistance Program). It also covers any fixed route or demand responsive transportation system operated by a public accommodation that is not primarily engaged in the business of transporting people (Rubin & Roessler, 2001).

Title IV of the ADA required a dual party relay service for intrastate and interstate telephone service (Rubin & Roessler, 2001). This meant that a person using a

telecommunications device for the deaf (TDD) could call an operator and request assistance in communicating with a person using a conventional telephone.

Title V of the ADA was called miscellaneous and prohibits retaliation against an individual who has opposed an act made illegal by the ADA. It also required the Architectural and Transportation Barriers Compliance Board to issue guidelines for making historic buildings accessible. The Architectural Barriers Act of 1968 (42 U.S.C.A. § 4151 et seq.) was the first federal law mandating access for individuals with disabilities. This law focused on physical accessibility in the construction of new buildings and reconstructions of buildings after 1968. The Access Board was a part of Architectural Barrier's Act and it was responsible for accessible standards for the federal government (Peterson, 1998).

Disability rights laws related to accessibility of information technology is stated as a "commitment to citizens with disabilities and their right to the same level of success to the internet and information" as all other citizens (Muir & Oppenheim, 2002b). Section 504 of the Rehabilitation Act of 1973 first established the implication of a right to accessible information and communication technologies (Kanayama, 2003). Later on Section 508 prohibited covered entities from "developing, procuring, maintaining, or using" non-compliant information technology (29 U.S.C. § 794d (a) (1) (A-B).

The IDEA (Individuals with Disabilities Education Act) guarantees a free appropriate public education to students with disabilities up to their graduation from high school (Fleischer & Zames, 2001).

The Telecommunications for the Disabled Act in 1982 (P.L. 97-410), Hearing Aid Compatibility Act in 1988 (P.L. 100-394), the telecommunications Accessibility Enhancement Act in 1988 (P.L. 100-542), and the Television Decoder Circuitry Act in 1990 (P.L. 101-431)

established that telecommunication services had to be predominantly compatible with the assistive technologies used by people with hearing impairments.

The WCAG (Web Content Accessibility Guidelines) was published in 1999 by World Wide Web Consortium. Three levels of implementation of accessibility have been defined for the web developers. The first Level, Level A, covers items on web pages that must be made accessible in order for individuals with disabilities to access the content at all. The second Level, Level AA, includes items on web pages that should be accessible to allow a wider group of users to access the content. The third Level, Level AAA, describes items on web pages that can be made accessible to allow the widest amount of individuals with disabilities to use the site (www.w3.org/TR/WCAG10/full-checklist.html).

**Web Accessibility Guidelines and Tools**

Web accessibility may have many definitions and there are several sets of guidelines by which one can determine whether a website is or is not accessible. Since the enactment of Section 508, a general consensus has been made that these and WCAG Priority One guidelines meet the minimum level of accessibility as dictated by current assistive technologies available to those with disabilities (Cardinali and Gordon, 2002). The W3C has changed the course of these minimum guidelines to create a higher level of accessibility, usability and quality in web development (Caldwell, 2006). The W3C is a group that has been universally peer-accepted in which many government agencies are directed for ensuring web accessibility (W3C, 2007a-c). W3C briefly defines accessibility as a website's ability to be navigated by a user with a disability (W3C, 2007a). According to Hudson (2002), many webmasters follow specific Section 508 guidelines and/or utilize the W3C's WCAG, and it tries to help enforce the minimum guidelines.

Table 2.1

*Section 508 Guidelines - WCAG Guidelines*

| Keywords | WCAG 1 | Section 508 |
|---|---|---|
| Text Equivalent | 1.1 Provide a text equivalent for every non-text element. This includes: images, graphical representations of text, image map regions, animations, applets and programmatic objects, ascii art, frames, scripts, images used as list bullets, spacers, graphical buttons, sounds, stand-alone audio files, audio tracks of video, and video. | 1194.22 (a) A text equivalent for every non-text element shall be provided (e.g., via "alt", "longdesc", or in element content). |
| Time-based Media | 1.4 For any time-based multi-media presentation (e.g., a movie or animation), synchronize equivalent alternatives (e.g., captions or auditory descriptions of the visual track) with the presentation. | 1194.22 (b) Equivalent alternatives for any multi-media presentation shall be synchronized with the presentation. |
| Captions | Generally covered in 1.4 but not specifically mentioned | Generally covered in 1194.22 (b). but not specifically mentioned |
| Audio or Video Only | Generally covered in 1.4 but not specifically mentioned | Generally covered in 1194.22 (b). but not specifically mentioned |
| Auditory description | 1.3 Until user agents can automatically read aloud the text equivalent of a visual track, provide an auditory description of the important information of the visual track of a multimedia presentation. | Generally covered in 1194.22 (b). but not specifically mentioned |

The Section 508 in conjunction with WCAG works well to assist in the further development and evaluation of web accessibility (Hudson, 2002; Kaplan-Leiserson, 2001). As shown in Table 4.2, Hudson (2002), Thatcher (2002), U.S. Access Board (2008) and W3c (2007b) listed both guidelines together to show similarities.

Although these automatic checkers are helpful in educating the webmaster, according to King et al. (2005), they are not sufficient in and of themselves to determine Section 508 or WCAG compliance since manual checks are still warranted. For example, automated checkers cannot check all points for accessibility, such as scripts or web page content that is generated by a script. Bobby can leave 30% of websites unevaluated because of the tool's limitations and the need for manual checks (Stewart et al., 2005). Other automatic verification tools also have limitations when manual evaluation is needed (Brajnik, 2000; Smith, 2007).

To determine which automated checker is more trustworthy, Diaper and Worman (2003) conducted a comparison between the leading tools at the time, Bobby and A-Prompt™. They suggested using A-Prompt™ for checking Priority one problem (in essence, Section 508 guidelines) as it outperformed Bobby on all Priority one evaluations (Diaper & Worman, 2003). Additionally, since 2003, the University of Toronto had improved upon A-Prompt™ with AChecker™, which is now also available for free to webmasters (Adaptive Technology Resource Centre, 2008). Nevertheless, these tools greatly highlight educational opportunities for training webmasters/developers, because most of them will usually indicate the Priority one issues as well as specify what and where manual checks should be made (Loiacono & McCoy, 2004; Zeng & Parmanto, 2004).

Hudson (2002) stated that Section 508 is useful in that this law tries to help enforce minimum guidelines for the higher education webmasters. In addition, usability and accessibility

are now important tenets for website designers, especially for educational institutions (Peterson, 2006). According to Sloan (2006), by correcting the accessibility issues for users with disabilities, a web developer can also improve the usability for all groups. A recent study of webmasters for government and commercial organizations found that many would only make websites accessible if the government forced them to (Lazar, Dudly-Sponangle, & Greenidge, 2004).

Though some of this neglect is the result of a lack of understanding of the needs of individuals with disabilities in the design process, policies have often been formulated with intent to exclude people with disabilities (Goggin & Newell, 2000, 2003; Keates & Clarkson, 2003). According to Goggin and Newell (2000), an understanding of disability is still not regarded as something that should be considered from the outset and made integral to the shaping of existing and new technologies.

**Assistive Technology Solutions**

The overall goal of assistive technology is to provide equivalent, sight-enhancement or sight-substitution rehabilitation mechanisms for computer and web access that are appropriate for the level of disability. For example, a person with visual disability would require non-visual alternatives for traditionally visual tasks such as reading text, selecting from menus, responding to system prompts, analyzing tables, and navigating between different parts of websites. In general, this is accomplished by translating the visual screen display into auditory output (e.g. a screen reading software with speech synthesizers), tactile output (e.g. a Braille display that echoes the screen display), or a combination of the two modalities.

For users with mild visual disability, screen magnification may be appropriate. According to Edyburn (2006), there are some challenges for assistive technology devices, for

example, translation of complex mathematical and scientific notation into computer-readable formats; interpretation and display of images and digital videos; efficient navigation and interpretation of web-based tables; and entry of data using web-based text boxes and forms. Successful solutions to these problems will require that website content and layout are organized to promote accessibility.

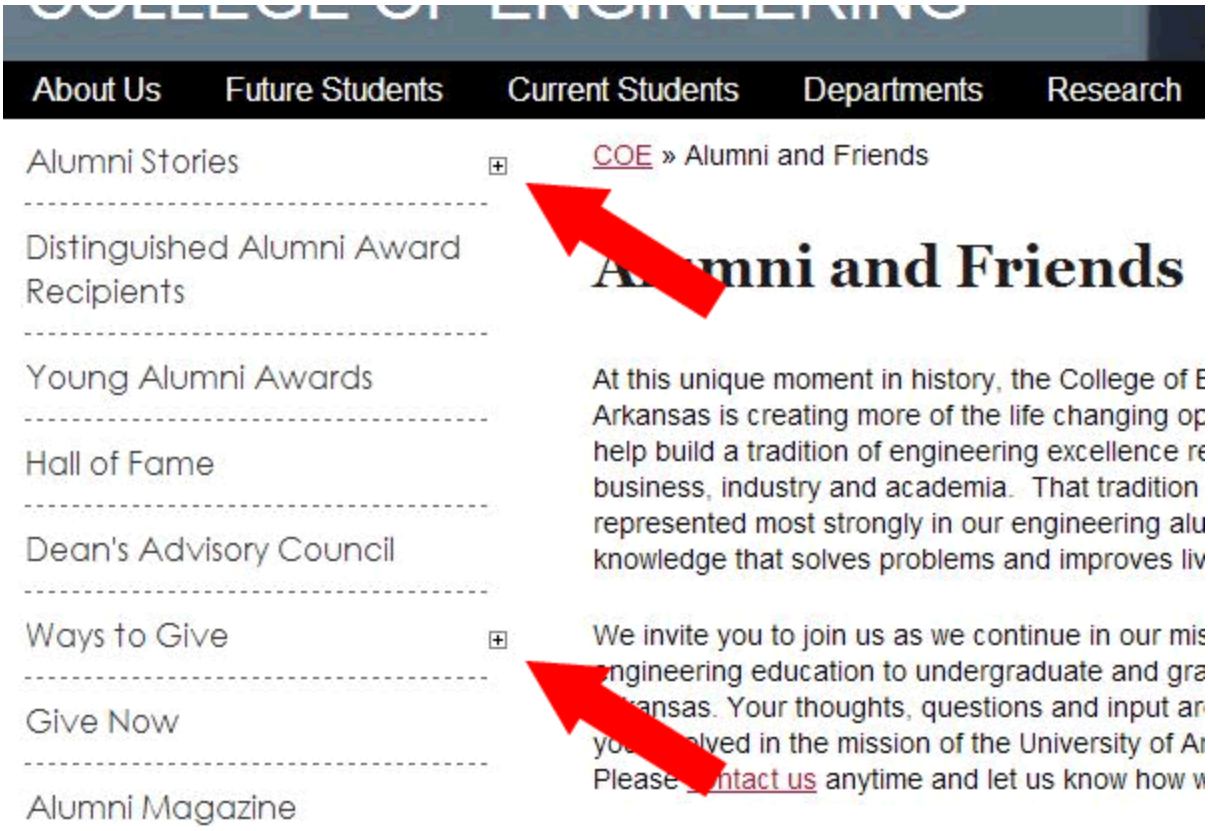
Another example of an assistive tool is the "screen magnifier" software application which runs as background tasks, with the typical screen magnifiers providing the capability to enlarge both text and graphics over a wide range of levels. Most of these products use image-smoothing algorithms to produce clear graphics and text even at large magnifications, and some products include special functionalities such as the ability to automatically scan and review an entire screen.

Another example is the use of Braille displays, which are typically connected to a keyboard and produce refreshable, line-by-line displays of text output (W3C). These devices consist of several arrays of movable pins that are connected to solenoids or piezoelectric outputs. These movable pins are raised or lowered to generate Braille characters depending on the specific electrical signal received from the source computer system. Computer data input may be performed using standard keyboards, although special Braille keyboards are also available to complement Braille displays. In general, Braille output displays have been useful for allowing patients with severe visual disability to perform accurate proofreading and review of computer screen layouts. According to recent statistics from the American Foundation for the Blind, there were 55,200 legally blind children in the United States in 1998-1999, of whom only 5,500 used Braille as their primary reading medium. However, since Braille output displays are purely text-based, they may not be helpful when used alone for web-based and other graphical interfaces.

The most widely used assistive tools for browsing the Internet are Screen Readers; the purpose of screen reading programs is to translate text and graphical displays into auditory output. This is performed using software synthesizer programs to drive sound cards that are built into most computer systems, or by using external hardware speech synthesizers. As in the case of screen magnifiers, screen readers are background software applications that operate transparently to word processors, spreadsheets, web browsers, and other commercial software packages.

Screen readers have become a popular technology among people with severe or complete visual loss, who may navigate the screen using keystrokes while the assistive software announces the word or line at the cursor location (Votta & Lloyd, 2001). Most commercially-available screen readers will automatically announce menu bars and pop-up windows, and will use standard protocols and voices to identify icons, radio buttons, text boxes, and other common graphical user interface widgets. When used with web browsers, screen readers will generally announce text and graphic content, and will note the presence of hyperlinks. In addition, they include specific features to orient web users by reading information about navigation bar contents, table column and row headings, and other page layout and navigation details.

A number of popular screen reading programs are published by Freedom Scientific (JAWS®; St.Petersburg, Florida), ALVA Access Group (outSPOKEN®; Oakland, California), and Dolphin Computer Access (Hal®; San Mateo, California). Although most screen readers work well with web browsers, several software packages that have been exclusively designed to provide speech access for web navigation and electronic mail purposes (e.g, IBM Home Page Reader®; White Plains, New York) are also available. A simple screen reading program, known as Narrator®, is available with the Microsoft XP operating system (Microsoft Corporation; Redmond, Washington).




(Internet Archive, 2013).

*Figure 2.1*. Common computer interface "widgets" contain graphical cues that are easily recognizable by sighted users, but which may cause significant accessibility problems for sight-impaired patients. This is because information is conveyed not only by reading textual labels, but also by visualizing their relationship with adjacent graphical features. Tabbed folders (1) are used to graphically organize and display information output. Checkboxes (2), slider bars (3), and buttons (4) are used for data entry. Menu bars (5) are used for data organization, input, and output. Icons (6) are a symbolic representation of information for data input and output, and rely on users' ability to identify images. Navigation bars (7) and hypertext (8) are used to organize data display on web pages. In each case, users must be able to recognize text and images, interpret the proper mechanism for human-computer interaction, and use a data input tool such as mouse or keyboard.

**Research on Web Accessibility**

Since the emergence of both Section 508 and WCAG, automatic web accessibility verification tools were created to help webmasters (Center for Applied Special Technology, [CAST], 2007; UsableNET, 2007; W3C, 2007c). According to Diaper and Woman (2003), the most popular automatic verification tool used in research has been Bobby, even though other updated tools may be more effective to diagnose priority one problems. In 1998, the National Center for the Dissemination of Disability Research reported that 43% of its grantees (n=92) had home pages that would receive Bobby approval. Flowers, Bray and Algozzine (1999) reported that 27% (n=24) of 89 departments of special education had home pages that would receive Bobby approval. Rowland (1999) used Bobby (version 3.0) data acquired from a random sample of 4000 prominent colleges, universities, and online learning institutions. The result indicated that less than one in four postsecondary institutions (n=90; 22%) had home pages that would receive Bobby approval. A study conducted in 1999 showed that only one fourth of the higher education institution websites were accessible (Waldon, Rowland, and Bohman, 2000). This study acquired data from 518 randomly selected distant education institutions from all 50 states and the District of Columbia during November 1999, only 24% (n=124) of home pages would receive Bobby approval. A study on 392 AACSB-accredited universities reported that only 31.6% (n=124) had home pages that would receive Bobby approval (Guitierrez and Long, 2001).

A number of studies have discussed the usefulness of different types of automated software. According to Brajnik (2000), although automated software or tools for determining usability and accessibility do exist, all of them have limitations in their evaluations. In 2004, four years after Brajnik's observation, , Abascal reported that even though these tools had evolved

and improved, they were still unable to fully identify problems that conflict with accessibility utilizing either Section 508 or WCAG guidelines.

Studies were performed on the websites of colleges and universities accredited by NCATE by Chilson (2002) and McCullough Stein (2002); both studies utilized the automatic verification tool Bobby and their results showcased poor web accessibility compliance. Chilson's results showed that only 12% (N = 25) of the NCATE institutions' home page studied in the Mountain region passed the automatic verification analysis. McCullough Stein's results showed only 6% (N = 32) of the NCATE institutions' home pages studied in the Pacific region passed the automatic verification analysis.

In contrast, a number of studies indicated improved web accessibility. One study by Byerly and Chambers (2003) showed positive results in overall increased accessibility. They also recommended that more work had yet to be accomplished in this area (Byerley & Chambers, 2003). Stewart, Narenda, and Schmetzke's (2005) study also showed positive results when they used both the automatic verification tools and users with disabilities with their assistive technologies. Their tested out accessibility of library website interfaces based on both Section 508 and WCAG. According to Caldwell (2006), study in higher educational e-libraries and e-learning resources are not yet accessible. The study conducted by Stewart et al. indicated that many library documents retrieved via searches were Acrobat pdf image documents which were not accessible, and those text-based pdf and HTML documents were not necessarily accessible; however, ASCII and Rich Text Format (RTF) documents retrieved were found to be accessible.

Some of the research on web accessibility noncompliance has included longitudinal studies, identifying the levels of accessibility over a period of time for a specific population. For example, David Comeaux and Alex Schmetzke (2006) studied the university libraries' websites

and their standards in meeting accessibility guidelines over a period of four years. They looked at 56 American Library Association (ALA)-accredited LIS school web pages and the pages of those schools' libraries, following up on Schmetzke's (2002) investigation of the same sites. Their 2006 findings indicate that from 2002 to 2006, percentages of web pages that were accessible went up, and the number of errors per page went down. The average number of hurdles faced by users with disabilities in 2006 was half what it had been four years earlier. Despite these improvements, however, only 47 percent of LIS schools and 60 percent of their libraries were fully accessible in terms of W3C web accessibility guidelines. But in terms of Section 508 guidelines, this percentage was lower, because many sites do not provide the requisite "skip-navigation" links. Such links allow people who use screen readers or navigate by keyboard only to navigate web pages more successfully. Without them, the screen reader will go to the top of the page each time a new page loads into the browser, requiring all of the previous content to be read again. This makes it difficult and time-consuming to navigate multilevel sites and get to the main content. In addition, sighted users who do not use a mouse may be required to use dozens of keystrokes to tab through every link in sequence. These links are a level two priority for W3C web accessibility guidelines, which means that providing these links "should" be accomplished, rather than "must be" accomplished. Section 508, on the other hand, promotes "skip navigation" as an important priority.

According to Hackett and Parmanto (2003 and 2005), Section 508 compliance has not been significantly improved and has actually become worse. Bray, Flowers and Algozzine (2007) analyzed 165 middle school websites and their results indicated that most had severe web accessibility issues. Diaper and Worman (2003) analyzed 32 United Kingdom university websites and most of them failed to meet the Priority one level of web accessibility checkers.

A study conducted by Hackett and Parmanto (2005) on higher educational websites showed that the majority of sites were not compliant and that their compliance decreased over time. Their study discussed the issue of increased complexity of modern websites which results in lower noncompliance even with law and more tools. Parmanto and Zeng (2005) used the web crawler tool, Kelvin$^{TM}$, to calculate the Complexity Scoring methodology. Their study found a relationship between the levels of accessibility of website with the levels of complexity designed into that website. According to Parmanto and Zeng (2005), as the web developers used more complex web technologies, the WAB score also increased, that is, the website became less accessible (WAB scores of 5.5 or lower were considered accessible). Their study indicated that the WAB score of educational websites went from an accessibility score in 1997 of 64.4 percent down to only 15.6 percent in 2002 (Hackett et al., 2002).

A study conducted by Badge and Dawson (2008) compared different tools that are used by the teaching practitioners to create web-based educational materials from PowerPoint presentations, adding a variety of different digital media, such as audio and animation. The study described different systems for producing multimedia presentations from existing PowerPoint files. The resulting resources were tested by a group of disabled students and a group of non-disabled students. The result indicated that there were statistically significant differences between the two groups in relation to their interaction with the resources. In particular, the students with disabilities were significantly more active in using the available controls to customize the running of the presentations. The data suggest that future work on why students with accessibility issues made different uses of these resources could encourage practitioners' deployment of multimedia resources for the benefit of all learners.

In a study of blind users, web accessibility conducted by Zend (2004), the use of WTG (Web Transcoder Gateway) showed significant improvement in accessible websites for persons with visual disabilities. The study employed WCAG checkpoints to a web transcoder gateway server that was designed to remove barriers and transform original pages into accessible pages. The study compared users' task performance by using the original site versus their task using the transformed site via the WTG server. The study found that users accessing the transformed site found information more efficiently and with fewer errors than those accessing the original pages.

In Europe, the European Union is increasingly focusing on issues regarding access to information for all (Mancini, 2005). In a recent study conducted in Italy, 170 websites were analyzed as to their compliance with the World Wide Web Consortium (W3C) Level A guidelines. 76% of the analyzed websites fail to satisfy the most basic (W3C) requirements (Mancini, 2005).

**Research on Web Complexity and the Use of Assistive Devices**

Website complexity and the use of multimedia technology leads to reduced accessibility; since they generally require users to rely on more than one sense, those with disabilities face barriers to understanding the content (civil rights division). A number of studies were conducted that addressed the issue of increased web complexity, such as video streaming and heavy reliance on graphics, tables, scripting, and so forth, which can negatively impact web accessibility. The reason that complexity has been increasing is due to the importance placed on visual attractiveness and interactivity produced through new designs/layouts, coding, programs, and technologies (Flowers et al., 2000).

According to Hackett and Parmanto (2005), website complexity in the past decade grew rapidly with web authoring tools and the latest technologies (e.g., imagery and video through the

use of Java applets, plug-ins, and scripting languages). These new technologies have been integrated into websites largely due to the goals of improved aesthetics, visual representations, and entertainment (Hackett & Parmanto, 2005; Hudson, 2002). A study discussed the necessity of new technology, since a vast amount of documents were converted to specific formats for the web, for example, e-libraries containing inaccessible PDF documents (Stewart et al., 2005).

According to Stewart, Narenda, and Schmetzke, the ASCII and RTF documents were accessible but they could not provide the necessary graphical formats for pictures, figures, and certain tables, that certain PDF files can produce. Stewart et al. (2005) reported that 85% did not have skip navigation links in the HTML to avoid complex or repetitive features for better website navigation for those using assistive devices. A skip navigation link at the beginning of the page can bypass all of the introductory and navigation items and go directly to the content.

A number of studies discussed the missing HTML code in many complex web pages, for example <alt> tags. According to Bray, Pugalee, Flowers and Algozzine (2007), not utilizing <alt> tags to explain graphical and video representations to the user with disabilities was the number one reason for website noncompliance. The research by Stewart et al. (2005) found that a third of the web pages had meaningless <alt> tags, and Axtell and Dixon (2002) found that the lack of <alt> tags were a leading problem in their study. Apart from <alt> tags, tables' tags are other accessibility problems in HTML. Many webmasters have utilized tables to create visually-appealing websites (Axtell and Dixon, 2002).

Nevertheless, for those with visual impairments who utilize screen readers, these aesthetically appealing sites may be unreadable. Webmasters can utilize specific strategies for web accessibility outlined in the guidelines with appropriate coding and design and manual checks for web pages with tables (Axtell & Dixon, 2002). Research conducted by Amtmann,

Johnson and Cook (2000) studied issues with table coding and accessibility problems. They evaluated how the <td> table tag should be utilized for data while its counterpart <th> should be utilized strictly for column headers or for design purposes. They also recommended not utilizing tables for layout at all unless it is understandable when reading the page from left to right. Additionally, they recommended that even though tables for layout may be problematic, they should always be used instead of the <pre> tag, which designates preformatted text and causes great problems with screen readers (Amtmann et al., 2000).

The research studies from the University of Pittsburgh as previously highlighted (Hackett & Parmanto, 2005; Hackett et al., 2005; Parmanto & Zeng, 2005; Zeng & Parmanto, 2004) focused specifically on how complexity affects web accessibility. The WAB and Complexity Scoring originated from these studies. These scores have been the means to analyze and evaluate the growing complexity of websites over time and how this complexity affects accessibility. Commercial websites tended to be more complex and less accessible, but, the rate of complexity and associated inaccessibility appeared to be growing for governmental, as well as educational websites (Hackett & Parmanto, 2005). Their recommendations were to avoid high technologies, but if those technologies were used, have an alternative text in place as well as programmed <alt> tags explaining the technologies used and their purpose for the site (Hackett & Parmanto, 2005). The recommendations of <alt> tags have been agreed upon by several researchers in the field (Strobel, Fossa, Arthanat, & Brace, 2006; Veal et al., 2005). The recommendation of an alternative, text-based site has been presented in a few studies, but some investigators do not advocate the choice of an alternative site for those with disabilities as it still creates a barrier to their participation in society (Bray et al., 2007).

It should be noted that HTML was originally created to ensure usability for all web navigators, which can be done with correct programming (Axtell & Dixon, 2002). Webmasters can also be assisted by automatic verification tools, as they are helpful in addressing many HTML code problems guided by Section 508 and WCAG (Hudson, 2002; Kaplan-Leiserson, 2001). According to Byerley and Chambers (2003), with a proper understanding of web accessibility, a webmaster has a much higher probability of producing an accessible website. According to the survey conducted by Lazar et al. (2004) of a sample of both publicly and privately employed webmasters, 64% stated that they had used proper HTML codes to make their site accessible.

Even though performing online verification accessibility testing was strongly recommended, this is not the sole answer to ensuring web accessibility, since manual checks are still warranted (Flowers et al., 2000; Kaplan-Leiserson, 2001). A number of studies recommended that webmasters should work with users with disabilities to gain a better understanding of how these end users needed to utilize web technologies (Byerley & Chambers, 2003; Hackett & Parmanto, 2005; Sloan, 2006). According to Hudson (2002), to address the various types of users with disabilities, an understanding of those users with visual impairment (ranging from low vision to blindness) and hearing, mobility, and cognitive impairments, as well as those suffering from seizure disorders is important. A number of studies used other alternatives in the absence of a user with disabilities. Fait, Juang, and Mankoff (2005) utilized simulations of users with disabilities for testing websites. The use of heuristic testing can also be conducted by which web accessibility experts test the website for compliance (Brajnik, 2000).

A number of studies have discussed alternative ways to test websites. Flowers et al (2000) suggested that webmasters can view web pages on a monochrome or high contrast screen,

turn off graphics; use the keyboard with no mouse; and print out the pages in text only and read to ensure simplistic and understandable language. According to Sloan (2004), a web developer could also be helped by utilizing a text browser, such as Lynx, that analyzes image, navigation, and frames issues as well as other accessibility problems. Sloan (2004) also suggested that a webmaster can have a person read the web page aloud without viewing to identify whether it is understandable; and turn off specific browser options while browsing (e.g., no frames) to ensure the website is navigable without this option.

According to Kaplan-Leiserson (2001), webmasters could use assistive devices for their accessibility training and analyzing levels of Section 508 compliance. Examples of these technologies include screen readers, such as JAWS™, Window-Eyes™, and IBM Home Page Reader™. These could be employed by a webmaster for Web page development and ongoing management (Byerley & Chambers, 2003). According to Axtell & Dixon (2002), trained webmaster could use refreshable Braille in conjunction with a screen reader, in which pins are elevated and leveled to produce Braille sequences. Testing whether these tools work with the website could help ensure website compliance per specific disability.

In a study of web accessibility, Kaplan-Leiserson (2001) suggested that webmasters could use the different assistive technologies for their accessibility training and analyzing levels of Section 508 compliance. For example, assistive technologies such as JAWS™, Window-Eyes, and IBM Home Page Reader could be employed by a webmaster for web page development and ongoing management (Byerley & Chambers, 2003). Axtell & Dixon (2002) suggested that, in conjunction with a screen reader, a webmaster could use a refreshable Braille, in which pins are elevated and leveled to produce Braille sequences.

According to Bevan and Ahmed (2007), it is improbable that designers can attain designs which adhere to all users issues and they should maximize web accessibility for the widest number of users as possible. In addition, websites should be designed according to standards, such as WCAG, as the number one need. The second and third highest needs were to design to meet the users with visual disabilities (e.g., blindness) and poor vision respectively as these audiences make up a considerable portion of the population in need of web accessibility. The next priorities were those with restricted mobility (number 4), those who are color blind (number 5), those with auditory disabilities (number 6), and those with epilepsy (number 7) (Bevan & Ahmed, 2007).

A number of studies emphasized on each individual user's needs rather than universal design. Kelly et al. (2004) stressed the need of webmaster use of accessible learning practices that could ensure web accessibility. Some studies have recommended that institutions should set a higher priority to adhering to accessibility guidelines, instead of depending on automatic verification tools (Law, Yi, Choi, and Jacko, 2006). Parmanto and Zeng (2005) conducted a study on a large number of websites that were considered to be accessible and that had been self-rated as 'A', 'AA', or 'AAA'. They found that even among websites that were self-declared as meeting 'AAA' conformance, only 8.81% were truly 'AAA'.

According to Wade and Parent (2002), there is a direct involvement of webmasters and end users which is very important for a successful web presence. Their study may not specifically address web accessibility, but it did relate to how webmaster's knowledge, education, training and experience is a requirement for a successful website. Both their and Lazar el al.'s (2004) research results on webmaster accessibility training showed an impact on web success, and for this, web success included web accessibility.

Jaeger (2006) applied the technology acceptance model (TAM) (Davis, 1989) to web accessibility study. The Technology Acceptance Model (TAM) is an information systems theory that models how users come to accept and use a technology. The model suggests that when users are presented with a new technology, a number of factors influence their decision about how and when they will use it; for example, the degree to which a person believes that using a particular system would enhance his or her job performance and the degree to which a person believes that using a particular system would be free from effort (Davis, 1989). Three accessibility models were used by Leung et al., (1999), Lazar et al. (2004), and Seale (2006a). These are a) *web accessibility integration model* (Lazar, Dudley-Sponaugle & Greenidge, 2004), b) *composite practice model* (Leung et al. 1999) and the *holistic model* (Kelly et al. 2005). Their studies identified that Sections 504 and 508 need to meet the demands of the end user (as does TAM), organizational policies, and key stakeholders as important variables. Leung et al. (1999) focused on the assistive technologies and problems with web accessibility; Lazar et al. (2004) analyzed the webmasters and their role in web accessibility; Kelly et al. (2004) developed a new research focus on meeting the needs of each specific user rather than prescribing universal design; and Seale (2006a) incorporated all these components as well as the perceptions held by various stakeholders regarding disability.

Many studies in the above literature review concluded that utilizing automated accessibility verification tools alone was not adequate to ensure Section 508 compliance or the minimum priority one levels of the WCAG (Brajnik, 2000; Byerley & Chambers, 2003; Hackett & Parmanto 2005). Stewart et al. (2005) provided additional measures, such as recommended manual checks, use of assistive devices by the researcher or webmaster, and/or the employment of users with disabilities to test web pages.

# Chapter 3: Methodology

## Introduction

This chapter discusses the methodology that is used in this study. The first section outlines the research design and rationale for choosing this design; the second section illustrates sample selection procedure; the third section discusses instrumentation of this study; the forth section illustrates the data collection procedure; and, the fifth section elucidates the data analysis procedure of this study.

This study comprises the analyses of 54 university websites for their compliance with the key law pertaining to disability access, known as Section 508 of the Americans with Disabilities Act of 1990. The review of literature has produced reoccurring themes emphasizing the importance of web accessibility compliance. As mentioned earlier, the majority of governmental and public educational websites are still not compliant with Section 508 standards even though the legal mandate was enacted in 1998. Some websites have become even less accessible for increased website complexity (Flowers et al., 2000; Parmanto & Zeng, 2005). Additionally a few studies suggested that testing the level of web accessibility cannot rely solely on automatic accessibility verification tools such as Bobby and other widely used tools (Brajnik, 2000; Byerley & Chambers, 2003; Hackett & Parmanto, 2005; Kelly et al., 2004).

The study is aimed at analyzing a selected number of online auto validation tools to evaluate the accessibility of various websites as well as comparing the findings of each tool to assess if there are any significant differences between their findings. The next phase of the study is to analyze the accessibility checkpoints of assistive technology (such as screen readers) and compare its findings with that of the three auto validation tools. This may further our research in

understanding the effectiveness of auto validation tools in addition to accessibility guidelines ensuring complete accessibility in the higher education websites. The specifics of the methodology are explained in detail in this chapter.

**Research Design**

A quantitative research methodology would be utilized in this study using three accessibility checking software (auto validation tool), one assistive tool (NVDA), and a Section 508 questionnaire instrument to assist in determining levels of web accessibility and to understand why or why not compliance is met. The study is going to be descriptive since simple mean and standard deviation will be used to describe data. Ratio data will be collected to perform ANNOVA and T-tests to determine if there are any significant differences between the findings of auto validation tools. The study is also correlational since during the final stage of the study nominal data will be collected using Section 508 questionnaire and an assistive tool (NVDA) to determine if there are any differences between the findings of auto validation tools and that of NVDA.

The research study will begin soon after it passes the requirements of the Institutional Review Board since it is mandatory to employ ethics in research training and an internal review of the proposed research. An Institutional Review Board (IRB) application had been submitted and the proposed research will begin with the approval prior to conducting this study. Throughout the research, all data and analyses will preserve and ensure anonymity. The data will be collected and coded for SPSS analyses and the de-identified data and research information will be held for seven years in a secure location and thereafter will be destroyed.

**Sample Selection**

According to Measuring University Performance (MUP), most national research universities measure themselves on a wide range of dimensions that the institutions believe to be important for determining improvement and success. One such dimension is the use of benchmark institutions which "provides the ability for universities to compare their performance against a chosen group of other universities" (The Center for Measuring University Performance, http://mup.asu.edu/). To improve the quality and productivity of a major national research university, its benchmark institutes help its faculty, students, staff, and supporters to follow a number of indicators that, taken together, give a reasonable approximation of accomplishment and strength relative to the best universities in the country (Measuring University Performance, http://mup.asu.edu/research.html). The University of Arkansas lists 54 research universities as its benchmark institutes, the list of which is attached as Appendix A. The 54 institutes are highlighted in the University of Arkansas' the office of institutional research website (http://oir.uark.edu/home/benchmark_top50.html) as well as on the MUP Center's annual report *The Top American Research Universities*. For the purpose of choosing samples of highly rated higher education websites, the researcher analyzed the home pages of the top 54 benchmark institutes of the University of Arkansas for their observance to Section 508 guidelines. These sample institutions are as heterogeneous as possible; that is, the subjects within this cluster are diverse and each sample is somewhat representative of the population as a whole.

**Instrumentation**

For this study, two evaluation methods will be used to collect data to provide two different perspectives: automated testing and user testing. The automated testing will consist of three auto evaluation tools: Eval Access, ETRE, and HERA 2.1 Beta. These tools will be used

to scan the home pages of each of the 54 benchmark universities to find accessibility errors. The automated tools will check the source code according to Web Content Accessibility Guidelines and will return a quantified report of three levels of accessibility errors, the type of those errors, and the level of conformance (W3C, 1999). The tools do this by auditing each home page against the Web Standards Commission's (W3C) Web Content Accessibility Guidelines (WCAG), which as a part of the Web Accessibility Initiative form the basis of all global legislation. The tools will also test all home pages across all mainstream browsers and platforms: Internet Explorer, Netscape Navigator, AOL, Opera, Safari and Mozilla on both Mac and PC. Finally, they will prioritize all errors and generate accessibility error reports that will show exactly what needs to be done to achieve basic, intermediate and advanced levels of accessibility. To provide a broader understanding of the three auto validation tools, brief descriptions of each of the tools are detailed below.

*EvalAccess*. An online web accessibility evaluation tool developed in 2006 by Laboratory of Human Computer Interaction for Special Needs (w3.org). This tool can be easily integrated into other applications such as authoring tools. This tool can evaluate a website for its accessibility in a variety of ways and evaluate a single web page or an entire web site. It returns a complete report of errors as a result of the evaluation.

*HERA 2.1 Beta.* An online web accessibility evaluation tool developed in 2005 by Fundación Sidar (w3.org). It performs automated WCAG 1.0 testing, and then guides the user through tests that need to be done or confirmed manually. Hera is multilingual and offers a translation interface to add new languages. The Hera system is written in PHP and is an open source software.

*ETRE*. An online web accessibility evaluation system, developed in 2005 by an UK based software institution that helps web sites to comply with accessibility laws and guidelines without sacrificing beauty, performance and sophistication**.** This system audits websites against Section 508 guidelines; generates a list of accessibility errors that need to be updated; as well as generates guidelines of understanding the objectives, common user tasks, and technical constraints (http://www.etre.com/accessibility/webstandardsdesign/).

The above three auto validation tools were short listed from a pool of auto evaluation tools published on W3.org website as commonly used software to check web accessibility. The basic characteristics of the three software that separated them from the other accessibility checkers are:

a. Open source product,

b. Free of cost,

c. Ability to identify errors based on the priority levels of Section 508,

d. Ability to provide errors by priority types and

e. Ability to categorize errors based on WCAG levels of A, AA, AAA which are similar to Priority 1, Priority 2 and Priority 3 levels of Section 508 requirements.

The researcher also took a closer look at the Software Reliability Engineering (SRE) of the above three tools. According to Lyu (1996), SRE is defined as the probability of failure-free software operation for a specified period of time in a specified environment. Auto evaluation tools Eval Access, HERA 2.1 beta, and ETRE have been enlisted as three of the top evaluation tools since its development and publication in 2006 (w3.org). The three auto validation tools

were chosen due to their popular use over the last seven years, which presumes that they were failure free for that specified period of time.

The second evaluation method utilized in this study is user testing. The method will be used to complete an accessibility test with the help of a screen reader and a checklist, such as the Section 508 checklist. The widely used screen reader Nonvisual Desktop Access (NVDA) was chosen to be used to analyze a number of home pages for web accessibility to ensure that the test result of the automation tools are compatible with the test result of the assistive tool. To conduct the accessibility test with the help of NVDA, the study will utilize a questionnaire based on the accessibility checkpoint of Section 508, available at access.va.gov website and also attached in Appendix B.

It is important to mention the reason for which the software NVDA was chosen for screen reading. NVDA is a free and open source screen reader for the Microsoft Windows operating system. The software provides feedback via synthetic speech and Braille, thereby enabling blind or vision impaired people to access computers running Windows for no more cost than a sighted person (http://www.rnib.org.uk ). In addition, NVDA software is capable of the following:

a. NVDA runs entirely from a USB drive with no installation;
b. NVDA provides a utility called "display synthesizer" that allows the user to see all spoken text in a separate window on the screen instead of hearing it through synthetic speech; and
c. The utility “Speech Viewer” lets the user simultaneously listen to speech and see the text on the screen.

According to Leung et al. (1999), assistive technology can assist webmasters in ensuring web compliance to Section 508. The assistive technologies were central to both Leung et al.'s work and literature, particularly since many of the studies utilized screen readers. This study used NVDA due to its popularity in screen reader technology for web navigators with visual impairments and was utilized in the literature by webmasters and users with disabilities. The researcher herself chose to use this software since research studies have recommended the use of assistive programs and means by the webmasters themselves to uncover web accessibility issues if the user with the disability is not available for testing the website (Axtell & Dixon, 2002; Byerley & Chambers, 2003; Flowers et al., 2000; Kaplan-Leiserson, 2001).

In this study, I will analyze the home pages of the 54 higher education institutions according to Section 508 Guidelines. The literature clearly shows a need to include users with disabilities to help ensure compliance (Hackett & Parmanto, 2005; Kelly et al., 2004; Phipps & Kelly, 2006). However, a number of research has recommended webmasters to use assistive devices for testing accessibility (Axtell & Dixon, 2002; Byerley & Chambers, 2003; Flowers et al., 2000; Kaplan-Leiserson, 2001). Since screen readers are widely used assistive devices, and the screen reader methodology was based on convenience and practicality purposes (Cooper & Schindler, 2003), this study chooses NVDA, a screen reader, to test accessibility by answering pre-tested questions available at access.va.gov website. According to Cooper (2003), the screen reader method is a heuristic means of testing: "Heuristic evaluation is a usability engineering method in which a small set of expert evaluators examine a user interface for design problems by judging its compliance with a set of recognized usability principles or heuristics" (as cited in Manzari & Trinidad-Christenson, 2006, p. 164).

The three automatic verification tools, Eval Access, ETRE, and HERA 2.1 Beta are functional accessibility evaluators used to analyze web resources for markup that is consistent with the use of HTML, best practices for development of functionally accessible web resources, and resources that support interoperability (W3C). And finally, because of the literature recommendations for further web accessibility testing, the screen reader NVDA will be used to further evaluate web accessibility. In order to determine if there is a connection between the findings of the two methods of evaluation, SPSS and Microsoft Excel will be used to measure data. SPSS will be used to analyze the findings of auto validation tools to see if all three tools projected similar accessibility errors. ANNOVA and t-test will be conducted to see if there is any significant difference in the accessibility errors found by the three automated tools. The ultimate goal of these two phases of study is to learn whether university websites are accessible for people with disabilities, and whether the process of validating web accessibility errors is reliable in predicting full access to those individuals.

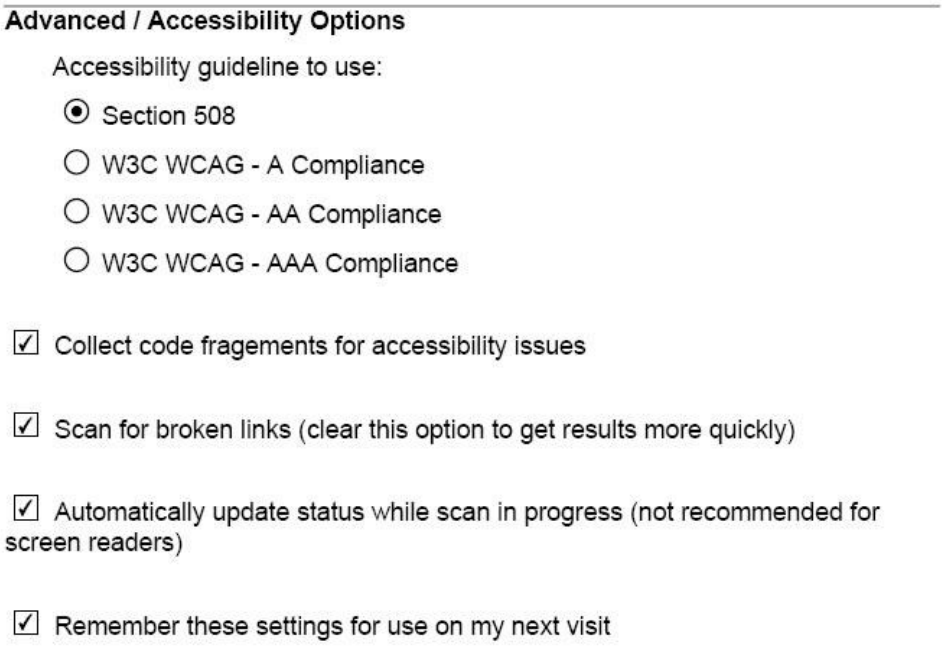
**Data Collection Procedures**

This research will incorporate primary sources to address the web accessibility problem through secondary instruments: Eval Access, ETRE, HERA 2.1 Beta, and NVDA. The first phase of the study will use three auto validation tools to scan 54 university websites. The second phase of the study will utilize NVDA to collect accessibility errors.

During the first phase of the study, each 54 university websites will be tested using online html validators – Eval Access, ETRE, and Hera 2.1 beta. In this phase of the study each sample, i.e., each home page of the 54 benchmark university websites is going to be tested three times by the above three auto validation tools. The WCAG report consists of three priority sections. The W3G WCAG –"A" Compliance are the Priority 1 compliance. Usually ensuring Priority 1

compliance is a ‘must” since Priority 1 errors extremely limit the usability of the webpage by individuals with disabilities. And, if no Priority 1 errors are found on the webpage, the page meets the conformance level ‘A’ of the web content guidelines. As it is shown in *Figure 3.1*, once we type the web address of the university website on html validator site, it will let us determine if we want the analysis of the website for Section 508 or W3C WCAG A compliance. With the selection of the radio buttons in *Figure 3.1*, we can control what accessibility data we would like to collect when scanning a web page. By selecting the first button, we would know if this page is compliant with the Section 508 of the Rehabilitation Act of 1993. The second selection would allow us to determine what level of accessibility the web page has to the people with disabilities.

*Figure 3.1*. Choosing the Section 508 as the principal rubric to scan a website for accessibility issues.



The Priority 1 approval is equivalent to the conformance level "A" of the website of the web content guidelines. A website meets the Section 508 conformance when the entire website reaches conformance level "A" standards for errors reported on the WCAG report.

The second Priority level is level AA, which is also known as W3C WCAG-AA compliant. Priority 2 errors are those that also limit usability of the web page; while they are not as serious as Priority 1 errors, they limit access by users with disabilities. If no Priority 1 or 2 errors are found on the web page, the page meets conformance level of AA of the WCAG.

The next level contains Priority 3, which are level AAA errors. Although Priority 3 errors do not limit the usability of a website for people with disabilities, they assist web developers in identifying the conformance level. If no Priority 1, 2, or 3 errors are found on the web page, the page meets the conformance level AAA of the WCAG. This level is the maximum conformance level that the web developers strive to reach on their web pages.

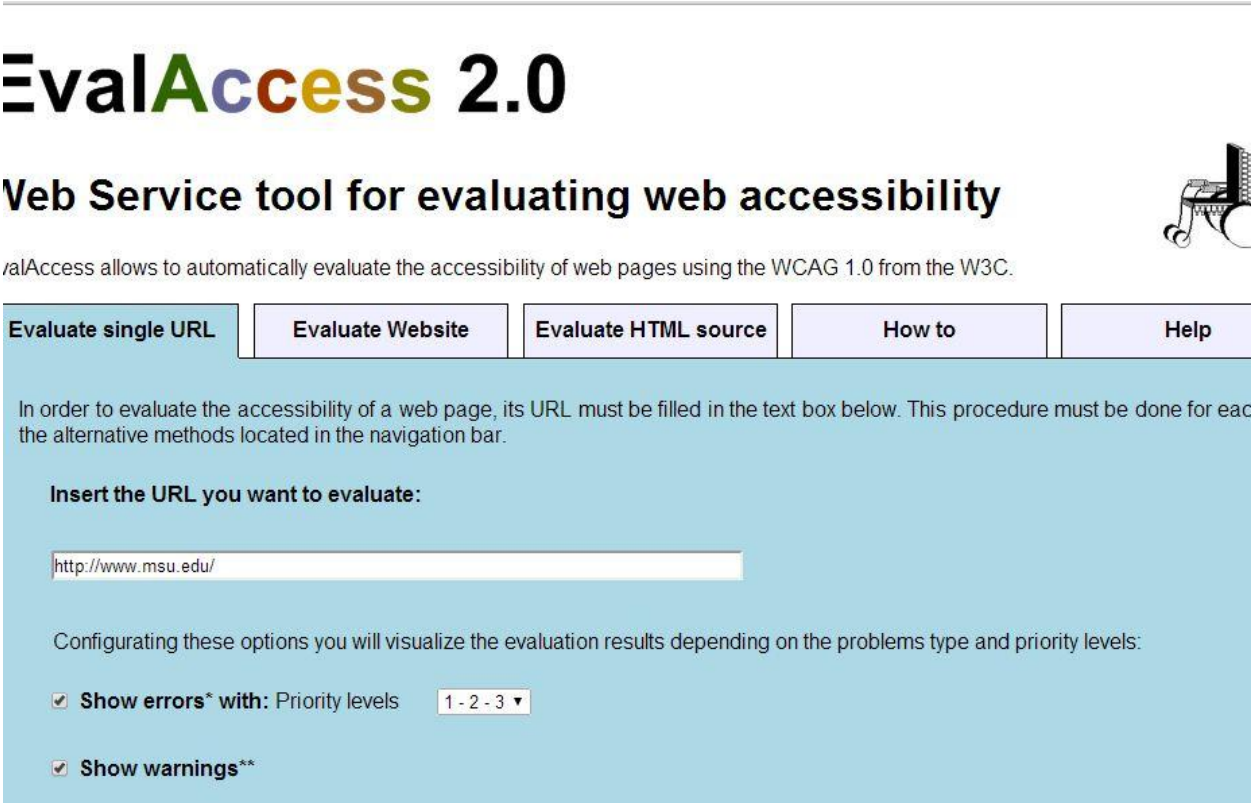
During the scan, the auto validation tools will be collecting data using the scanning, analyzing and reporting of online security, privacy, quality, accessibility and compliance issues. These tools check HTML against select accessibility guidelines and then report as to the accessibility of each page. Each tool displays accessibility errors in a different format. Usually a red icon informs the web developer that the tool has detected a Priority 1 (Level A) accessibility problem. A question mark indicates that there is a possible Priority 1 problem. A yellow icon indicates Priority 2 (Level AA) accessibility problems, etc. To visualize the step by step data collection procedure a brief sketch of the process is displayed below:

Sample: Home page of Michigan State University

Instrument: EvalAccess

Step 1: Online auto validators will be retrieved to check accessibility errors (*Figure 3.2*)

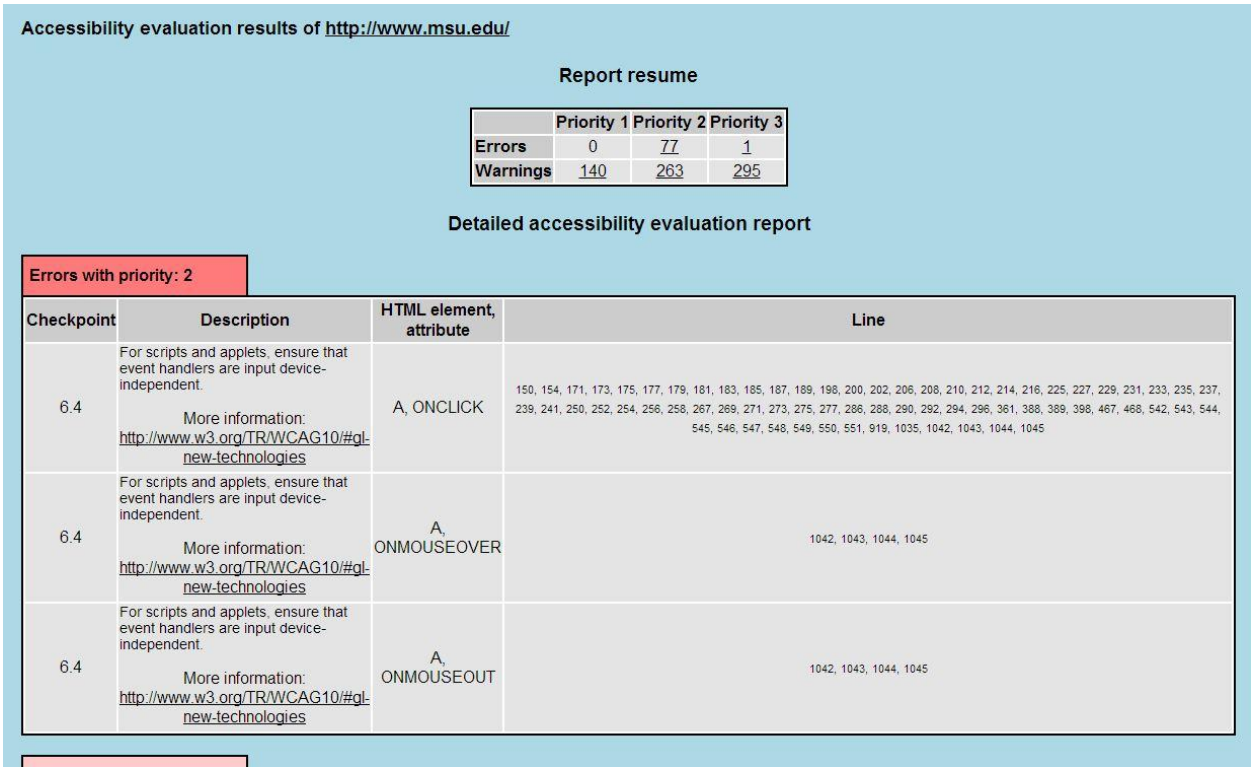
*Figure 3.2.* An illustration of an online auto validator site.




(EvalAccess, 2013).

Step 2: Collect data from accessibility test as it is shown in the following image (*Figure 3.3*):

*Figure 3.3.* An illustration of a web page after piloting an online Functional Accessibility Evaluator analysis.



Accessibility evaluation results of http://www.msu.edu/

Report resume

| | Priority 1 | Priority 2 | Priority 3 |
|---|---|---|---|
| Errors | 0 | 77 | 1 |
| Warnings | 140 | 263 | 295 |

Detailed accessibility evaluation report

Errors with priority: 2

| Checkpoint | Description | HTML element, attribute | Line |
|---|---|---|---|
| 6.4 | For scripts and applets, ensure that event handlers are input device-independent. More information: http://www.w3.org/TR/WCAG10/#gl-new-technologies | A, ONCLICK | 150, 154, 171, 173, 175, 177, 179, 181, 183, 185, 187, 189, 198, 200, 202, 206, 208, 210, 212, 214, 216, 225, 227, 229, 231, 233, 235, 237, 239, 241, 250, 252, 254, 256, 258, 267, 269, 271, 273, 275, 277, 286, 288, 290, 292, 294, 296, 361, 388, 389, 398, 467, 468, 542, 543, 544, 545, 546, 547, 548, 549, 550, 551, 919, 1035, 1042, 1043, 1044, 1045 |
| 6.4 | For scripts and applets, ensure that event handlers are input device-independent. More information: http://www.w3.org/TR/WCAG10/#gl-new-technologies | A, ONMOUSEOVER | 1042, 1043, 1044, 1045 |
| 6.4 | For scripts and applets, ensure that event handlers are input device-independent. More information: http://www.w3.org/TR/WCAG10/#gl-new-technologies | A, ONMOUSEOUT | 1042, 1043, 1044, 1045 |

(EvalAccess, 2013).

Step 3: Add data in an excel spreadsheet. Data will be collected in three levels of accessibility errors from each tool.

*Figure 3.4.* Number of errors found by three auto validators - home page of Michigan State University website

| | Priority 1 | Priority 2 | Priority 3 |
|---|---|---|---|
| Eval Access | 0 | 65 | 1 |
| ETRE | 0 | 0 | 0 |
| Hera 2.1 Beta | 2 | 6 | 2 |

The second phase of the study will test university home pages with the help of an assistive device. A screen reader NVDA will be used to scan each sample for accessibility issues. Commonly, auto evaluation tools will show a warning as to whether the site is Section 508

compliant or not. The report then typically presents an analysis of how this site failed to comply with accessibility guidelines. For example:

a) Alt missing: Every image has to have alt text - this is a text that is read out by a screen-reading application for those who cannot see the image.
b) Links are not validated: Every link phrase should make sense when read out of context, for example, "more information on this subject is available on the X page."
c) Links warning: No two links with the same link phrase, if they point to different locations, we cannot use the same link phrase in more than one link.
d) Invalid space: Links must be separated by more than a white space; screen-readers will often read these as one link, causing confusion to the user.
e) Color warning: Colors contrast must be sufficient.
f) Form is not validated: form fields must have explicit labels; form fields must have placeholder content. This applies equally to elements like check boxes and radio buttons.
g) Tables must be marked up correctly, using a <table> tag with a 'summary' property to describe its contents, plus <tr> and <th> to describe row and column headings tags.

A screen reader usually represents accessibility errors as actual stumbling blocks for individuals with a disability. For example, if a home page of a university website has a large image without an “alt” tag it appears as empty for a screen reader. Images without “alt” tag, color blocks, forms without labels, and tables without labels are only jargons for an individual visiting the website with the help of a screen reader. Data will be collected from the findings of the screen reader in an excel spreadsheet.

**Data Analysis Procedures:**

For this study, three auto validation tools and screen reader will be utilized to study 54 university websites' home pages. The researcher will enter every web page three times through the validation software and collect errors found by the three auto validation tools in an excel spreadsheet. Data results will be collected in three levels of WCAG validation: Priority 1, Priority 2 and Priority 3. Each of the 54 university websites will be tested three times with three auto validation tools per test. Since this study is based on the assumption that there may be differences between the findings of the three auto validation tools, researcher will attempt to use ANNOVA to analyze ratio data. After that, if the 54 university home pages exhibit a diverse number of accessibility errors generated from the three auto validation tools, the study will perform more tests that will include paired T-test to find differences between the performances of each auto validation tools.

The second phase of the study will utilize NVDA, a screen reader, to determine accessibility errors. The criteria for meeting Section 508 standards through assistive technology tools will be measured using the Section 508 checklist outlined in 1194.22 of the Web-based Intranet and Internet Information and Applications form (http://www.section508.va.gov/docs/checklist_1194_22.pdf ). Three samples will be randomly chosen to analyze their accessibility errors using Section 508 checklist. The Section 508 checklist outlines 16 variables range from paragraphs (a) through (b) of Section 1194.00, where each paragraph consists of one variable of accessibility. The study will categorize the answers of accessibility tests in three nominal data set; the answer 'meets standard' will be categorized as 'yes', the answer does not meet standards will be categorized as 'no', and the answer 'not applicable' will be categorized as 'N/A'. Data will be collected in an excel spreadsheet. At the

final stage of comparison test, data from the findings of the NVDA will be analyzed to find significant differences between the findings of auto validation tools and assistive tool.

# Chapter 4: Results of the Study

## Introduction

The purpose of this study is to evaluate the accessibility of higher education websites in relation to Section 508 of the Rehabilitation Act of 1973 (29 U.S.C. §794d). The goal of accessibility testing is to make technology available to as many users as possible (Jaeger, 2003a; Mueller, 2003; Slatin & Rush, 2003). However, studies by Hackett and Parmanto (2005) showed that the accessibility failure rates of university websites have consistently existed across all sectors, thereby making it difficult or preventing people with disabilities from accessing vital university information. To see what percentage of university home pages comply with Section 508, three accessibility checkers were used to test 54 benchmark university home pages. The test results were then analyzed and further examined using an accessibility tool to determine the validity of the errors in relation to the Section 508 checklist.

The following section is divided into three subsections. The first subsection presents the test results of the accessibility check points and the initial analysis of the results. The second subsection comparatively presents the diverse number of accessibility errors found in the home pages of fifty-four universities. The third subsection describes the findings of accessibility errors using assistive tools in relation to the checkpoints identified by the Section 508 checklist.

## Descriptive Demographics

Web accessibility means that individuals with disabilities can perceive, understand, navigate, and interact with the web and that they can contribute to the web (W3C, 2008). By using exacting standards to assess accessibility, a much better sense of the true scope of the accessibility problem is possible (Jaeger, 2005).

The World Wide Web Consortium (W3C, 2010b) maintains a composite listing of Markup validation tools, which provides information on over 140 auto-validation tools for testing accessibility. The researcher reviewed three Markup validation tools to evaluate the accessibility of the home pages of 54 university websites: Eval Access, ETRE and Hera 2.1 Beta.

The use of the above three tools provided quantified data that show the number of errors of a particular web page based on a selected set of accessibility checkpoint of Section 508 standards. Automated software testing products typically allow the user to select the specific criteria of evaluation, from several available options (Fagan & Fagan, 2006). The specific criteria of evaluation for this study are to determine violations that are types of errors categorized within Section 508. This method ensured that the data addressed the study's research questions. For this study, the validation tools were shortlisted based on the availability of the latest version of the software capable of finding Section 508 checklist validation.

The first phase of data analysis consisted of consolidating all of the test data from the three tools into Microsoft Excel spreadsheets for each of the home pages of 54 university websites. The consolidated data shows that each home page has a significant number of errors in every level of accessibility, which are Priority 1, Priority 2 and Priority 3 checkpoints. To understand the importance of these three Priority level checkpoints in accessing a website, W3 provided a brief explanation which may be helpful at this time. The three Priorities has the following impact on accessibility (W3 checklist:-http://www.w3.org/TR/WCAG10/full-checklist.html )

> Priority 1: A Web content developer must satisfy this checkpoint. Otherwise, one or more groups will find it impossible to access information in the document. Satisfying this checkpoint is a basic requirement for some groups to be able to use Web documents.

Priority 2: A Web content developer should satisfy this checkpoint. Otherwise, one or more groups will find it difficult to access information in the document. Satisfying this checkpoint will remove significant barriers to accessing Web documents.

Priority 3: A Web content developer may address this checkpoint. Otherwise, one or more groups will find it somewhat difficult to access information in the document. Satisfying this checkpoint will improve access to Web documents.

If there are no Priority 1 errors found on the web page, the page therefore meets the Conformance Level A of the WCAG; the absence of Priority 2 errors indicate a conformance level of WCAG –AA, and no errors from Priority 3 means a conformance level of WCAG AAA.

For this study, fifty four home pages of university websites were validated through the use of the three tools. The researcher entered every web page three times through the validation software and noted any errors found in the three Priority levels in an excel spreadsheet. The results showed that every university home page contained all three levels of errors. The table below shows the total number of errors found by the three auto-validation tools in just one university's website, the University of Minnesota:

Table 4.1

*Number of errors found by three auto validation tools in one university -University of Minnesota*

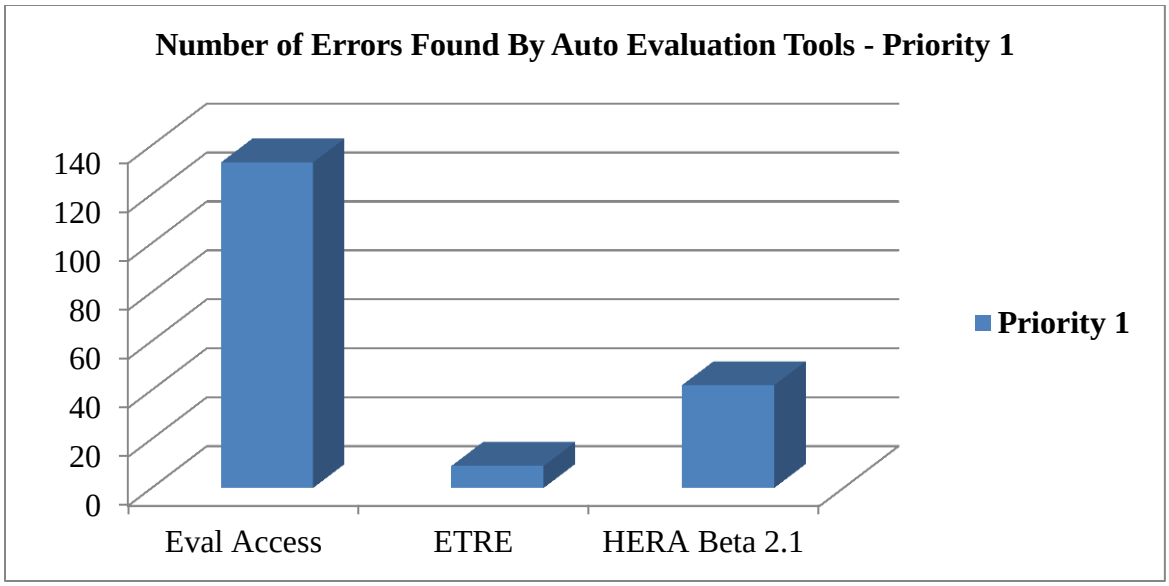
| Variables | Eval Access | ETRE | Hera 2.1 Beta |
|---|---|---|---|
| Priority 1 | 1 | 0 | 1 |
| Priority 2 | 22 | 1 | 4 |
| Priority 3 | 0 | 1 | 3 |

Data presented in Table 4.1 show that of the three evaluation tools, the tool Eval Access found 23 errors with one error from Priority 1 level and twenty-two from Priority 2 level; the tool ETRE found two errors from the same home page of University of Minnesota; and the third tool Hera 2.1 Beta found eight errors in the same home page. As shown in Appendix B, a complete list of number of accessibility errors found on each page by the three validation tools may provide a broader perspective.

The Priority 1 checkpoint ensures text equivalent for every non-text element, such as images, frames, etc., and text equivalent of scripts, applets etc. For example, screen readers will not recognize an image if there is no alternative text. Similarly, scripts and applets work as a backend for any websites which is not readable by a screen reader tool. Text equivalent or 'alt' of non-text elements includes images, graphical presentations, image map regions, animations, frames, and scripts, audio and video files. Similarly, if it is not possible to make the page usable without scripts, a text equivalent or NOSCRIPT element is required by the Priority 1 checkpoint of Section 508. The home pages of fifty-four universities showed one hundred eighty-four accessibility errors on Priority level 1.

*Figure 4.1*

*Priority 1 checkpoint.*

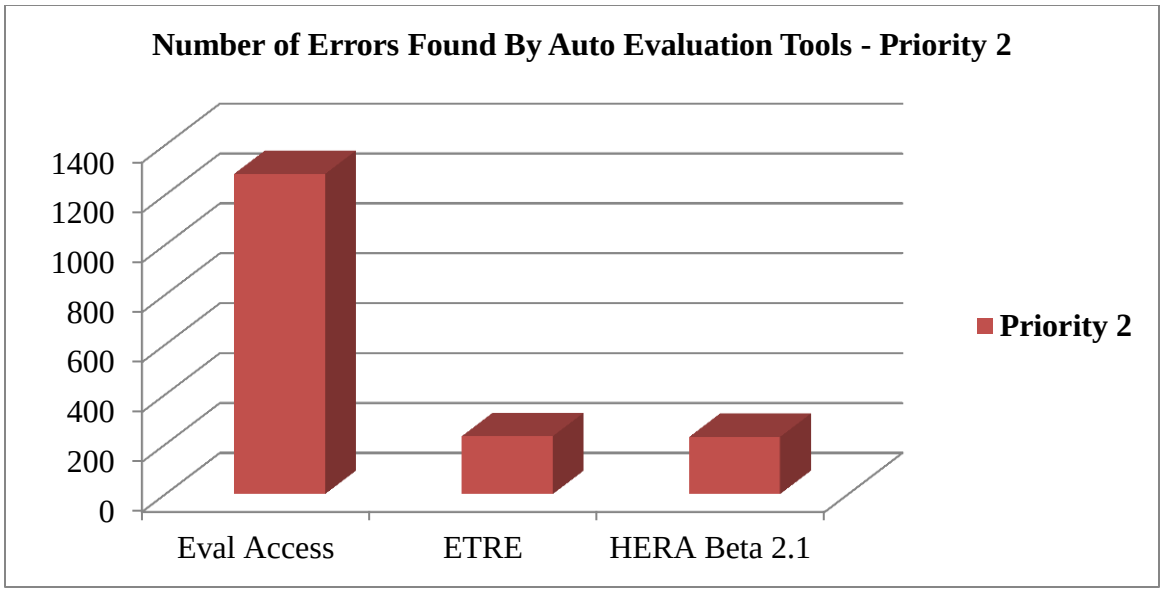



From the perspective of the visually impaired, passing Priority 1 validation is the most important requirement of a web page since this level ensures that the user will be able to access the page's information (http://www.w3.org/TR/WCAG10/full-checklist.html ). As shown in table 4.2, 37 universities out of the 54 tested, or 31.5%, did not pass the validation test. The web pages therefore contain information that is impossible for individuals with disabilities to access. Navigation beyond the home page for enrollment, academic courses, or other general information also need to be accessible, but newcomers to the website are less likely to go further if the home page has any accessibility issues.

Priority 2 checkpoints ensure the declaration of a valid doc type, the presence of a style sheet, the inclusion of appropriate labels, the identification of targets, and the inclusion of metadata. The three accessibility validation tools found 1,744 Priority 2 errors on the home pages of 54 university websites.

*Figure 4.2*

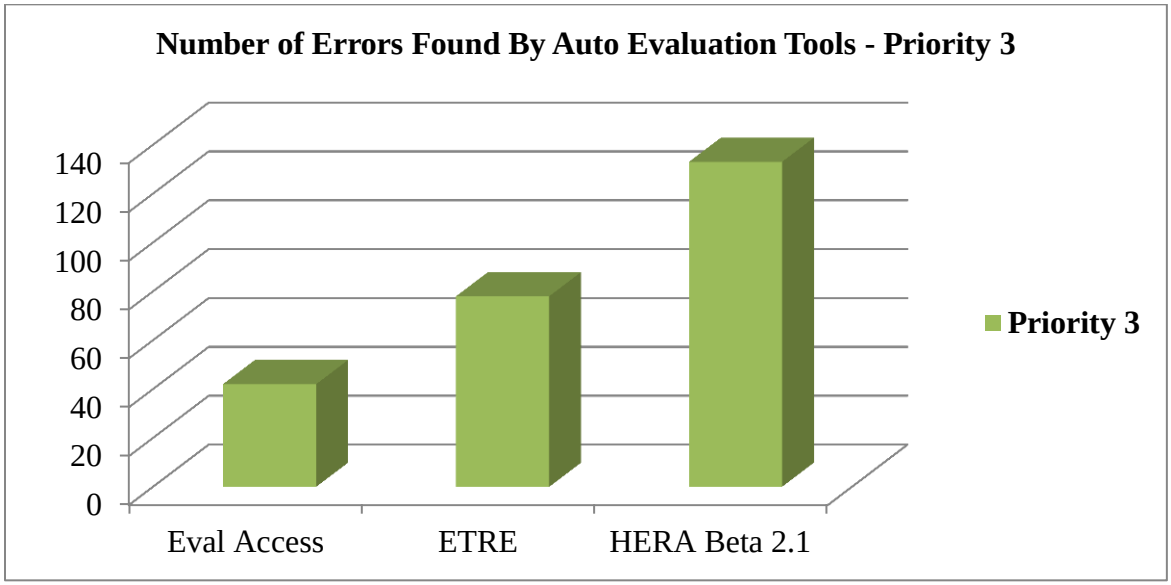
*Priority 2 checkpoint.*




Priority 3 checkpoints examine the primary language of a web document, ensure logical tab order through form controls and objects, and ensure key board shortcuts to important links. The accessibility validation tools used by this study found two hundred fifty-three Priority 3 errors on the home pages of fifty-four universities.

*Figure 4.3*

*Priority 3 checkpoint.*



**Results of Research Hypotheses Testing**

The complete results of the accessibility test on 54 university websites are shown in Appendix B. The variable of interest in the test is whether the web pages meet the accessibility requirement of the three Priority levels of WCAG and whether the test results of the three auto validation tools would find similar accessibility errors. Data analysis using mean, standard deviation, t-test and correlation were used. Table 4.2 presents the results of the data analysis:

Table 4.2

*Result of Priority 1 errors checkpoint*

Specific hypothesis: There is a difference in the findings of the three accessibility evaluation tools using dependent variable Priority 1.

| | Eval Access | ETRE | Hera 2.1 Beta |
|---|---|---|---|
| Mean | 2.46 | .17 | .83 |
| SD | 9.86 | .38 | .86 |
| Sample size | 54 | 54 | 54 |

As shown in Table 4.2, the one way ANOVA was used to test the hypothesis. The *f*-value of 2.30 at $\alpha = 0.05$ level of significance and with 2 and 159 degrees of freedoms, the calculated $p$=.103 indicates that there is no significant difference in the results of Priority 1 checkpoint errors found by the three evaluation tools with a $\alpha = 0.05$, $f(2,159)=2.301$, $p=0.103$.

Post Hoc test is used to find the significant difference between any of the three validation tools:

Table 4.3

*Priority 1 – findings of evaluation tools*

Specific hypothesis: There is a difference in the findings between the tools in comparing the Priority 1 errors.

*4.3.a. Priority 1- findings of two evaluation tools - Eval Access and ETRE*

| | Tool | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Priority | Eval Access | 54 | 2.46 | 9.87 | 1.34 |
| 1 | ETRE | 54 | .17 | .38 | .05 |

It can be seen in Table 4.3.a that ETRE has a result of $\alpha$=0.05, which indicates that there is no statistically significant difference between the two validation tools Eval Access (N=54, M=2.46, SD=9.87) and ETRE (N=54, M=.17, SD=.38), t (106) =1.709, *p*=.090.

*4.3.b. Priority 1- findings of two evaluation tools - Eval Access and HERA2.1 Beta*

| | Tool | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Priority | Eval Access | 54 | 2.46 | 9.87 | 1.34 |
| 1 | HERA 2.1 Beta | 54 | .83 | .86 | .12 |

Table 4.3. b also indicates that HERA 2.1 Beta, with a result of $\alpha$= 0.05, also does not show a statistically significant difference with Eval Access (N=54, M=2.46, SD=9.87) and HERA 2.1 Beta (N=54, M=.83, SD=.86), *t* (106) =1.209, *p*=.229.

*4.3.c. Priority 1- findings of two evaluation tools - ETRE and HERA 2.1 Beta*

| | Tool | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Priority | ETRE | 54 | .17 | .38 | .05 |
| 1 | HERA 2.1 Beta | 54 | .83 | .86 | .12 |

As it is shown in Table 4.3.c, with a result of α=0.05, statistically significant difference is found between ETRE (N=54, M=.17, SD=.38) and HERA 2.1 Beta (N=54, M=.83, SD=.86), t (106) =-5.202, *p*=0.

Test results presented in the above tables show that two out of three tools presented similar test results in findings Priority 1 errors and there are significant differences between the results of each tool in the same group.

Fulfillment of the Priority 1 checkpoint is the basic requirement of websites for ensuring that a website is accessible to every individual, including those with disabilities. Failing to meet the Priority 1 checkpoint indicates full inaccessibility, which is not acceptable by law. It is alarming that the auto evaluation tools did not coincide in the number of errors each one found. Test results show that there is a significant difference between the findings of HERA 2.1 Beta and ETRE. In an attempt to find similarity in the test results of Priority 2 and Priority 3 level errors, the researcher will continue to run statistical tests on these variables.

To test the results of the second Priority level errors, researcher adopted a one way ANOVA. The specific hypothesis for this test is = there is a significant difference between the test results of three evaluation tools in finding Priority 2 errors.

Table 4.4

*Priority 2 – findings of evaluation tools*

Specific hypothesis: There is a difference in the findings between the tools when comparing the Priority 2 errors.

*4.4.a. Findings of three evaluation tools – dependent variable Priority 2*

| | N | Mean | Std. Deviation |
|---|---|---|---|
| Eval Access | 54 | 23.78 | 43.06 |

| | | | |
|---|---|---|---|
| ETRE | 54 | 4.30 | 14.49 |
| HERA 2.1 Beta | 54 | 4.28 | 2.10 |

As shown in Table 4.4.a, with a result of α=0.05, there is a significant difference between groups and within groups in the Priority 2 errors, $f$ (2, 159) = 9.91, $p$ = .00

To determine if there is any difference within the tools in finding Priority 2 errors, the researcher decided to do a post hoc test on the variable Priority 2.

*4.4.b. Two evaluation tools; Eval Access and HERA 2.1 Beta– Dependent variable Priority 2*

| | Tool | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Priority 2 | Eval Access | 54 | 23.78 | 43.07 | 5.86 |
| | HERA 2.1 Beta | 54 | 4.28 | 2.09 | .28 |

With a result of α=0.05, a statistically significant difference is found between Eval Access (N=54, M=23.78, SD=43.06) and HERA 2.1 Beta (N=54, M=4.28, SD=2.09), t (106) =3.32, $p$=.001.

*4.4.c. Two evaluation tools; Eval Access and ETRE – dependent variable Priority 2*

| | Tool | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Priority 2 | Eval Access | 54 | 23.78 | 43.06 | 5.86 |
| | ETRE | 54 | 4.29 | 14.49 | 1.97 |

With a result of α=0.05, a statistically significant difference is found between Eval Access (N=54, M=23.78, SD=43.06) and ETRE (N=54, M=4.29, SD=14.49), t (106) =3.15, $p$=.002.

*4.4.d. Two evaluation tools ETRE and HERA 2.1 Beta – dependent variable Priority 2*

| | Tool | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Priority | ETRE | 54 | 4.30 | 14.49 | 1.97 |
| 2 | HERA 2.1 Beta | 54 | 4.28 | 2.09 | .28 |

With a result of $\alpha$=0.05, there is no significant difference between ETRE (N=54, M=4.30, SD=14.49) and HERA 2.1 Beta (N=54, M=4.28, SD=2.09), $t$ (106) =.009, $p$=.993.

Fulfillment of Priority 2 checkpoints is an important requirement of making web content understandable and navigable. Priority 2 checkpoints ensure that the web page is published with formal web-grammars (doc type, language type, etc.), that the page is using a style sheet to control layout and presentation (headings, lists, block quotes, etc.) and the page is not dependent on colors to convey information. Data from the test results indicates that there are significant differences between the findings of the evaluations tools, which, in brief, indicate that there are discrepancies in finding the obstacles to meeting the standards of an accessible website.

The final step is to test the Priority 3 errors found by the three validation tools. Priority 3 errors are the least limiting with the respect to usability of the web page by individuals with disabilities. A one-way ANOVA on Priority 3 errors shows the following:

Table 4.5

*Priority 3 – findings of evaluation tools*

Specific hypothesis: there is a difference in the test results of the three evaluation tools in their findings of Priority 3 errors.

*4.5.a. Findings of three evaluation tools – dependent variable Priority 3*

| | N | Mean | Std. Deviation |
|---|---|---|---|

| | | | |
|---|---|---|---|
| Eval Access | 54 | .77 | 1.99 |
| ETRE | 54 | 1.44 | 2.18 |
| HERA 2.1 Beta | 54 | 2.51 | .92 |

As shown in Table 4.5.a, with a result of α=0.05, statistically significant difference is found in the Priority 3 errors, $f$ (2, 159) = 13.06, $p$ = .00

To test the difference within groups, the researcher used a t-test to find statistical significance.

*4.5.b. Difference within groups; Eval Access and ETRE - dependent variable Priority 3*

| | Tool | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Priority | Eval Access | 54 | .77 | 1.99 | .27 |
| 3 | ETRE | 54 | 1.44 | 2.18 | .29 |

With a result of α=0.05, there is no statistically significant difference between ETRE (N=54, M=1.44, SD=2.18) and Eval Access (N=54, M=.77, SD=1.99), t (106) =-1.66, $p$=.099.

*4.5.c. Difference within groups; Eval Access and HERA 2.1 Beta - dependent variable Priority 3*

| | Tool | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| P3 | Eval Access | 54 | .77 | 1.99 | .27 |
| | HERA 2.1 Beta | 54 | 2.52 | .93 | .12 |

With a result of α=0.05, there is a statistically significant difference between Eval Access (N=54, M=.77, SD=1.99) and HERA 2.1 Beta (N=54, M=2.52, SD=.93), $t$ (106) =-5.84, $p$=.0.

*4.5.d. Difference within groups; ETRE and HERA 2.1 Beta - dependent variable Priority 3*

| | Tool | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| P3 | ETRE | 54 | 1.44 | 2.18 | .29 |
| | HERA 2.1 Beta | 54 | 2.51 | .93 | .12 |

With a result of $\alpha$=0.05, there is a statistically significant difference between ETRE (N=54, M=1.44, SD=2.18) and HERA 2.1 Beta (N=54, M=2.52, SD=.93), $t$ (106) =-3.33, $p$=.001.

Table 4.6

*Summary of the findings of evaluation tools*

| Variables | Variables within group | Significant Difference |
|---|---|---|
| Priority 1 | Among three tools | No |
| | Between Eval Access & ETRE | No |
| | Between Eval Access & Hera 2.1 Beta | No |
| | Between ETRE & Hera 2.1 Beta | Yes |
| Priority 2 | Among three tools | Yes |
| | Between Eval Access & Hera 2.1 Beta | Yes |
| | Between Eval Access & ETRE | Yes |
| | Between ETRE & Hera 2.1 Beta | No |
| Priority 3 | Among three tools | Yes |
| | Between Eval Access & ETRE | No |
| | Between Eval Access & Hera 2.1 Beta | Yes |
| | Between ETRE & Hera 2.1 Beta | Yes |

Differences among the numbers of violations of Section 508 identified by the automated accessibility testing tools were accumulated in the table 4.6. By comparing the results between these three tools, we could see distinct differences or patterns in the error types. Such differences might offer important insights concerning error propagation or provide indications of further validation for attaining full accessibility. Since these tools analyzed source code HTML and the potential issues with other objects on the page such as applets, images, plug–ins, and scripts, they allow the researcher to set preferences when conducting an analysis. To meet the WCAG AAA Conformance Level, which is the maximum conformance level that web content developers and designers strive to reach on their websites, it is necessary that auto evaluation tools find similar errors. Sloan (2008) identified drawbacks of automated validation tools as:

- Inability to determine the actual impact of the problems identified;
- Failure to accurately identify all accessibility problems that exist on a web page;
- Reported findings tend to be excessively technical.

However, with all of the above shortcomings, the differences between the findings of the validation errors may be confusing to some web developers. To determine which findings are valid, a web developer will have to match the source code of each website to identify each error. It is possible that the errors found by ETRE include the same errors that were found by Eval Access or HERA, but an examination of the source code and comparison to the results is the only way to determine the types of errors.

**Using Assistive Tool and Section 508 Checklist**

The next step involved testing a website using assistive tools. Appendix B is used to select a sample. The range of discrepancies in the tools' test data on the above table

demonstrates just how much variation comes into play for Web developers when using multiple tools to evaluate their websites for compliance to Section 508 standards. The nearest the tools came to an agreement on a home page was site 41. At the same time, website 51 is an example of the lowest level of agreement between three tools in their findings. According to Eval Access this site had 216 errors; ETRE found 10 errors; and HERA 2.1 Beta found 11 errors.

There are a number of assistive technologies available, such as screen magnification software, screen readers and Braille displays and text based browsers. For this study, the researcher chose to use screen reader software NVDA (Non-Visual Desktop Access). The screen reader reads out the content and structure of the web page in linear order, from top to bottom and left to right. Keyboard commands can be used to navigate around the structure of the site.

To use NVDA software to its full capability, the researcher used the key board shortcut as attached in Appendix D (Tsaran, 2009). NVDA software is used to test the accessibility of website based on the Section 508 checklist. The researcher selected three home pages:

d. Site number 41 with lowest number of errors on this page;

e. Site number 50 with highest number of errors on this page; and

f. One random Site number 22.

According to Web-based Intranet and Internet Information and Applications (1194.22), a website will be in compliance with the 508 standards if it meets paragraphs (a) through (p) of Section 1194.22 (http://www.access-board.gov/sec508/guide/1194.22.htm). To check the above three websites, the researcher used the Section 508 checklist as it shown on Appendix C which can be retrieved from http://www.section508.va.gov/docs/checklist_1194_22.pdf . A brief introduction to the Section 508 checklist may be helpful at this point.

The Section 508 checklist includes paragraphs (a) through (p) of Section 1194.22 which, in brief, highlights the use of text labels or descriptors for graphics and certain format elements, and addresses the usability of multimedia presentations, image maps, style sheets, scripting languages, applets and plug-ins, and electronic forms. Section 508 provides minimum standards for what is deemed acceptable by following the simple steps:

(q) Adding descriptive alt text for every non-text element;

(r) Adding closed captions for audio and video presentations;

(s) Information conveyed with colors should also be available without colors;

(t) Web page should be readable with style sheet turned off;

(u) Test links shall be provided for server side image map;

(v) Client side image maps shall be provided;

(w) Table row and column headers shall be identified for data;

(x) Adding appropriate attributes for complex tables;

(y) Adding titles to frames;

(z) Avoiding blinking text or flickering images;

(aa) A text only alternate page should be available;

(bb) Provide accessible alternatives for scripts and applets;

(cc) Link to plug-ins and applets should be provided;

(dd) Electronic forms should have appropriate labels;

(ee) Adding skip navigation function to skip over repetitive links; and

(ff) 'Time out' feature should have warnings and offer the ability to indicate that more time is needed.

To test the three home pages in relation to the above mentioned sections from (a) through (p), the researcher used the following answers as suggested by section508.va.gov website:

d. Meets standard

e. Does not meet standard

f. Not applicable

Three websites were tested by NVDA screen reader, and were labeled as Meets standard = "1", Does not meet Standard = "0", and, Not applicable = "N/A". In other words, pass=1, fail=0, and not applicable=N/A.

Table 4.7

*Summary of the findings of assistive tool NVDA*

| | Site number 41 University of Michigan | Site number 50 University of Michigan | Site number 22 |
|---|---|---|---|
| Passed | 43 | 3 | 23 |
| Failed | 4 | 60 | 38 |
| Not Applicable | 42 | 26 | 29 |

*Note.* A full checkpoint by checkpoint summary, with pass, fail and 'not applicable data' is presented in Appendix D.

As it is shown in Table 4.7, the university with the least number of errors found by the auto validation tools passed 43 questions out of 47 questions. The university with the highest number of errors found by the auto validation tools passed on 3 checkpoints, and failed on 60 checkpoints. The university with an average number of errors found by the auto validations tools passed 23 checkpoints and failed 38 checkpoints. However, listening to the web content rather than looking at it can be an illuminating experience that takes sighted users out of their normal comfort zone. It gives sighted users a chance to evaluate their content from an entirely different

perspective: from the perspective of a blind person (webaim.org). Checking the above three websites using NVDA provided a deep insight and a greater understanding of accessibility issues to the researcher.

**Summary**

The importance of this study lies in its intent that university websites are accessible to everyone. The criteria used to determine web accessibility are the standards defined in Section 508 of the Rehabilitation Act of 1973 (29 U.S.C. §794d). The methods used in this study are:

c. Automated testing of 54 benchmark university websites by three evaluation tools

d. Manual testing of 3 benchmark university websites by assistive technology tool

The findings of the first batch of test results demonstrated that there were substantial differences in the results between evaluation tools Eval Access, ETRE, and HERA 2.1 Beta when testing the websites for compliance to Section 508 standards. The accessibility errors found by the three automated tools were diverse in numbers, but generally shared a common type of error.

The findings of the second test result demonstrated that there was a common theme of failing to provide alternatives for assistive technologies. The use of the assistive tool NVDA demonstrated that the accessibility errors were just not numbers, but they were the actual stumbling blocks people with disabilities must deal with while visiting a university website.

This chapter illustrates that automated testing can be an effective tool for web developers as a quick and easy way to identify basic issues of non-compliance. However, as can be seen in the differences between the numbers of accessibility errors found by each of the three automated tests, the tools do not demonstrate full dependability. Rather, the use of assistive tools demonstrates the accessibility error the way people with disabilities encounter such errors. Also,

there are a few limitations in the findings of this chapter. The study is focused on the home pages of 54 benchmark universities of the University of Arkansas. Since the study focused on the university home pages only, it generalizes the non-compliancy of the home page even though the rest of the website could be Section 508 compliant. The second limitation in the accessibility tests is the potential problem which accompanies any free online tools. The fears that these tools may miss or misidentify many issues make many potential users wary of these products. In many cases, the most potentially significant accessibility barriers will go undetected (Sloan, 2008).

The above limitations could have been overcome had the researcher done extensive testing of source codes in addition to the auto validation tests. Such tests include, but are not limited to, html validation of the codes; html validation of backend scripts, and analysis of the development of the software of the three validation tools.

To summarize the procedures of this chapter, the study covers an elaborate analysis of the three Priority levels of WCAG guidelines and all of the 14 checkpoints of Section 508 guidelines to check the accessibility of higher education websites, and the results of accessibility tests indicate that 100% of the home pages fail to meet the Section 508 requirement. In an effort to compare the tools that are commonly used as measures of web accessibility checkpoints, the study presents descriptive data showing all Means, Standard Deviations of the three levels of errors a) Priority 1, b) Priority 2 and, c) Priority 3 found by the three auto validation tools: a) Eval Access, b) ETRE, and c) Hera 2.1 Beta. A one-way ANNOVA and a series of T-Tests are used for pairwise comparisons to determine whether there are any significant differences between the means of three levels of errors found by the three auto validations tools. The study finds that the auto validation tools do not agree with each other's findings; there are significant

differences in those findings. In an effort to find an alternative solution, the study uses an assistive tool, a screen reader, and, the Section 508 checkpoint to test the home pages of the three websites. Results of the 3rd phase of the tests indicate that assistive tools can provide additional help in determining the accessibility of websites.

## Chapter 5: Summary, Conclusions and Implications

This chapter presents three sections: the first section is a summary of the study; the second section is a summary of key findings in answering research questions and their substantiation with previous related studies; and the third section discusses implications of the key findings.

### Summary of the Study

This section includes a brief restatement of the study, a brief review of the procedure followed in conducting the study, and the research hypothesis tested.

**Statement of the problem.** It has been more than two decades since the Americans with Disabilities Act was created to protect individuals with disabilities from discrimination based on the limitations posed by their disabling conditions. Section 508 of the Act is the principal legislation that requires accessible web design to ensure that all web-based resources are accessible to people with disabilities. University websites in particular need to be accessible since they are the gateway to college experience for qualified students with special needs (Burke, Friedl and Rigler, 2010). Accessibility barriers affect the ability to navigate through a website, which may discourage a potential student from pursuing a higher education since core services and information are delivered via the web in this digital age. An accessible website is crucial to helping a university achieve its mission in the digital age. The problem addressed by this study is determining how well university websites comply with Section 508 of the Rehabilitation Act of 1973 (29 U.S.C. §794d). In determining the web accessibility of university homepages, the study also measured the number and type of accessibility errors found by three auto validation and one assistive tool to determine the extent of validity and reliability of such tools as a functional assessment that assesses usability relative to legislative law.

**Statement of the procedure.** This research study investigated the levels of accessibility of university websites in the terms of compliance with Section 508 standards. To obtain an accurate depiction of the levels of university website accessibility, the study utilized two evaluation methods: automated validation and assistive technology. Automated validation is defined as 'Markup Validator,' a free service by W3C that helps check the validity of Web documents (W3C, http://validator.w3.org/about.html ). Assistive technology is used by individuals with disabilities to perform functions that might otherwise be difficult or even impossible. In brief, an auto validation tool evaluates web languages, such as html, xhtml, xml, css, etc., whereas an assistive tool evaluates the degree of difficulty encountered when accessing a website. Three popular auto validation tools, Eval Access, ETRE and Hera 2.1 Beta., were used to test the home pages of 54 higher education institutions listed as University of Arkansas' benchmark institutes. In addition, the study utilized an assistive technology tool commonly known as a screen reader to compare the findings of the auto validation tools.

The study was conducted in two phases. The first phase consisted of collecting data using automated tools to scan the 54 university home pages. The second phase consisted of collecting data using a screen reader and Section 508 checkpoints.

Data results of the first auto validation tool accessibility tests were collected in three levels of WCAG validation: Priority 1, Priority 2 and Priority 3. Each of the 54 university websites were tested three times with three auto validation tools per test. Results indicated that each of the 54 university sites exhibited a diverse number of errors. Data obtained from the automated testing was analyzed to answer research question 1: *what percentage of university home pages comply with the three compliance level guidelines set forth by Section 508?* The use of the three automated tools determined that none of the selected web pages complied with

Section 508. Although the final results obtained were in agreement that each of the evaluated web pages failed to pass the minimum requirement, the findings also revealed that there were significant differences between the three automated tools in unique areas of the results.

To answer research question 2, *are there any differences among the findings of the three Auto Validation Tools within the group?* the study compared the findings of the three different tools. Although the study did not find any significant differences for variable Priority 1, it did find significant differences for Priority 2 and Priority 3 variables. In addition, the combined comparative test results for the three variables demonstrated that there were significant differences among the findings of auto validation tools.

The second phase of the study utilized NVDA, a commonly used screen reader, to determine accessibility errors following the use of the Auto Validation Tools. The criteria for meeting Section 508 standards through assistive technology tools was measured using the Section 508 checklist outlined in section 1194.22 of the Web-based Intranet and Internet Information and Applications form. The checklist outlined 16 variables ranged from paragraphs (a) through (p) of Section 1194.22, where each paragraph consists of one variable of accessibility. Three samples were shortlisted from the dataset of the first phase of the study. The first sample consisted of the website with the lowest number of errors and the second sample consisted of the website with the highest number of accessibility errors. The third sample was chosen randomly. The Section 508 checklist and the screen reader NVDA were then used to test each sample. The 16 variables of Section 508 were categorized in three criteria; the answer 'meets standard' was categorized as 'yes', the answer 'does not meet standards' was categorized as 'no', and the answer 'not applicable' was categorized as 'N/A'.

Data from the findings of the assistive tool were analyzed to answer the third research question: *Are there any differences between the findings of Assistive Technology and Auto Validation Tools?* The results showed that, compared to the number of accessibility errors found by the auto validation tools, the screen reader alone found 4 errors in sample one, 215 errors in sample two and 217 errors in sample three. The numbers of errors using the Section 508 checklist were found to be lower than those found using auto validation tools. Although the final results of the assistive tool were in agreement with the test results of the first phase, that is, each of the evaluated websites failed to pass a minimum accessibility requirement; the findings also showed that there were significant differences between the two types of evaluation tools. There was a low agreement between the number of errors collectively found by the three auto validation tools and the ratings given by the screen reader. In sample two, the screen reader found only 60 errors in contrast to the 215 errors found by Eval Access. One possible explanation for this discrepancy is that the automated tools and the accessibility tool judged the pages based on different criteria. The automated tools judged the pages against the priority checklist, whereas the user of the screen reader judged the pages against the degrees of difficulty. For example, under Priority 1, the automated tools checked webpages according to criteria such as whether the font sizes of the site were adjustable, if the page layouts were in a sequential order, and whether the navigations could be skipped. If the automated tools did not find these requirements, the page failed to meet Priority 1 criteria. The user of the screen reader, on the other hand, checked webpages based on the criteria different from those of the automated tools; thus, the criteria of Priority 1 errors were irrelevant to the user of a screen reader, and accessibility errors found by NVDA were fewer than the accessibility errors found by the auto validation tools.

**The specific research hypothesis.** The specific research hypothesis of the study is whether the websites of the 54 benchmark universities are compliant with the Section 508 of the Rehabilitation Act of 1973 (29 U.S.C. §794d). As can be seen in Table 5.1, more than two-thirds of the sites tested did not meet the basic accessibility requirements mandated by the policy requirements of the Section 508. This failure to fully meet the objectives of Section 508 indicates that university websites remain to a large degree inaccessible. As a result, these websites are denying fair and equal access to higher education information resources to individuals with disabilities.

**Summary of Key Findings:**

**Research question #1:** To answer the first research question of this study "what percentage of the home pages of university websites comply with the three compliance level guidelines set forth by Section 508?", this study finds that less than one third of the sites tested were compliant on Priority 1 errors; none of the sites tested met all three Priority levels of compliance. In simple words, 100% of the home pages of the university websites did not meet all three levels of compliances, and, more importantly, 69% failed to meet the basic requirements of web accessibility guidelines.

A number of studies were conducted to answer the first research question of this study. In a study conducted in 1999, Flowers, Bray and Algozzine (1999) found that only 27% of special education institution websites were accessible. During the same year, Rowland (1999) conducted a study on 4000 higher education institutes which showed that only 22% of the websites were accessible. In 2002, two studies were performed on the college and university websites by Chilson (2002) and McCullough Stein (2002) with a result showing 12% of the websites were accessible. A longitudinal study published in 2006, Comeaux and Schemetzke

(2006) collected data related to standards in meeting accessibility guidelines over a period of four years. Their findings indicated that from 2002 to 2006, percentage of accessible web pages went up. On the other hand, a study conducted by Hackett and Parmanto (2005) showed that the majority of sites were not compliant and that their compliance decreased over time as a result of increased density and complexity of modern websites.

In comparison to the above mentioned studies, the findings of the first research question of our current study is somewhat similar since the current study established that 69% of the university websites did not meet accessibility requirement. However, it was astonishing that, after a long period of the initiation of the ADA, higher education institute website home pages are still non-compliant as they were used to be 20 years back.

**Research question #2.** The second research question "are there any differences among the findings of the three auto validation tools within the group?" determined the effectiveness of the performance of three auto validation tools. The study finds that there are no significant differences in finding Priority 1 errors between three tools. However, there is a significant difference in finding Priority 2 errors of three tools. In addition, there is a significant difference in finding Priority 3 errors between three tools. Five out of nine paired T-tests steered by this study established significant differences between the test-results of auto validation tools.

The literature review of this study showed that auto validation tools had been used as an instrument to test accessibility issues, examples include: studies conducted by Hackett and Parmanto (2005), Badge and Dawson (2008), and Mancini (2005). Many studies have suggested that testing the levels of web accessibility cannot rely solely on automatic accessibility verification tools such as Bobby (Brajnik, 2000; Byerley & Chambers, 2003; Hackett & Parmanto, 2005; Kelly et al., 2004). Brajnik's (2000) study presented a survey of automatic

usability evaluation tools which was concluded with a suggestion "in order to be able to advance the state of the art in automatic usability evaluation, the test effectiveness problem needs to be formulated and solved." The study conducted by Byerley & Chambers (2003) used an email survey to examine accessibility of web-based abstracting and indexing services. A few studies analyzed the use of tools that are utilized to enhance the performance of a website, for example, a study conducted by Badge and Dawson (2008) compared different tools that were used by the teaching practitioners to create web-based educational materials such as PowerPoint presentations, audio and animation etc. However, the above studies mainly discussed the performance of the websites instead of focusing on the performance of the auto validation tools. In contrast to the above studies, the current study focused on the enactment of the auto validation tools that were utilized to corroborate websites to investigate how reliable these tools were. Data collected by this study were utilized to measure the performance of the auto validation tools from users with disabilities perspective. The result of this study showed that there were significant differences between the findings of the auto validation tools, which was alarming since these had been widely used instruments to improve web accessibility issues for user with disabilities since 1999.

**Research question #3**. The third research question "are there any differences between the findings of assistive technology and auto validation tools?" addressed the issue of similarity or dissimilarity between the two types of tools – assistive tool and auto validation tools. In other words, the third research question indicated a comparative approach towards two types of tools - auto validation tools and assistive tools. The study recognized that auto validation tools and assistive tool collected similar accessibility errors from the sites tested. The study also acknowledged that auto validation tools were quicker and easier way to test sites for accessibility

errors, whereas assistive tool was comprehensive in showing errors, and provided a deeper understanding to the researcher.

A number of studies have discussed alternative ways to test websites, for example, Flowers (2000), Sloan (2004). A few studies recommended that webmasters should work with users with disabilities to ensure web accessibility, for example Byerley & Chambers (2003), Kackett & Parmanto (2005). In addition, an issue in understanding web accessibility noncompliance stems from research findings that have rendered the existing guidelines used in ensuring web accessibility to be ineffective (Choi, Yi, Law, & Jacko, 2006; Kelly et al., 2005; Phipps & Kelly, 2006). Moreover, a study conducted by Schmetzke's (2002) indicated that 47% of its samples were fully accessible in terms of WCAG, but the percentage was lower in terms of Section 508 guidelines.

The current study used an assistive tool, NVDA to collect accessibility errors found by this tool using Section 508 guidelines. Data collected to compare these errors to those found by the auto validation tools. However, auto validation tools used WCAG levels as the standard to measure the accessibility errors whereas NVDA used Section 508 questionnaire instrument as its standard to check accessibility. The result indicated that the number of errors found by NVDA is less than the number of errors found by auto validation tools which questions the effectiveness of accessibility guidelines. Further research was suggested to examine the efficacy of existing web accessibility guidelines.

**Conclusion**

A wide variety of online resources that ensure website accessibility are available for web developers. The resources include auto validation tools and assistive technology tools, such as those used in this study are free, available in any platform, and do not require any technical

knowledge. Despite the availability of these valuable resources, many studies have found that websites remain inaccessible because web developers choose not to utilize them. Recent studies by Hacket, Parmanto, and Zeng (2005) as well as by Lazar and Greenidge (2006) indicated that websites may even become less accessible over time. This study found that all of the tested websites had accessibility problems and 69% of the tested sites did not meet the minimum requirements of accessibility as mandated by Section 508 of the Rehabilitation Act.

To improve the accessibility of university websites, it is important to identify the common accessibility problems the websites failed to correct. In general, the contents and structural layout of websites are constantly changing. In addition, the automated tools used to conduct accessibility tests, are rarely static in nature since software are usually subject to multiple upgrades every year. If accessibility tests could instead be conducted on an ongoing basis, then common accessibility errors can be projected differently in a longitudinal study. To minimize the effect of periodic changes, the data collection of finding accessibility errors in this study covered a two-week period. As a result, the test results of this study are reflecting a snapshot in time.

However, the number of evaluations conducted with the help of auto validation tools and assistive tools provided some understanding of the common accessibility errors that affect individuals with disabilities as they attempt to comprehend the information presented on the university websites.

**Implications**

The study indicates a disappointing accessibility situation of the home pages of higher education websites. We can see that 69% of the sample websites did not meet the basic requirement of the web accessibility law. As we know, websites are supposed to provide

information to everyone (Section 508, The Rehabilitation Act, 1973); however, there are individuals within the audiences who are not able to see, hear or simply pick up the mouse. The Rehabilitation Act of 1973 is a mandatory law that requires equal access for everyone, which the aforementioned websites failed to meet. The lack of accessibility of these webpages will prevent individuals with a limited ability to obtain the information they require from the site. The 69% failure rate in web accessibility means that the home pages of 69 university websites out of one hundred will not be able to let students go beyond the home pages of the 54 university websites tested to explore the possibilities of higher education options. It also means that 69% of the higher education websites are essentially excluding a large number of potential visitors to their website.

The study indicated that the part of the reason of the large number of the inaccessible website may be that these universities were only depending on auto validation tools. The first phase of the study found significant differences in the findings of auto validation tools which indicated that these tools were not sufficiently dependable to test the accessibility requirements of WCAG standard. Although the study acknowledged the usefulness of the auto validation tools in reducing the time and effort to perform web maintenance activities, further research is suggested to assess accuracy and effectiveness of the auto validation tools in general.

Results of the second phase of this study indicated that the use of assistive tool in addition to auto validation tool may reduce the number of basic inaccessibility issues. In addition, a general observation was made that it was due to the negligence of web developers who failed to attend to what could be easy fixes in the coding of the inaccessible page. The examples were used for the general observation were; the use of 'alt' text to describe a graphic or image in a way that allows a screen reader to detect the image only requires adding a description

to the non-text element, the use of flash elements, the absence of labels, the use of videos without closed captions, etc. Suggestions were made to educate web developers on the importance of web accessibility by providing mandatory accessibility training thru Human Resources to maintain job security. In addition, study suggested that the mandatory use of assistive tool alongside the use of auto validation tool might help web design team identify accessibility errors accurately.

From an ethical point of view, every person is equal in his/her rights to receive information regardless of whether they speak a different language, have a certain disability, or lack access to certain technology. The 69% failure rate in the university web accessibility reveals a lack in knowledge of accessibility law, and a limited empathy towards a large audience of website visitors. Every year there are potentially thousands of individuals with disabilities that are unable to access the information they need to further their education. Meanwhile, every year it becomes harder and harder to get employment as an increasing number of companies/bureaucracies require higher education or employees with more specialties. Thus, as the technology age progresses, there is an increasing number of individuals who are falling behind with no way to further their careers. It is up to the higher education institution websites that provide the first step to acquiring higher education – those that make available the information of universities and how to apply to them/learn about them – to make the hard decision of getting higher education that much easier for individuals with disabilities. With this kind of access, a person with disability can finally have a chance equal to anyone else to pursue his or her academic goals. Improving university websites to cater to this significant population will not only improve their quality of life, but also bring about a new group of people ready to

enter the workforce with valuable/higher knowledge and make the world a better place to live in for everyone.

In brief, this research study performed a number of tests to analyze percentage of accessible higher education websites, illustrated three kinds of automatic tests they perform, explored assistive technology, and finally compared the findings of these tools. The study then presented and conferred the elements that impacted the 69% of the inaccessible higher education websites even after 14 years of publication of WCAG and Section 508, which uncovers the salient wireframes of the instruments commonly utilized to ensure web accessibility, questions the effectiveness of these instruments, and lastly, opens further research to determine the efficiency of accessibility guidelines.

## Chapter 6: Limitations and Suggested Further Research

The home pages of university websites sampled for compliance to Section 508 of the Rehabilitation Act did not meet all three Priority level compliance. Only 17 out of the 54 sites tested met Priority 1 compliance, while none of the websites met Priority 2 and Priority 3 compliance. In brief, there is a 69% failure rate at Priority 1, and 100% failure rate at Priority 2 and Priority 3. The failure rate of 69% at Priority 1 is alarming as it is a basic requirement of accessibility standards. Simply put, if these universities were to be subjected to the Section 508 law, then the law is being broken. In addition, it is likely that any user with an accessibility issue will not browse further than the home page of website. Research suggests that web-based education increases opportunities for underserved populations to be integrated into educational activities (Schmetzke, 2001; Opitz, Savenye, & Rowland, 2003). Moreover, accessibility is not only for the disabled. A number of users that are not traditionally recognized as disabled such as individuals with poor reading skills, the elderly, and the uneducated – all use the Internet. Universities should take responsibility for being accessible and supporting all potential students. Higher education institutions cannot afford to segregate disabilities from their larger campus diversity agendas and initiatives. If they do, society will not experience a reversal in the trend of individuals with disabilities failing access to higher education, attain postsecondary degrees or secure gainful employment.

### Limitations

The researcher identified a few key limitations inherent to this research effort. One key limitation is that the study provided only a snapshot examination, in which a single look was taken at the websites for each evaluation. As a result, the study was not able to analyze changes in accessibility errors over time. Another key limitation is that the study did not include any

usability testing that could have broadened the scope of analyzing the accessibility of university websites. It is important to note that the findings of this study may have been different if the researcher had utilized a different type of assistive technology or additional auto evaluation tools.

Recommendations:

Based on the findings of this study and the relevant literature review, the following recommendations proposed:

*First*, due to the significant differences among the findings of the automated tools, it is important to have an accessibility expert included in the higher education web team. No tool exists that you can run against your website (or web page for that matter) in order to determine that it is accessible and/or complies with the Section 508 provisions or the Web Content Accessibility Guidelines, (Thatcher, 2002).

*Second*, due to the fact that the results of using a screen reader did not agree with the number of errors found by the auto validation tools, this area of the study requires further investigation.

*Third*, the findings of this study imply that passing the evaluations of auto validation tools is not enough to ensure accessible websites to individuals with disabilities. Any accessibility testing must be viewed as a process that combines automated software tools with human judgment (Thatcher, 2002). An assistive tool increases understanding of the stumbling blocks of a website. It is important to utilize assistive tools to determine web accessibility issues as websites appear to individuals with disabilities.

**Suggested Further Research**

Since this study performed a basic accessibility testing on the home pages of 54 universities, the study can be considered as a starting point for further comprehensive studies of

access issues for the individuals with disabilities. Several important areas can be explored based on this study.

*First*, since this study found that the results from the use of three automated tools consisted of significant differences between the findings of each tool; future research should explore the validity and reliability of the auto validation tools. Studies conducted by Molinero and Kohun (2006) also found discrepancies among the findings of the automated tools. Their study utilized three automated tools to test 50 websites and compared the finding s for consistency. Their findings indicated that the inconsistent results among the three automated tools were due to the subjective components of the guidelines.

*Second*, the investigation on the specific requirements of the accessibility guidelines to support assistive technology is important in this emerging technical age. Ambiguities in the accessibility guidelines should be investigated to avoid mixed results of validation errors.

*Third*, research could be done to investigate the educational background of the web developers of the institutions of higher education examined in this study in order to determine whether the observed web inaccessibility may have been due to those web developers' ignorance or negligence. The same technique of using software could be conducted in addition to a survey research on the demographic background and attitude of the web developers of higher education institutions in the United States. The expert testing, user testing, and webmaster questionnaires could help to more accurately assess their level of knowledge concerning web accessibility standards.

*Fourth*, since this study investigated only a few types of disabilities, it is important to fully understand the phenomena of web accessibility problems; that being the case, it would be

useful to conduct additional research to explore the problems of students with broader range of disabilities.

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**Appendix A: 54 Benchmark Institutions of University of Arkansas**

Auburn Univ - Main Campus
Clemson University
College of William and Mary
Florida State University
Georgia Institute of Technology
Indiana University - Bloomington
Iowa State Univ
Miami Univ - Oxford
Michigan State University
North Carolina State Univ.
Ohio State Univ (The) - Main Campus
Pennsylvania State Univ
Purdue Univ
Rutgers - New Brunswick
SUNY - Binghamton
SUNY College Environmental Science and Forestry
Texas A&M
Univ of Alabama
Univ of Arizona
Univ of Arkansas
Univ of California - Berkeley
Univ of California - Davis
Univ of California - Irvine
Univ of California - Los Angeles
Univ of California - Riverside
Univ of California - San Diego
Univ of California - Santa Cruz
Univ of California - Santa Barbara
Univ of Colorado - Boulder
Univ of Connecticut
Univ of Delaware
Univ of Florida
Univ of Georgia
Univ of Illinois at Urbana-Champaign
Univ of Iowa
Univ of Kansas - Main Campus

Univ of Maryland - College Park
Univ of Massachusetts - Amherst
Univ of Michigan - Ann Arbor
Univ of Minnesota - Twin Cities
Univ of Missouri - Columbia
Univ of New Hampshire
Univ of North Carolina - Chapel Hill
Univ of Pittsburgh
Univ of Tennessee - Knoxville
Univ of Texas at Austin (The)
Univ of Vermont
Univ of Virginia
Univ of Washington
Univ. of Wisconsin - Madison
Virginia Tech
Washington State University
West Virginia University

## Appendix B: Accessibility Errors

| | | Eval Access | | | ETRE | | | HERA 2.1 Beta | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **P1** | **P2** | **P3** | **P1** | **P2** | **P3** | **P1** | **P2** | **P3** | **ALL Total** |
| 1 | Arizona State University | 0 | 0 | 1 | 1 | 1 | 2 | 2 | 3 | 2 | **12** |
| 2 | Auburn Univ - Main Campus | 0 | 14 | 1 | 0 | 3 | 0 | 0 | 2 | 2 | **22** |
| 3 | Clemson University | 0 | 51 | 1 | 0 | 4 | 2 | 2 | 8 | 4 | **72** |
| 4 | College of William and Mary | 0 | 28 | 0 | 0 | 1 | 2 | 1 | 5 | 3 | **40** |
| 5 | Florida State University | 0 | 3 | 0 | 0 | 1 | 1 | 1 | 5 | 2 | **13** |
| 6 | Georgia Institute of Technology | 0 | 7 | 1 | 0 | 0 | 1 | 0 | 4 | 2 | **15** |
| 7 | Indiana University - Bloomington | 0 | 23 | 1 | 0 | 0 | 2 | 1 | 5 | 3 | **35** |
| 8 | Iowa State Univ | 0 | 6 | 0 | 0 | 0 | 0 | 1 | 4 | 1 | **12** |
| 9 | Miami Univ - Oxford | 0 | 14 | 2 | 0 | 0 | 1 | 1 | 7 | 3 | **28** |
| 10 | Michigan State University | 0 | 65 | 1 | 0 | 0 | 0 | 2 | 6 | 2 | **76** |
| 11 | North Carolina State Univ. | 0 | 22 | 0 | 0 | 1 | 0 | 1 | 5 | 2 | **31** |
| 12 | Ohio State Univ (The) - Main Campus | 1 | 1 | 1 | 1 | 3 | 1 | 0 | 4 | 4 | **16** |
| 13 | Pennsylvania State Univ | 0 | 0 | 0 | 1 | 2 | 1 | 0 | 2 | 1 | **7** |
| 14 | Purdue Univ | 0 | 3 | 1 | 0 | 1 | 0 | 0 | 4 | 4 | **13** |
| 15 | Rutgers - New Brunswick | 16 | 63 | 0 | 0 | 20 | 6 | 2 | 8 | 3 | **118** |
| 16 | SUNY - Binghamton | 0 | 10 | 1 | 1 | 12 | 0 | 0 | 4 | 2 | **30** |
| 17 | SUNY College Environ Sci & Forestry | 59 | 13 | 0 | 0 | 16 | 2 | 1 | 6 | 3 | **100** |
| 18 | Texas A&M | 0 | 4 | 1 | 0 | 0 | 3 | 0 | 3 | 2 | **13** |
| 19 | Univ of Alabama | 0 | 2 | 1 | 0 | 1 | 2 | 0 | 3 | 4 | **13** |
| 20 | Univ of Arizona | 0 | 8 | 0 | 1 | 0 | 1 | 1 | 2 | 3 | **16** |
| 21 | Univ of Arkansas | 0 | 16 | 1 | 0 | 2 | 0 | 1 | 8 | 3 | **31** |
| 22 | Univ of California - Berkeley | 0 | 4 | 1 | 0 | 3 | 2 | 0 | 0 | 1 | **11** |
| 23 | Univ of California - Davis | 0 | 6 | 0 | 0 | 0 | 1 | 1 | 3 | 3 | **14** |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 24 | Univ of California - Irvine | 0 | 74 | 1 | 0 | 2 | 2 | 1 | 5 | 2 | **87** |
| 25 | Univ of California - Los Angeles | 0 | 5 | 0 | 0 | 1 | 0 | 0 | 6 | 4 | **16** |
| 26 | Univ of California - Riverside | 0 | 28 | 0 | 0 | 1 | 1 | 0 | 4 | 3 | **37** |
| 27 | Univ of California - San Diego | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | **6** |
| 28 | Univ of California - Santa Cruz | 0 | 4 | 0 | 0 | 1 | 3 | 0 | 2 | 2 | **12** |
| 29 | Univ of California - Santa Barbara | 0 | 89 | 14 | 0 | 104 | 1 | 2 | 9 | 3 | **222** |
| 30 | Univ of Colorado - Boulder | 0 | 8 | 0 | 0 | 1 | 1 | 3 | 7 | 3 | **23** |
| 31 | Univ of Connecticut | 0 | 29 | 0 | 0 | 1 | 0 | 1 | 3 | 3 | **37** |
| 32 | Univ of Delaware | 0 | 8 | 1 | 0 | 17 | 0 | 2 | 6 | 3 | **37** |
| 33 | Univ of Florida | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 4 | 1 | **7** |
| 34 | Univ of Georgia | 0 | 5 | 1 | 0 | 2 | 1 | 0 | 3 | 2 | **14** |
| 35 | Univ of Illinois at Urbana-Champaign | 0 | 58 | 0 | 0 | 0 | 0 | 1 | 6 | 2 | **67** |
| 36 | Univ of Iowa | 1 | 18 | 0 | 0 | 1 | 0 | 1 | 5 | 1 | **27** |
| 37 | Univ of Kansas - Main Campus | 0 | 24 | 0 | 0 | 2 | 14 | 0 | 3 | 2 | **45** |
| 38 | Univ of Maryland - College Park | 0 | 0 | 0 | 1 | 3 | 2 | 0 | 4 | 4 | **14** |
| 39 | Univ of Massachusetts - Amherst | 12 | 6 | 1 | 0 | 1 | 2 | 1 | 2 | 2 | **27** |
| 40 | Univ of Michigan - Ann Arbor | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 2 | 1 | **6** |
| 41 | Univ of Minnesota - Twin Cities | 1 | 22 | 0 | 0 | 1 | 1 | 1 | 4 | 3 | **33** |
| 42 | Univ of Missouri - Columbia | 0 | 11 | 0 | 0 | 0 | 2 | 0 | 1 | 3 | **17** |
| 43 | Univ of Nebraska Lincoln | 0 | 4 | 1 | 0 | 9 | 5 | 0 | 3 | 2 | **24** |
| 44 | Univ of North Carolina - Chapel Hill | 40 | 5 | 1 | 0 | 0 | 3 | 2 | 5 | 2 | **58** |
| 45 | Univ of Pittsburgh | 1 | 27 | 0 | 0 | 1 | 0 | 1 | 4 | 3 | **37** |
| 46 | Univ of Tennessee - Knoxville | 0 | 8 | 0 | 0 | 2 | 0 | 0 | 4 | 2 | **16** |
| 47 | Univ of Texas at Austin (The) | 0 | 3 | 0 | 0 | 0 | 1 | 0 | 2 | 3 | **9** |
| 48 | Univ of Vermont | 1 | 4 | 0 | 0 | 1 | 1 | 0 | 1 | 2 | **10** |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 49 | Univ of Virginia | 1 | 215 | 0 | 0 | 6 | 4 | 2 | 6 | 3 | **237** |
| 50 | Univ of Washington | 0 | 217 | 1 | 0 | 3 | 2 | 1 | 5 | 2 | **231** |
| 51 | Univ. of Wisconsin - Madison | 0 | 3 | 0 | 1 | 1 | 1 | 0 | 2 | 1 | **9** |
| 52 | Virginia Tech | 0 | 20 | 4 | 0 | 0 | 1 | 2 | 8 | 3 | **38** |
| 53 | Washington State University | 0 | 19 | 1 | 0 | 0 | 0 | 2 | 5 | 2 | **29** |
| 54 | West Virginia University | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 5 | 3 | **11** |
| | | **133** | **1283** | **42** | **9** | **232** | **78** | **42** | **229** | **133** | **2181** |

## Appendix C: Shortcut Keys for NVDA Screen Reader

General.  NVDA+T -- read the window title of the currently-active application.
TAB or SHIFT+TAB -- move between objects in the tab order.
NVDA+TAB -- read the object currently in focus.
NVDA+Up_Arrow -- read the current line under NVDA cursor.
ENTER or SPACE bar key -- activate the item under the cursor, e.g., an HTML link, a button, etc.
More shortcuts under NVDA Help menu.
Navigating web pages:

(Applicable in "browse mode" only)
CONTROL+HOME -- move to the top of the page.
CONTROL+END -- move to the bottom of the page.
Up and DOWN arrows -- navigate between elements in a linear fashion.
Left and Right arrows -- navigate character by character.
NVDA+F7 -- display a list of all the HTML links and headings on the page; start typing to narrow down your search.
B or SHIFT+B -- move between buttons.
C or SHIFT+C -- move between combo boxes.
D and SHIFT+D -- move between ARIA landmarks.
E or SHIFT+E -- move between edit fields.
F or SHIFT+F -- move between form fields.
G or SHIFT+G -- move between graphics; NVDA will speak alt text if one is present or will speak a lot of gibberish if no alt text is found.
H or SHIFT+H -- move between HTML headings.
1 through 6 or SHIFT+1 through SHIFT+6 -- move between HTML headings of a particular level.
I or SHIFT+I -- move between list items of an HTML list (note: you have to be inside an HTML list to use this function).
K and SHIFT+K -- move between links.
L or SHIFT+L -- move between HTML lists.
M or SHIFT+M -- move between frames and iframes on the page.
N or SHIFT+N -- skip to the first block of text (non-link elements).
O or Shift+O -- move between embedded objects, such as Flash movies, press SPACE bar to start interacting with object; press NVDA+SPACE to stop interacting with the object.
Q or SHIFT+Q -- move between blockquotes on the page.
R or SHIFT+R -- move between radio buttons on the page.
S or SHIFT+S -- move between separators (HR tags) on the page.
T and SHIFT+T -- move between HTML tables.
U or SHIFT+U -- move between unvisited links.
V or SHIFT+V -- move between visited links.
X or SHIFT+X -- move between check boxes.
ESCAPE -- move out of the "focus mode".

## Appendix D: Checklist – The Section 508

| Section 508 checklist through NVDA screen reader | Yes=2; No=1; N/A=0 | University of Michigan | University of Virginia | University of Arkansas |
|---|---|---|---|---|
| (a) A text equivalent for every non-text element shall be provided (e.g., via "alt", “longdesc", or in element content). | a.1 Is alt text provided for every image? | 0 | 0 | 0 |
| | a.2 Can screen readers speak all alt text? | 1 | 0 | 0 |
| | a.3 Is alt text provided for every hotspot on a client-side image map? | N/A | 0 | 0 |
| | a.4 Is alt text meaningful? | 1 | 0 | 0 |
| | a.5 Is alt text provided for every animated image? | N/A | 0 | 0 |
| | a.6 Is alt text provided for every applet? | N/A | 0 | 0 |
| | a.7 Is alt text provided for programmatic objects? | N/A | 0 | 0 |
| | a.8 Are empty alt attributes (“”) provided for images used for list bullets, decorative purposes, and as spacers? | 1 | 0 | 0 |
| | a.9 Is alt text provided for background images that convey meaning? | 1 | 0 | 0 |
| | a.10 Is alt text provided for interactive content? | 1 | 0 | 0 |
| | a.11 Is alt text provided for animated content? | 1 | 0 | 0 |
| | a.12 Is alt text provided for every image-type button in forms? | 0 | 0 | 0 |
| | a.13 When scanned information is an image is equivalent text provided? | 1 | 0 | 0 |
| | a.14 Is non animated alternative texts based methods provided to access and complete an animated process? | N/A | 0 | 0 |
| | a.15 Can keyboard and | 1 | 0 | 0 |

| | | | | |
|---|---|---|---|---|
| | voice input users' access all text equivalent alternatives for non-text elements? | | | |
| | a.16 Is all alt text or any equivalent exposed by the keyboard or voice input? | 1 | 0 | 0 |
| | a.17 If textual links are not possible, is the screen name of the non-text element at the beginning of alt text, long description, title attribute, etc.? | 1 | 0 | 0 |
| | a.18 Do expando links have meaningful alt text that appears when the expando is collapsed and when the expando is expanded? | N/A | 0 | 0 |
| | a.19 Do audio files have transcripts? | N/A | N/A | N/A |
| | a.20 Do video files have captions? | N/A | N/A | N/A |
| (b) Equivalent alternatives for any multimedia presentation shall be synchronized with the presentation. | b.1 Does the multimedia presentation have captions? | N/A | N/A | 1 |
| | b.2 Are captions large enough to be read? | N/A | N/A | 1 |
| | b.3 Are captions presented on a solid background with high contrast so that they can be distinguished from the pictorial content? | N/A | N/A | 1 |
| | b.4 Are the captions synchronized with the audio in the presentation? | N/A | N/A | 0 |
| | b.5 Does the multimedia presentation have video description? | N/A | N/A | 0 |
| | b.6 Is the video description synchronized with the video of the | N/A | N/A | N/A |

| | | | | |
|---|---|---|---|---|
| | presentation? | | | |
| (c) Web pages shall be designed so that all information conveyed with color is also available without color, for example from context or markup. | c.1 If color is used to convey information, is the information presented by another method? | N/A | 0 | N/A |
| | c.2 Are meaningful text equivalents readily apparent for any color coded screen element? | 1 | 0 | N/A |
| (d) Documents shall be organized so they are readable without requiring an associated style sheet. | d.1 Can the page be understood without style sheets? | 1 | 0 | 1 |
| | d.2 Do screen readers speak the page properly if style sheets are turned off? | 1 | 0 | 1 |
| | d.3 Can screen readers speak all controls properly when style sheets are turned off? | 1 | 0 | 1 |
| | d.4 Can user controlled accessibility options be used in the application? | 1 | 0 | 1 |
| (e) Redundant text links shall be provided for each active region of a server-sideimage map. | e.1 Are redundant text links provided for each region of a server-side image map? | N/A | 0 | 0 |
| (f) Client-side image maps shall be provided instead of server-side image maps except where the regions cannot be defined with an available geometric shape. | f.1 Are client-side image maps used instead of server-side except where a geometric shape is not available for a client-side image map? | N/A | 0 | 0 |
| | f.2 Are there meaningful text alternatives for links that are images of text? | 1 | 0 | 0 |
| | f.3 Can keyboard users access text alternatives with the keyboard? | 1 | 0 | 0 |
| | f.4 Are client-side image map links selectable by keyboard/voice? | N/A | 0 | 0 |
| (g) Row and column headers | g.1 Are row and column | N/A | N/A | N/A |

| | | | | |
|---|---|---|---|---|
| shall be identified for data tables. | headers identified in data tables with a <TH> tag? | | | |
| | g.2 Is the <td> tag used for table data cells? | N/A | N/A | N/A |
| | g.3 Can assistive technology associate row and column headers with data elements when navigated to within a table? | N/A | N/A | N/A |
| | g.4 Are header elements and associated data included in the same table? | N/A | 0 | N/A |
| | g.5 Do all coded header and data cells have content? | N/A | 0 | N/A |
| | g.6 Is the scope attribute used to delineate rows and columns? | N/A | N/A | N/A |
| | g.7 Are colspan and rowspan used for data and header cells that span multiple columns or rows? | N/A | N/A | N/A |
| | g.8 Do cells have only one set of data? | N/A | N/A | N/A |
| (h) Markup shall be used to associate data cells and header cells for data tables that have two or more logical levels of row or column headers. | h.1 In complex tables, do colspan or rowspan attributes use either the scope attribute or id attributes to associate data with header cells? | N/A | 0 | N/A |
| | h.2 In complex tables, are data cells and header cells associated by using id attributes? | N/A | N/A | N/A |
| (i) Frames shall be titled with text that facilitates frame identification and navigation. | i.1 Do all frames have meaningful descriptive titles? | 1 | 0 | 0 |
| | i.2 Are frame names available to assistive technology? | N/A | 0 | 0 |
| | i.3 Is navigation to frames with a keyboard equivalent to navigating | 1 | 0 | 0 |

| | | | | |
|---|---|---|---|---|
| | with a mouse? | | | |
| | i.4 Can voice recognition navigate to frames the same as mouse/keyboard navigation? | 1 | 0 | 0 |
| | i.5 Does the website ensure that hidden frames or other elements used for storage or work areas are not spoken or exposed to assistive technologies? | 1 | 0 | 0 |
| (j) Pages shall be designed to avoid causing the screen to flicker with a frequency greater than 2 Hz and lower than 55 Hz. | j.1 Does the page avoid using blinking text and/or images with a frequency greater than 2 Hz and lower than 55 Hz and/or images? | 1 | 1 | 1 |
| (k) A text-only page, with equivalent information or functionality, shall be provided to make a website comply with the provisions of this part, when compliance cannot be accomplished in any other way. The content of the text-only page shall be updated whenever the primary page changes. | k.1 Is there an equivalent text alternative page for this page if compliance cannot be accomplished in any other way? | 1 | 0 | 1 |
| | k.2 Is the equivalent page updated whenever the original page is updated? | 1 | N/A | 1 |
| | k.3 Are the meaningful contents of the equivalent page the same as the original page and does it provide the same functionality? | 1 | N/A | 1 |
| (l) When pages utilize scripting languages to display content, or to create interface elements, the information provided by the script shall be identified with functional text that can be read by assistive technology. | l.1 Are accessible alternatives provided for scripts and applets that are inaccessible with assistive technologies? | 1 | 0 | 0 |
| | l.2 Are all contents and | 1 | 0 | 1 |

| | | | | |
|---|---|---|---|---|
| | interface elements keyboard or voice accessible? | | | |
| | l.3 Do all content and interface elements have a well-defined visual focus? | 1 | 0 | 1 |
| | l.4 Is sufficient information about a user interface element including the identification, operation and state of the element available to assistive technology? | 1 | 0 | 1 |
| | l.5 Is there a logical tab order? | 1 | 0 | 1 |
| | l.6 Is keyboard focus clearly indicated? | 1 | 0 | 1 |
| | l.7 Is keyboard focus programmatically exposed? | 1 | 0 | 1 |
| (m) When a web page requires that an applet, plug-in or other application be present on the client system to interpret page content, the page must provide a link to a plug-in or applet that complies with §1194.21(a) through (l). | m.1 If a page uses plug-ins, applets, etc. is a link to that plug-in or applet provided? | 0 | 0 | 0 |
| | m.2 Are plug-ins, including but not limited to Flash, e-Learning players, or multimedia programs compliant with 1194.21 software requirements? | 1 | 0 | 1 |
| | m.3 If a web page uses a plug-in can it be loaded on VA computers? | N/A | 0 | 1 |
| (n) When electronic forms are designed to be completed on-line, the form shall allow people using Assistive Technology to access the | n.1 Can the form be used with assistive technologies? | 1 | 1 | 0 |

| | | | | |
|---|---|---|---|---|
| information, field elements, and functionality required for completion and submission of the form, including all directions and cues. | | | | |
| | n.2 Is instructive text at the beginning of the form? | 1 | 0 | 0 |
| | n.3 Are all form controls explicitly associated with labels, are the labels properly positioned and are they meaningful? | 1 | 0 | 0 |
| | n.4 Can you navigate and follow forms with the keyboard? | 1 | 1 | 0 |
| | n.5 Can screen readers speak all controls, labels, directions, and cues in a logical order? | 1 | 0 | 0 |
| | n.6 Does the keyboard get focus on all controls, labels, directions, and cues in a logical order? | 1 | 0 | 0 |
| | n.7 Does all error information receive focus and is navigation to errors available to the keyboard with a minimum number of keystrokes? | 1 | 0 | 1 |
| | n.8 Is error message text associated with each error element so that all error messages are understandable in order to correct the error? | 1 | 0 | N/A |
| | n.9 Is navigation precise to each identified error and without the necessity to navigate the entire form? | 1 | 0 | N/A |
| | n.10 Do audio cues have accessible alternatives? | N/A | 0 | N/A |
| | n.11 Are there accessible alternatives to security measures such as | N/A | N/A | N/A |

| | | | | |
|---|---|---|---|---|
| | CAPTCHAs? | | | |
| | n.12 Are elements grouped logically with the proper structure e.g. a meaningful fieldset and legend in HTML or proper coding in Flash? | N/A | 0 | 1 |
| | n.13 Do online PDF forms speak in a logical reading order (that is, fields must speak as fields in the order they appear on the form)? | N/A | N/A | N/A |
| | n.14 Do PDF documents and forms retain the same clarity with screen magnification software, as they do when not magnified? | N/A | N/A | N/A |
| | n.15 Do PDF fillable forms comply with 1194.21.a-l? | N/A | N/A | N/A |
| | n.16 Do PDF forms track with Braille displays? | N/A | N/A | N/A |
| (o) A method shall be provided that permits users to skip repetitive navigation links. | o.1 Is there a way to skip over a group of repetitive links? | 0 | 0 | 1 |
| | o.2 Are links visible or made visible when tabbed? | 1 | 0 | 1 |
| | | | | N/A |
| (p) When a timed response is required, the user shall be alerted and given sufficient time to indicate more time is required. | p.1 When a timed response is activated is the user alerted and offered the ability to indicate that more time is needed? | N/A | N/A | N/A |
| | p.2 If there is a "time-out" feature, are users clearly advised up-front in the application that it exists? | N/A | 0 | N/A |
| | p.3 Does the time-out message pop-up, speak, and get focus? | N/A | N/A | N/A |

| | | | | |
|---|---|---|---|---|
| | p.4 If users time-out, do they have the capability to return easily to the last addressed page? | N/A | N/A | N/A |
| | p.5 Does the page avoid automatic redirects, automatic refreshing, etc? If not is there a warning that alters the user? | N/A | N/A | N/A |