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Case study of information searching experiences of high school students with visual impairments in Taiwan

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A CASE STUDY OF INFORMATION SEARCHING EXPERIENCES OF HIGH SCHOOL STUDENTS WITH VISUAL IMPAIRMENTS IN TAIWAN

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ABSTRACT

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The purpose of the study was to provide comprehensive insight into high school students' experiences by examining their information search behaviors on the Web through G-mouse screen readers to answer academic fact-based questions. Six participants were high school students from grades 10 through 12 at a school for the visually impaired in Taiwan. They were selected by using purposeful sampling based on their use of G-mouse screen reader and experience in searching information on the Web. Qualitative research methods and case study design were used to provide detailed descriptions of participants' information searching behaviors and to learn about their understanding of accessibility and usability issues. Four sources of data collected from pre-task interviews, observations, online information search task sessions, and post-task interviews were transcribed and analyzed.

This study identified information search behaviors of the participants on the Web using G-mouse screen reader and challenges they encountered during the information searching process as well as the strategies they used to overcome these challenges. Regarding the participants' action, the participants skimmed through a web page by jumping from link to link and scanning the first few words of a link. By using limited of use of G-mouse keyboard commands, the participants only looked at the first

page of search results but visited more than one website per task. In relation to the participants' cognition, they chose a search engine/port or a specific website to search for information. After the participants got oriented to the search edit box automatically or by tabbing to it, they formulated the first search query from the task description and then modified the search queries with new terms found from result pages or web pages. The participants examined the search result lists based on the page title and browsed the textual content of a website by jumping through links and reading through the entire page. The participants faced six accessibility and usability problems, including graphics, Flash and tables without text alternative, navigation menu at the top, inappropriate labeling of links, the structure of specific websites, and excessive information. Searching information on the Web became a challenge for the participants when G-mouse screen reader failed to pronounce English words in an understandable way, to give indication when a web page had finished loading, and to provide sufficient feedback to verify the participants' actions. The obstacles encountered by the participants could be caused by individual's insufficient search competence, including not having the conceptual model of a web page's layout and strategies to deal with information overload. When the participants experienced problems on the Web, they employed six strategies, including note-taking, trial and error, backtracking, looking for assistance, skipping, and giving up.

The recommendations for screen reader developers are to support automatic term suggestions, to provide the overview of content arrangement, and to provide a non-speech notification for a content change. The recommendations for web designers are to include auditory previews and overviews for search engines, and to provide

support in keeping track of information. The recommendations for educators are to provide training in formulating effective search queries, overcoming information overload, and building mental models, and to provide students with opportunities to share experience. Future research is also discussed.

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CHAPTER I

INTRODUCTION

Background

In the twenty-first century, the Internet has become a prominent source of information for students' school learning and everyday lives. In 2011, a national survey on the impact of the Internet on Americans "*Digital Future Report*" (Center for the Digital Future, 2011) revealed that ninety-six percent of children aged 18 years and under considered that use of the Internet was of general importance for their schoolwork. Another survey in the U.S. conducted by Lenhart, Arafeh, Smith, and Macgill (2008) found that "the internet is a primary source for research done at or for school" (p. iv) and forty-eight percent of teenagers stated that they used the Internet to do research for school assignments once a week or more.

Information on the Internet is not always accessible to all students, especially students with disabilities (Schmetzke, 2001; Waits & Lewis, 2003). People with visual impairments typically face significant barriers to access to the Internet (Lazar, 2006; Slatin & Rush, 2003). According to Paciello (2000), "Of all the disability communities concerned by the inaccessibility of the Web, people with visual disabilities probably rank first" (p. 7). In 2002 federal report, "*A Nation Online*" (U.S. Department of Commerce, 2002) indicated that among those between the ages of three and twenty-four who used the computer and Internet, 267,000 individuals (0.4 %) reported having blindness or severe visual impairments (U.S. Department of Commerce). Therefore, it is clear that access to the Internet is becoming increasingly important for school-aged students with visual impairments.

Because it may be difficult for people with visual impairments to find information using traditional materials, such as books and magazines due to access to large print and braille (Williamson, Schauder, & Bow, 2000), success in searching for information on the Internet for educational purpose is particularly important for students with visual impairments. The Internet presents an opportunity for independent access to an enormous amount of information that students who are visually impaired may not have been able to access in the past (Burgstahler, 2002; Gerber, 2002a; Pitt & Edwards, 1996; Williamson, Wright, Schauder, & Bow, 2001). However, the Internet includes many complex websites full of complicated structured content that can make searching for information on the Internet for students with visual impairments a challenging task (Brophy & Craven, 2007; Lazar, Allen, Kleinman, & Malarkey, 2007). This is why it is important to examine access technology that students with visual impairments use including screen readers.

Students who are visually impaired are able to access information on the World Wide Web through screen readers. Individuals with visual impairments rely upon screen readers to convert text on a computer screen into digitized audio speech (Coombs, 2010; Fuglerud, 2011). In recent years, Web design elements have rapidly expanded beyond simple text. However, more complicated elements on the Web such as multimedia and web application pose considerable challenges to Web accessibility for students with visual impairments (Hailpern, Guarino-Reid, Boardman, & Annam, 2009; Miyashita, Sato, Takagi, & Asakawa, 2007). Instead of omitting these more complicated features, web designers must provide solutions for access to content by screen readers.

The World Wide Web Consortium's Web Accessibility Initiative has developed a comprehensive and unified set of accessibility guidelines and checklists, called the Web Content Accessibility Guidelines (WCAG). WCAG provides official global web accessibility guidelines and recommends possible alternatives to help web designers create or revise a site to better meet accessibility needs of people with disabilities (Caldwell, Cooper, Reid, & Vanderheiden, 2008). The other authoritative resource that provides guidance for accessible web pages is the Federal Access Board Standards, issued under Section 508 of the Rehabilitation Act. All federal departments and agencies are required to follow these standards (United States Access Board, 2000a). Although Section 508 is targeted at federal government, the standards have inspired legislative action at U.S. state governments (Lazar, 2010).

Because of Web's inherently visual nature, the majority of these principles for accessibility particularly targets web design elements that create barriers for people with visual impairments who use screen readers. For example, specific features of WCAG 2.0 appropriately address accessibility concerns of students with visual impairments: text alternatives for any non-text content, link texts for hyperlinks, descriptive titles for Web pages, a meaningful name for identifying frames, and labels for form elements (Caldwell et al., 2008). When accessibility features are incorporated into the design process, students with visual impairments are able to navigate the Web with freedom as their sighted peers do in this visually-orientated approach.

WCAG and Section 508 standards facilitate a sustained progress toward accessible websites. A necessary component of this process is Web accessibility evaluation tools. These software programs or online services, like the W3C Markup Validation Service (World Wide Web Consortium, 2012), help Web designers check the compliance with guidelines effectively. However, the conformance to accessibility guidelines does not necessarily guarantee a good experience for students with visual impairments.

Web pages may be accessible, but they are not really usable for people with visual impairments (Babu, Singh, & Ganesh, 2010; Di Blas, Paolini, & Speroni, 2004; Leuthold, Bargas-Avila, & Opwis, 2008). A usable web site enhances users' ability to learn and remember the site content, supports productive task performance, minimizes chance for user errors, and increases users' satisfaction (Nielsen, 2003). Nielsen's research (2001) revealed that perceived usability for websites was three times better for users without disabilities than for users with disabilities. This represents less efficiency in searching for information on the Web for users with visual impairments which can lead to increased frustration (Lazar et al., 2007).

Meeting the WCAG technical guidance for accessibility is a good start, but it does not ensure the quality of user's experience for students with visual impairments when searching for information on the Web (Leuthold et al., 2008). The needs of students with visual impairments go beyond purely having access (Hanson, 2004). Therefore, a direct approach to this issue is to integrate Web accessibility and ease of use that can considerably produce a better experience for students with visual impairments. Such an approach can also help these students search for information on the Web effectively and efficiently.

Statement of the Problem

The "usability" concept is officially defined in International Standard Organization/Draft International Standard (ISO/DIS) 9241-11 (International Organization for Standardization, 1998) as “the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use” (p.8). According to this definition, the usability of websites can simply mean how effortless and comfortably people may accomplish the task of finding desired information on the web sites.

Nielsen (2000) established Web usability elements that facilitate the production of usable web sites. They included speed, hyperlinks, multimedia, navigation, and accessibility. People with visual impairments may also benefit from web sites that implemented many of these usability elements. However, the usability needs of blind users fundamentally differ from the usability needs of sighted users (Jones, Farris, Elgin, Anders, & Johnson, 2005; Babu et al., 2010). In fact, the problems may be even more serious when in some situations the Web usability needs of people with visual impairments appears to be in conflict with the best interests of those who are sighted (Theofanos & Redish, 2003). The difference in usability needs may be due to the ways people with visual impairments search for information on the Web.

People with visual impairments gain access to information on the Web in a very different way from sighted people (Kurniawan, Sutcliffe, Blenkhorn, & Shin, 2003;

Leporini, Andronico, & Buzzi, 2004). For individuals with visual impairments, the accessibility of information on the Web is best achieved with the use of the additional specialized software or hardware, referred to as “assistive technology”. The screen reader is the type of assistive technology that is used to interact with computers and the Internet among individuals with diverse levels of visual impairments (Evans & Blenkhorn, 2008).

Unlike sighted people who utilize visual feedback on the monitor screen, people with visual impairments reply on screen readers that convert the text information to synthetic speech and/or refreshable braille to access the content of Web pages. Due to the prohibitive cost of refreshable braille displays, they are rarely available outside the classroom (Strobel, Fossa, Arthanat, & Brace, 2006). Thus, accessing the Internet through screen readers is the most frequent choice for the vast majority of individuals with visual impairments.

This study attempted to explore how high school students with visual impairments use a screen reader to search for information on the Web. Previous studies considered mostly enhancing the design and structure of existing specific websites or operating systems as an important step toward meeting the needs of people with visual impairments who use screen readers (Hailpern et al., 2009; Han & Mills, 2007; Takagi, Asakawa, Fukuda, & Maeda, 2004; Tonn-Eichstädt, 2006; Yu, Kuber, Murphy, Strain, & McAllister, 2006). Craven and Brophy (2003) suggest that there is a great need for further exploration into the behaviors of people with visual impairments who use screen readers to seek information on the Web.

While there have been quantitative studies that emphasized the interface design of Windows environment or Web pages for people with visual impairments who use screen readers (Buzzi, Andronico, & Leporini, 2004; Correani, Leporini, & Paterno, 2006; Earl & Leventhal, 1999; Leventhal & Earl, 1997; Zeng, 2004), qualitative research into their experience or searching process and behaviors is relatively scarce (Craven, 2003; Jones et al., 2005). In addition, studies that describe difficulties and challenges encountered by people with visual impairments during their Web information searching process are needed. They would provide rich detail that is needed to fully understand and therefore, be able to solve the issues.

Despite the fact that the use of the Web as an information resource in education is rapidly increasing (Kuiper, Volman, & Terwel, 2005), limited effort (Shimomura, Hvannberg, & Hafsteinsson, 2010) has been made to explore the online information searching behaviors of adolescents with visual impairments. Although there has been some research focused on Web searching behaviors of adults with visual impairments when using screen readers (Craven, 2003; Jones et al., 2005; Lazar et al., 2007; Theofanos & Redish, 2003), their findings may not be entirely generalizable to high school students with visual impairments who are developing their Web information searching skills via screen readers. The manner in which younger adults with visual impairments search for and find information on the Web while using screen readers is a virtually unexplored area. To support high school students with visual impairments in finding information on the Web, studies are needed to understand students' experiences by examining their behaviors associated with the use of the Web in aid of screen readers.

Purpose of the Study

The primary goal of this study was to gain an understanding of information searching experiences of high school students with visual impairments who accessed the Web with the aid of screen readers. Thus, the purpose of the study was to provide a comprehensive insight into high school students' experiences by examining their information search behaviors on the Web through screen readers.

The findings were used (1) to help educators develop effective approaches to instruction for efficient Web exploration by students with visual impairments, and (2) to provide Web designers and screen reader developers with general input for improving the Web navigation experiences for students with visual impairments.

Research Questions

The purpose of this study was to explore behaviors of high school students with visual impairments when they used G-mouse screen reader to search for information on the Web to answer academic fact-based questions. This study identified challenges high school students encounter during the information searching process as well as the strategies they used to overcome these challenges.

The research in this study addressed the following questions:

Q1 How do high school students with visual impairments search for information on the Web to answer academic fact-based questions using G-mouse screen reader?

Q2 What challenges or barriers do high school students with visual impairments encounter during information searches on the Web using G-mouse screen reader?

Q3 How do high school students with visual impairments overcome challenges or barriers during information searches on the Web using G-mouse screen reader?

Significance of the Study

Searching for information within a specific area of interest on the Internet can be difficult for many people (Aula, Khan, & Guan, 2010; Wang, Hawk, & Tenopir, 2000). Nevertheless, the failure to search for answers to questions that are needed may be a significant problem for students with visual impairments. When using screen readers to search for information on the Internet, inaccessibility can become extremely frustrating for students with visual impairments (Lazar et al., 2007), and may ultimately force them to be excluded from the benefits of Internet.

The significance of this study was twofold: First, high school students with visual impairments are the subject of the examination that add to the limited body of knowledge of adolescents who are visual impaired and use screen readers to navigate the Web. Second, whereas previous research has illustrated usability problems of particular Web sites, this study extended the scope of investigation to understand the behaviors of students with visual impairments when finding information on the Web using screen readers.

The study was significant because it addressed issues that were specific to people with visual impairments who used screen readers from a user-experience perspective. As the use of images, graphics, animations, and multimedia to present information on the Web increases, Web information searching via screen readers may become highly ineffective for people with visual impairments due to the complexity involved. A shift of approach from an interface design perspective toward a view of user behaviors needed to be developed in order to take a step further to help improve Web information searching experience of students with visual impairments.

Overall, the previous investigations of Web information searching or the use of screen readers tended to focus on how to build better interfaces for people with visual impairments, removing any context of use. They didn't pay attention to the sequential way of processing information search on the Web. To truly meet the needs of people with visual impairments, it was necessary to understand how they search information on the Web in addition to interface design and technical issues. This study was from a user-experience perspective since the behaviors of students with visual impairments were taken into consideration. An emphasis on the types of behaviors students with visual impairments engaged in provided a deeper understanding of the complex process involved in Web information search.

In addition, it was an important step to incorporate input and feedback from real users from a user-experience perspective. In order to gain an accurate understanding of the behaviors, the process needed to be described from the point of view of students with visual impairments. Insights from comments and suggestions of students with visual impairments may increase knowledge of the underlying reasons for their searching behaviors and the main problems encountered while exploring a web page with a screen reader. This information may be useful in helping students with visual impairments move into more effective and satisfying search experiences on the Web.

Definition of Terms

The following terms were defined as they apply to this study.

Accessibility: In the era of electronic and information technology, accessibility refers to the ease with which everyone can reach and use technology and information products despite types of disabilities they have and kinds of technology they are using. Access can be achieved by complying with the requirements of the Section 508 of the Rehabilitation Act standards (United States Access Board, 1998).

Assistive Technology: According to the Individuals with Disabilities Education Improvement Act (IDEA, P.L. 108-446) of 2004, assistive technology refers to “any item, piece of equipment, or product system, whether acquired commercially off the shelf, modified, or customized, that is used to increase, maintain, or improve functional capabilities of a child with a disability” (IDEA, 2004, 34 C.F.R. Sec 300.5).

Information searching: Information searching refers to an individual’s conscious effort to locate and acquire content on the Web in an attempt to satisfy an information goal.

Internet: Internet refers to the worldwide connection of publicly accessible information network that are linked together by a set of standard protocols, such as Hypertext Transfer Protocol (HTTP). The term Internet is used interchangeably with “the Web” or "World Wide Web" (Slone, 2002).

Screen Reader: A screen reader is a software program used by people with visual impairments to interact with the computer. It is used in conjunction with a speech synthesizer and/or a braille refreshable display to convert information that is on a computer screen to speech and/or braille characters.

Usability: Defined by the International Organization for Standardization (ISO) 9241-11, usability refers to the extent to which a product can be effectively used by target users in performing a set of required tasks efficiently and satisfactorily (International Organization for Standardization, 1998).

Web Accessibility: Web accessibility refers to the degree that digital information presented in a Web site can be perceived and understood by people with disabilities through the use of assistive technologies as it is for individuals with no disabilities. Web accessibility can be evaluated with respect to compliance with international standards and guidelines, such as the Web Content Accessibility Guidelines established by World Wide Web Consortium (Caldwell et al., 2008).

Web Usability: Web usability refers to how easy and quick a user can explore the web site to locate, understand and use whatever information they want (Brinck, Gergle, & Wood, 2002).

Website or Web site: Website refers to a collection of interrelated web pages containing text, graphics, and multimedia contents. Each web site has a unique web address. Websites are the basic organizational element of the WWW.

World Wide Web (WWW) or the Web: World Wide Web (WWW) refers to a collection of hypermedia documents which can be accessed internationally via the Internet. Documents are formatted in a language called Hypertext Markup Language (HTML). They can be retrieved via Web browsers such as Microsoft Internet Explorer.

Summary

People with visual impairments who used screen readers frequently express confusion and frustration at various stages of Web information searching process

(Lazar et al., 2007). Websites containing accessibility and usability barriers can actually limit their pursuit of benefit from Internet which can provide opportunities for their success in education, employment, and independent living. The perspective of students with visual impairments was essential to the understanding of behaviors applied by them and barriers to usability in the Web information searching process. This study provided insights regarding how high school students with visual impairments conducted information searching on the Web using screen readers from a user-experience perspective. A rich data set about the process and behaviors involved can guide educators, Web designers, and screen reader developers toward improvement of the Web navigation experiences for students with visual impairments.

CHAPTER II

LITERATURE REVIEW

This chapter includes an overview of literature on the use of Internet and screen readers by people with visual impairments as well as on specific concerns about the accessibility and the usability when searching for information on the Web using screen readers. The review of literature begins by discussing potential benefits of the Internet for people with visual impairments and particular importance of the Internet for high school students with visual impairments.

The following section describes assistive technologies and their limitations when navigating through a Web site. The chapter continues with a discussion of guidelines and evaluations supporting the development of Web accessibility as well as specific barriers that people with visual impairments face when they use the Web. Furthermore, usability problems for users of screen readers on the Web are presented. This chapter ends with exploring the auditory learning for people with visual impairments.

Internet Use and People with Visual Impairments

Definition of Visual Impairments

Visual impairment is used to describe a broad variety of visual malfunction in an individual that includes both blindness and low vision (Russotti & Shaw, 2004;

World Health Organization, 2007). The definition of blindness and low vision varies across studies, depending on the purpose for the definition. From a public health perspective, blindness is considered visual acuity of less than 3/60 (20/400) in the better eyes, or corresponding visual field loss to less than 10 degrees, with best possible correction (World Health Organization). The World Health Organization's (2007) definition of low vision includes a visual acuity of less than 6/18 (20/60), but equal to or better than 3/60 (20/400), or corresponding visual field loss to less than 20 degrees, in the better eyes with best possible correction.

For government administrative purposes in the United States, legal blindness is defined as a person having best corrected acuity of 20/200 or worse in the better-seeing eye or his/her visual field is restricted to 20 degrees or less. This definition is derived from the Social Security Act in 1935 to determine people's eligibility for a wide range of federal and/or state services, benefits and specialized aids (Koestler, 2004). Although there is no legal definition of low vision in the United States (Corn & Koenig, 1996), low vision usually refers to best corrected acuity of 20/40 (6/12) or worse, but better than 20/200 (6/60) in the better-seeing eye. This level of vision is consistent with the eligibility criteria for obtaining a restricted driver's license in most states in the U.S. (Huss & Corn, 2004; Marta & Geruschat, 2004; Peli & Peli, 2002).

From both public health and governmental perspectives, the loss of clinically measured visual acuity and visual field are used as the key components for defining level of visual impairments. However, Corn and Koenig (1996) argue that these definitions provide little information for understanding how an individual use vision to perform activities of daily living. For educational purposes, a more functional definition of visual impairment has been established under federal law. According to the Individuals with Disabilities Education Improvement Act (IDEA, P.L. 108-446) of 2004, "visual impairment including blindness means impairment in vision that, even with correction, adversely affects a child's educational performance. The term includes both partial sight and blindness" (IDEA, 2004, 34 C.F.R. Sec 300.8(c)(13)). This definition of visual impairment is rather broad and nonspecific, and indicates that the level of visual function depends largely on the individuality and circumstances.

In fact, these three approaches to definition of visual impairments are different but all suggest that most people with visual impairments have some residual sight, although the degree of usable vision can vary greatly. Consequently, the effects of visual impairment on daily living and learning are unique to each individual. People with visual impairments are far from being a homogeneous group. Their needs are so diverse that cannot be easily met by one product or one service. For example, people with significant visual loss use screen readers when accessing information on the Web while people with low vision tend to use screen magnifications. However, people with low vision may experience fatigue when read online information and so they may need to use their auditory channel to access information. It is necessary to provide people with blindness and low vision with auditory means when it comes to access information on the Web.

Benefits

As the Internet become more prevalent and an integral part of everyday life, it is crucial for people with disabilities to be able to participate in them. Online information has benefits and potential for people with visual impairments. The results of considerable research indicated that the Internet has significant benefits for people with disabilities in terms of increasing participation, productivity, and independence in their daily living, information acquisition, employment, and social interaction.

Daily living. The use of the Internet can contribute to greater improvement of quality of life for individuals with disabilities than any other population group. Of those people with disabilities who are online, 48% reported that the Internet has significantly improved their quality of life, compared with 27% of those people without disabilities (Taylor, 2000a). One of the great benefits that the Internet has brought to the lives of people with disabilities was the independence. The Internet seems to help people with disabilities lead a more self-determined life (Cook et al., 2005; Grimaldi & Goette, 1999). Particularly for people with visual impairments, the Internet access has been shown to decrease their dependency on others (Berry, 1998; Williamson, Albrecht, Schauder, & Bow, 2001)

Information acquisition. The Internet helps people with visual impairments acquire information equally to their sighted peers in the information society. Traditionally, people with visual impairments were unable to access the information contained in an on-paper format. Edwards and Lewis (1998) stated that "access to the printed word has long been recognized as a significant barrier to the integration of visually impaired individuals into school and work environments" (p. 302). People with visual impairments used to wait months or years for printed information before they were converted into more accessible formats, such as in braille or on audiotapes (Kaye, 2000). The Internet is often considered a means by which people who are visually impaired are able to gain access to information that had previously been inaccessible or available only to sighted people (Berry, 1998; Williamson et al., 2001). By using the Internet, individuals with visual impairments can have direct access to the very same information it is immediately available to the sighted people (Kaye). Not only does use of the Internet allow people with visual impairments equal access to published information, it also provides unprecedented opportunities for true independence (Goggin & Newell, 2003). They can get all kinds of information all by themselves through the Internet without relying on others for assistance.

Employment. One of the factors that may hinder employment opportunities for individuals with visual impairments was the lack of information about possible jobs (Crudden & McBroom, 1999; O'Day, 1999). The Internet has the possibility to eliminate the previous limitations of gaining access to employment opportunities for people with visual impairments (Williamson et al., 2001). Douglas, Pavey, Clements, and Corcoran (2009) interviewed 500 working-age people with visual impairments and found that the Internet was one of the commonly used information sources for seeking employment.

Social interaction. While the Internet is able to provide an equal and independent information access, the interactive communication capabilities of the Internet can also be beneficial to individuals with visual impairments. The Internet opens up new channels of communication between people and becomes an alternative medium of interaction beyond and outside family, particularly for people who are socially isolated because of their disabilities (Taylor, 2000b; Williamson et al., 2001). In the study of Zúnica and Clemente (2007), people with visually impairments see the Internet as a valuable tool for communicating with others.

One of the advantages of online communication is access to disability-specific support groups from people with similar disabilities. It is especially important for people with visual impairments who have difficulty traveling and identifying people. One study reported that chat rooms and mailing lists dedicated particularly to people with disabilities were the preferred online places of individuals with disabilities (Seymour & Lupton, 2004). People with visual impairments perceived increased levels of social support particularly in online chat/instant messaging (Smedema & McKenzie, 2010). The Internet has great potential for nurturing social connectedness in individuals with visual impairments.

Another important benefit of online communication for people with visual impairments is that they are able to control others' perceptions of them using anonymous identity, and hence to avoid the stigma associated with their disabilities during the interaction with others (Dobransky & Hargittai, 2006). The general public may hesitate to interact with a person who has a disability due to a fear or uncertainty (Lenney & Sercombe, 2002). For people with disabilities, online communication can be a rare opportunity to interact with others without immediately revealing their disability until it is relevant (Bowker & Tuffin, 2002). Because of the relatively anonymous nature of the Internet, online communication affords people with visual impairments to liberate the disabled identity (McKenna & Seidman, 2005). In this way, individuals with visual impairments do not see themselves differently from other members of society (Williamson et al., 2001). Thus, online communication successfully provide an opportunity for people with disabilities to interact with others to the extent that may be impossible offline (Guo, Bricout, & Huang, 2005; Seymour & Lupton 2004).

Importance for High School Students with Visual Impairments

In order to successfully overcome potential problems during the transition from adolescence to adulthood, young people with disabilities must equip themselves with the necessary competencies and experiences they will need in the future (Groce, 2004). For high school students with visual impairments, being able to find and use information on the Web is becoming a key element of success in postsecondary education and employment as well as independent living.

Postsecondary education. As the Web-based environment has become a virtual space for students to learn (Berenfeld, 1996), the use of the Web is now required at all levels of academic activities by most of university classes (Allen & Seaman, 2010). For college students with visual impairments who have difficulty making use of the Web through screen readers, researching information on the Web provides special challenges. In exploring the engagement of college students who are legally blind with their coursework, Overton (2005) found that their prior high school experiences with technology contributed to or interfered with the ability to achieve academic success. The participants who incorporated various technologies into their class work in high school gained the knowledge of how to access the Web. In addition, they obtained the necessary skills to learn how to use new technology-based resources, such as course management systems. One participant who was provided minimal technology during the high school initially withdrew from the college because the participant was not able to use technology successfully to engage with the learning environment.

Employment. For high school students who choose not to go to college, their ability to adequately search for specific information still remains essential in today's employment arena. The U.S. Bureau of Labor Statistics employment projections for 2006–2016 indicated that there has been an increased demand for occupations within computer-related fields (Dohm & Shniper, 2007). Consequently, a high percentage of jobs will require some level of skill in computers and the Internet. Students with many years of experience in developing Internet information handling skills in school will be more employable (Kapperman & Sticken, 2000). This means that any high school student who enters the workforce with few Internet skills will have difficulty competing.

In the labor market, the problem of persistently high unemployment is especially serious among youth who are visually impaired. The preliminary data of the National Longitudinal Transition Study- 2 showed that among youth who are between ages of 16 and 21 years, those with visual impairments worked in paid employment at a rate of 31% during one or more years following high school (Cameto & Levine, 2005) and the rate of their labor force participation was only half that of the 63% employment rate of youth without disabilities (Wagner, Newman, Cameto, Garza, & Levine, 2005). Among the barriers in the ability of youth with visual impairments to engage in employment is efficient access to information (Shaw, Gold, & Wolffe, 2007). It was demonstrated that employment and computer use/Internet access go hand in hand in today's information era for youth who are visual impaired (Gerber & Kirchner, 2001).

Therefore, high school students with visual impairments need to possess proficiency in effective information access upon graduation in order to be competitively employed in the long run.

Independent living. With an abundance of information resources, the Internet opens up windows of opportunity for people with disabilities to live more independently (Goggin & Newell, 2003). Traditionally, students with visual impairments access information by means of braille, radio, audio cassettes and telephones. However, not only is it expensive to convert the information by using these assisted methods, the information can quickly become out of date. With the Internet, students with visual impairments have immediate and direct access to the same information as their sighted peers (Kaye, 2000; Williamson et al., 2001). Through screen readers they are able to read for themselves in order to complete daily living and educational tasks (Williamson et al., 2000). It is not simply the sheer volume of information that the Web provides, but the independent way in which the information is being accessed.

Assistive Technologies

Assistive Technologies

People who are visually impaired interact with computers and the Internet very differently from sighted people (Lazar, Feng, & Allen, 2006). To obtain access to Internet-based information, people with visual impairments typically use additional software or hardware to understand information that displays graphically on a computer's screen. This specialized software or hardware is commonly known as assistive technology (Axtell & Dixon, 2002; Kapperman & Sticken, 2000). The

Individuals with Disabilities Education Act (IDEA) (Individuals with Disabilities Education Act, 2004) defines the term of assistive technology device as "any item, piece of equipment or product system, whether acquired commercially off the shelf, modified, or customized, that is used to increase, maintain, or improve functional capabilities of a child with a disability" (20 U.S.C. Section 1401, sect. 602 [22]). Assistive technology helps students with visual impairments gain access to the same information as their sighted peers (Postello & Barclay, 2012).

A wide variety of assistive technologies are currently available which provide alternative approaches to enable people who visually impaired to access to information (Hersh & Johnson, 2008). Some of the assistive technology devices include screen readers, screen magnification, and braille displays (Leventhal & Jacinto, 2008). Enabling audio output of Internet content is possible either through the combination of a screen reader with a standard browser (Evans & Blenkhorn, 2008; Thatcher et al., 2002) or an audio browser (Asakawa & Itoh 1998; Zajicek, Powell, & Reeves, 1998). Concurrent tactile representation of Internet content can be achieved through refreshable braille displays (Hersh & Johnson; Paciello 2000). People with visual impairments often combine the above assistive technologies to increase their ability to access and use the Internet. Brophy and Craven (2007) explained that people with visual impairments may use a screen reader primarily, with a refreshable braille display to confirm missing information, for example, while they may use a screen magnification to browse the Web, with a screen reader to read out text-only parts of the webpage.

Screen Readers

The most common assistive technology used by people with any level of visual impairment to access the Internet is the screen reader (Slatin & Rush, 2003; Zhao, Plaisant, Shneiderman, & Lazar, 2008). Screen reader technology has developed and evolved over the last three decades. Screen reader used for converting text into speech became available with a general acceptance of the personal computer in the 1980s. However, the introduction of Graphical User Interfaces (GUIs) presented new issues for people with visual impairments (Boyd, Boyd, & Vanderheiden, 1990; Smith et al., 2004). The solution to the problem of access of GUIs for people with visual impairments eventually emerged (Thatcher, 1994). Screen readers have improved quickly as developers strive to catch up with the current trend of mainstream technology in Web applications (Axtell & Dixon, 2002; Evans & Blenkhorn, 2008).

A screen reader is a software application that works in conjunction with the output hardware to identify and interpret what appears on the computer screen (Presley & D'Andrea, 2008). A screen reader captures the information being sent to the screen and directs it either to a speech synthesis device to provide audio feedback or to a braille refreshable display for tactile output (Evans & Blenkhorn, 2008). Tactile displays may have some advantages in presenting information to people who are visually impaired, but braille refreshable displays require special experience or education in braille reading (Evans & Blenkhorn). Speech output is the most likely choice for understanding what is shown on the computer screen (Hersh & Johnson, 2008). For people with visual impairments, the auditory learning channel is an important alternative for processing information (Zhao et al., 2008). Speech output provides information access to many individuals who don’t understand braille (Evans & Blenkhorn; Pitt & Edwards, 1996). Most screen reader software provides basic features including:

- Screen readers can be configured to work with a wide variety of software applications such as word processors and Internet browsers (Amtmann, Johnson, & Cook, 2002; Presley & D'Andrea, 2008). While the users continue to access other software applications, screen readers automatically run in the background of system operation (Pitt & Edwards, 1996).
- Screen readers can read and pronounce screen content as words or characters. When reading sentences, screen readers pause for periods, semi-colons, commas, and at the end of paragraphs (Web Accessibilty in Mind, n.d.). Information is read from top left to the bottom right, line by line, in a sequential manner (Paciello, 2000; Leuthold et al., 2008).
- Screen readers speak characters aloud as they are keyed in (Hersh & Johnson, 2008).
- The acoustic features of synthesized speech, such as speed, pitch, and tone, can be adjusted to suit individual needs (Presley & D'Andrea, 2008).

As screen readers do not require the use of a mouse, the interaction with the computer can be achieved exclusively by using the keyboard (Harper, Bechhofer, & Lunn, 2006; Presley & D'Andrea, 2008) and all input comes from cursor keys and other keyboard shortcuts (Axtell & Dixon, 2002; Evans & Blenkhorn, 2008). In addition to reading text in a Windows environment, screen readers are also designed to access the Web pages by running alongside the Internet browser in an intelligent way. Internet browsers create visual presentations of Web pages from HyperText Markup Language (HTML) code and screen readers intercept the HTML code of the presented pages to interpret it for audio output (Buzzi, Buzzi, Leporini, & Akhter, 2009; Zajicek & Powell, 1997). Generally speaking, the audio rendering from screen readers is generated based on the Web page's source code. Basically, screen readers read images with ALT text but say nothing when ALT text is not present (Web Accessibilty in Mind, n.d.). Screen readers also allow users to move quickly around the Web pages by jumping from link to link, heading to heading, or paragraph to paragraph with specific keyboard commands, although the users may miss important information this way (Buzzi et al., 2009).

Currently, there are a number of commercial and free screen readers available for various operating systems. Some of well known screen readers include Job Access With Speech (JAWS) (Freedom Scientific, Inc., 2009), Window-Eyes (GW Micro Inc., 2009), both for working only on the Windows, VoiceOver (Apple Inc., 2009) for accessing the Macintosh, and G-Mouse (Lin, 2003) for processing Traditional Chinese on the Windows. There are unique variations in every screen reader as no two technologies are identical. The differences between various screen readers are that (1) the keyboard shortcuts of different screen readers seldom posses equivalent functions; (2) the synthetically generated voices in one screen reader rarely sound identical with those in the others; and (3) the significant information, such as link text, is pronounced in different ways (Web Accessibilty in Mind, n.d.). Despite differences in keyboard shortcuts, voices and notifying important information, the overall functionality and capabilities of various screen readers are extremely similar (Web Accessibilty in Mind).

They are similar enough that a technique effective for one screen reader is somewhat effective in others. In some situations, one of the screen readers is better at supporting certain contents than the other screen readers (Web Accessibilty in Mind).

Limitations of Screen Readers

Screen readers have improved greatly over the past decade in terms of effectiveness and efficiency. Despite currently technological advances, the usability of screen reader software remains limited for those with visual impairments (Leporini & Paterno, 2004). Due to the software incompatibility and limitations on the keyboard commands, the GUI adaptation and the Web navigation, screen readers can provide a partial solution for people with visual impairments.

Compatibility. It is noted that the main limitation of screen readers is the incompatibility of software to successfully interoperate with other applications (Lazar et al., 2007). Screen readers frequently conflict with other software and led to computer crashes, which were the second-highest cause of frustration for Internet users who are blind (Lazar et al.).

Keyboard commands. The second notable limitation of screen readers for those with visual impairments concerns the utilization of complex keyboard commands. Screen readers work on the basis of keyboard operation since people who are blind are unable to use the mouse function (i.e. pointing, scrolling, selecting, etc.) (Andronico, Buzzi, Castillo, & Leporini, 2005; Presley & D'Andrea, 2008). Many specialized software programs do not provide keyboard commands and become inaccessible for people with visual impairments who use screen readers to access electronic information (Presley & D'Andrea). Theofanos and Redish (2003) found that some of the combination of keystrokes required to execute the desired function can be difficult to remember. Jones et al. (2005) suggested that the reason people with visual impairments experienced difficulties in remembering keyboard commands might be a large number and the non-intuitive nature of these commands. One main barrier to keyboard operation is that it requires training on how to use it to best take advantages of the screen reading features (Milchus & Bruce, 2008). This was consistent with the results of a survey conducted by Williams, Sabata, and Zolna (2006), which revealed the requirement for training in the use of screen readers. Fourteen percent of working adults with visual impairments under age 55 were more likely to report the use of screen readers, while no working adults with visual impairments over the age of 65 reported the use of screen readers due to lack of training

Graphical user interfaces. The third limitation concerns the inability of screen reader to adapt to the graphical user interfaces (GUIs) (Hale, 2000; Ratanasit & Moore, 2005; Wersényi, 2010). The evaluation of screen readers in a Windows environment by Barnicle (1999) identified poor translation of visual displays by JAWS screen reader prevented people who are blind from forming a correct mental model of GUIs. The static spatial representation of a GUI seems to be the most difficult to transfer and is also hard to map auditorily (Wersényi).

Web navigation. Perhaps, the most significant limitation of screen readers is that they have been designed to be a general-purpose tool and not specifically for the purpose of navigating the Web (Zajicek & Powell, 1997). Consequently, screen readers impose several constraints on Web navigation. Screen readers provide people with visual impairments only with the textual components, but exclude access to spatial layout of web pages (Murphy, Kuber, McAllister, Strain, & Yu, 2008). Additionally, visual attributes like formatting features on the web pages are not processed or detected by screen readers (Leporini et al., 2004; Leuthold et al., 2008). Therefore, screen readers are not able to extract the visual cues, such as changes in font style or text sizes, for facilitating fast navigation or skimming web pages (Murphy et al.). Another constraint of using screen reader to navigate the Web is related to how screen readers present the information from the web pages. Often the information on the Web is read by screen readers on a word-by-word and line-by-line basis, starting from the top-left and coming down to the bottom-right of the web page, so only a small portion of the information can be accessed at one time (Goble, Harper, & Stevens, 2000; Lazar et al., 2007). Unfortunately, the overall picture of the web page is easily lost (Andronico et al., 2005). Moreover, screen readers serialize the content of the web pages as if in the form of a single column (Leporini, et al.). They force users to navigate in a sequential manner which may fail to convey the original design of the web page (Murphy et al.). Andronico et al. (2005) stated that screen readers present everything on the web page almost every time, even if it is the same as the previous page. The static portions of the web page such as banners, menu, links, may overload the reading, thus the navigation time can significantly increase for the user.

Accessibility on the Web for People with Visual Impairments

In addition to the problems discussed above concerning the limitations of the currently existing screen readers, poor accessibility of Web content is the other factor that hinders people who are visual impaired in fully benefiting from online information and service (Leuthold et al., 2008; Kelly, 2008; Zúnica & Clemente, 2007). The followings present a review of literatures related to guidelines for making the Web accessible to people with visual impairments, evaluation methods that help designers develop a more accessible Web, and the access barriers of web pages that needs to be addressed.

Guidelines

There have been several attempts to provide guidance and to aid in technical solutions to the design of a Web site in order to render it more accessible to users, in particular users of assistive technologies. Two guidelines are considered authoritative in providing comprehensive guidance for accessible web design: the Web Content Accessibility Guidelines (WCAG) from the World Wide Web Consortium's Web Accessibility Initiative (W3C/WAI) and the federal Access Board standards from Section 508 of the Rehabilitation Act of 1973, as amended in 1998.

WCGA 1.0. A comprehensive set of guidelines has been developed by the Web Accessibility Initiative (WAI), a subcommittee of the World Wide Web Consortium (W3C). The mission of this group is to promote a high degree of Web usability for people with disabilities. The WAI offers a set of recommended guidelines and checkpoints for creating accessible websites, known as the Web Content Accessibility Guidelines (WCAG). WCAG is a set of international standards for the design of accessible Web content.

The guidelines address two general themes- that is ensuring graceful transformation to accessible designs, and making content understandable and navigable. The WCAG 1.0 is made up of 14 guidelines and is divided into 65 checkpoints. Each checkpoint is assigned a priority level to define the importance of each checkpoint:

- failing to satisfy Priority 1 will make accessing the site “impossible” for some people;
- failing to satisfy Priority 2 will make accessing the site “difficult” for some people; and
- failing to satisfy Priority 3 will make accessing the site “somewhat difficult” for others (Chisholm, Vanderheiden, & Jacobs, 1999).

There are three levels of conformance to the Web Content Accessibility Guidelines 1.0:

- Conformance Level "A" -- all Priority 1 checkpoints are satisfied;
- Conformance Level "Double-A" -- all Priority 1 and 2 checkpoints are satisfied;
- Conformance Level "Triple-A" -- all Priority 1, 2, and 3 checkpoints are satisfied. This is the highest level of conformance possible, indicating that all barriers to web site accessibility have been adequately addressed. (Chisholm et al., 1999)

The WAI also suggests the following ten "Quick Tips" (World Wide Web Consortium, 2001), which should cover the main issues needed to ensure a Web page is accessible:

- Images and animations—use the "ALT" attribute to describe the function of each visual
- Image maps—use client-side image maps and text for hotspots
- Multimedia—provide captioning and transcripts of audio and descriptions of video
- Hypertext links—use text that makes sense when read out of context. For example avoid "click here"

- Page organization—use headings, lists and consistent structure. Use CSS for layout and style where possible
- Graphs and charts—summarize or use the "longdesc" attribute
- Scripts, applets and plug-ins—provide alternative content in case active features are inaccessible or unsupported
- Frames—use <noframes> and meaningful titles
- Tables—make line-by-line reading sensible. Summarize
- Check your work, validate—use tools, checklists and guidelines at: http://www.w3.org/TR/WCAG

The 65 checkpoints are aimed at a multitude of disabilities. However, a vast majority of the checkpoints are concerned with people with visual impairments (Lunn, Harper, & Bechhofer, 2011).

WCAG2.0. Since the guidelines were implemented in 1999, some of the proposed guidelines in WCAG 1.0 are considered as out-of-date. In December 2008, a revised version of WCAG 1.0 was released which is called WCAG 2.0 (Caldwell et al., 2008). Unlike WCAG 1.0, WCAG 2.0 does not have a list of checkpoints, but has a set of principles with a number of guidelines. WCAG 2.0 rests on four key principles:

> Anyone who wants to use the Web must have content that is: (1) Perceivable—Information and user interface components must be perceivable by users; (2) Operable — User interface components must be operable by users; (3) Understandable — Information and operation of user interface must be understandable by users; and (4) Robustness— Content must be robust enough

> that it can be interpreted reliably by a wide variety of user agents, including assistive technologies (Caldwell et al., 2008).

There have also been a number of studies that demonstrate the weaknesses in guidelines. According to Moss (2006), the guidelines are presented at a very abstract level using general and vague terms; they are difficult to use because they are couched in even more obscure terminology than WCAG 1.0, and they require a great deal of explanation to become comprehensible. Kapsi, Vlachogiannis, Darzentas, and Spyrou (2009) found several usability issues of WCAG 2.0 that they suggested could be significantly improved if usability issues could be communicated to the evaluators more clearly.

Section 508. Section 508 was amended to ensure that persons with disabilities have equal access to electronic information, directing the Architectural and Transportation Barriers Board (Access Board) to set standards for federal agencies to ensure compliance. The Access Board published standards that set forth a definition of electronic, information technology, and the technical and functional performance criteria necessary for such technology in order to comply with Section 508 (United States Access Board, 1998). The authors of Section 508 adopted many of the ideas in the WCAG 1.0, so a large amount of overlap exists between the two (United States Access Board, 2000b).

Thatcher (2001) provided a point-by-point comparison of the Section 508 standards and the WCAG 1.0 guidelines. The author indicated that paragraphs (a) through (k) of Section 508 corresponded to the Priority 1 checkpoints of WCAG 1.0. Table 1 outlines the corresponding sections from the Section 508 standards and WCAG

1.0 Priority 1 checkpoints as adopted from Thatcher (2001). The author also presented the differences between these two guidelines. The requirements for paragraphs (l), (m), (n), (o) and (p) under Section 508 standards differed from WCAG 1.0 Priority 1 checkpoints, and four WCAG 1.0 Priority 1 checkpoints, 1.3 (Auditory descriptions), 4.1 (Natural language), 6.2 (Dynamic content) and 14.1 (Clear language), were not addressed by Section 508 standards. The difference between the WCAG guidelines and Section 508 standards is that WCAG guidelines represent a higher level of accessibility and are also specific to actions in making websites accessible, while Section 508 standards define the minimum level of web accessibility (Poore-Pariseau, 2010). Although design guidelines exist to help developers and designers in this regard, conformity does not guarantee effective accessibility for the blind (Clark, 2006; Mankoff, Fait, & Tran, 2005).

Table 1

Section 508 Standards and Web Content Accessibility Guidelines 1.0 (WCAG 1.0) Priority 1 Checkpoints That Correspond.

Adopted from Thatcher, J. (2001). Section 508 Web standards and WCAG priority 1 checkpoints: A side by side comparison. The Research Exchange, 6(3), 1-12.

Topic	Section 508 Standards	WCAG 1.0 Priority 1 Checkpoints
Text Equivalents	(a): A text equivalent for every non-text element shall be provided (e.g., via "alt", "longdesc", or in element content).	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, frames, images used as list bullets, spacers, graphical buttons, audio files, and video.

Table 1, continued

Topic	Section 508 Standards	WCAG 1.0 Priority 1 Checkpoints
Synchronized multimedia	(b): Equivalent alternatives for any multimedia presentation shall be synchronized with the presentation.	1.4: For any time-based multimedia presentation (e.g., a movie or animation), synchronize equivalent alternatives (e.g., captions or auditory descriptions of the visual track) with the presentation.
Color	(c): Web pages shall be designed so that all information conveyed with color is also available without color, for example from context or markup.	2.1: Ensure that all information conveyed with color is also available without color, for example from context or markup.
Style Sheets	(d): Documents shall be organized so they are readable without requiring an associated style sheet.	6.1: Organize documents so they may be read without style sheets. For example, when an HTML document is rendered without associated style sheets, it must still be possible to read the document.
Server-Side Image Maps	(e): Redundant text links shall be provided for each active region of a server-side image map.	1.2: Provide redundant text links for each active region of a server-side image map.
Client-Side Image Maps	(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.	9.1: Provide client-side image maps instead of server-side image maps except where the regions cannot be defined with an available geometric shape
Table Headers	(g): Row and column headers shall be identified for data tables.	5.1: For data tables, identify row and column headers.

Table 1, continued

Topic	Section 508 Standards	WCAG 1.0 Priority 1 Checkpoints
Complex Tables	(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.	5.2: For data tables that have two or more logical levels of row or column headers, use markup to associate data cells and header cells.
Frames	(i): Frames shall be titled with text that facilitates frame identification and navigation.	12.1: Title each frame to facilitate frame identification and navigation.
Flicker	(j): Pages shall be designed to avoid causing the screen to flicker with a frequency greater than 2 Hz and lower than 55 Hz.	7.1: Until user agents allow users to control flickering, avoid causing the screen to flicker.
Alternative Pages	(k): A text-only page, with equivalent information or functionality, shall be provided to make a web site 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.	11.4: If, after best efforts, you cannot create an accessible page, provide a link to an alternative page that uses W3C technologies, is accessible, has equivalent information (or functionality), and is updated as often as the inaccessible (original) page.

Evaluation

The evaluation of Web accessibility can be undertaken using a variety of methods. The W3C/WAI recommends the automatic, expert and user testing (World Wide Web Consortium, 2008). Automatic testing detects problems that require knowledge of html, while expert and user testing can identify issues that require human judgment.

Automated tools. The use of automatic evaluation tools is the first step for web sites evaluation because they quickly identify accessibility problems that can be recognized at the level of the source code of a web page and produce reports with accessibility errors and warnings according to a set of WCAG guidelines. This is a popular way of assessing the accessibility of a web site because many of the automated evaluation tools available are provided online and often free of charge such as LIFT and W3C Validator. But the results from automated testing can be misinterpreted and may not provide the whole picture in terms of accessibility mainly because accessibility. This is not solely a technical issue, but primarily requires human judgment. In fact, Ivory and Chevalier (2002) observed that neither automated evaluation tools nor guidelines alone, are adequate for insuring accessibility for users who are disabled.

For example, a simple principle like the WCAG checkpoint 1.1 recommends a text equivalent for every non-text element, but the description of an image is often provided without considering what function the image is in the context. It is meaningless to people with visual impairments when an image for the spacer is displayed with an alternative text “space” (alt=“space”) and an image of the decorative horizontal rule is displayed with an alternative text “line” (alt=“line”) (Takahashi, 2005). The appropriate alternative text should be the empty string (alt=””). Another example is the inappropriate text equivalents for hyperlinks and navigation icons such as "Click Here", ”Link to”, "Back", "Home" and "Forward". Without their surrounding context, these alternative texts always mislead or confuse people with visual impairments who use screen readers (Fukuda, Saito, Takagi, & Asakawa, 2005). Furthermore, none of the automated evaluation tools are capable of evaluating whether alternative texts, titles, labels, or table summaries are presented in a meaningful manner (Ivory, Mankoff, & Le, 2003).

Expert testing. Expert testing is conducted by accessibility experts who examine the source codes and also view web pages, applying their expert knowledge to assess the accessibility of the page. Expert inspections of accessibility can identify a considerable number of problems that are not possible to find by using automated evaluation tools alone. WCAG explicitly refers to accessibility issues that require human check and provides techniques that can assist expert evaluators to simulate access situations that users may meet due to limitations of assistive technology and access environment. These include strategies such as turning frames off, turning sound off, navigating without a pointing device, accessing the web site via multiple browsers, accessing the web site via text browsers, accessing the web site via a voice browser, testing with different screen resolution, and others (World Wide Web Consortium, 2005).

User testing. The involvement of users with disabilities in accessibility testing is an important aspect of accessibility evaluation, as people who are disabled will often pick up specific and detailed problems overlooked by automated evaluation tools (Mankoff et al., 2005). User testing also reveals usability issues related to the design of the web page. Unfortunately, user testing with disabilities is often beyond the expertise or financial resources of a web developer, and is more time consuming than other methods (Mankoff et al.). Clark (2002) lists several difficulties that may preclude testing with users who are disabled including the difficulty of finding potential users and the accessibility of the testing location. His conclusion is that there is no immediately obvious or attainable solution for the problem of testing web sites with actual disabled users. He suggests the hope that outside consultancies will fill this gap.

In summary, some comparisons have been done between automated evaluation tools (Ivory & Chevalier, 2002) and other techniques have been studied (Coyne & Nielsen, 2001). There is disagreement about the best methods for evaluating web pages for accessibility. In the absence of other options, developers are often advised to use automated evaluation tools, despite their known flaws (Mankoff et al., 2005).

Accessibility Barriers

People who are visually impaired interact with the Web through a screen-reader. For screen readers to work properly, web pages must be appropriately designed and must conform to various guidelines for accessibility. Unfortunately, many pages are not appropriately designed, thus causing difficulties for people who are visually impaired. The features in the Web which are significant barriers to people with visually impairments are summarized by the researcher as follows:

Links. Screen-reader users rely on the underlying structure to navigate Web sites, with the labeling of links playing an important role in determining whether a Web site was considered as accessible or inaccessible (Stein, 2000). On a Webpage, there are many links or sub-links which direct online users to another Webpage or other. Links hinder the swift navigation of a Website. Screen readers cannot distinguish each link unless an “alt-text” is provided to describe what each link is connected to. Without an “alt-text,” screen readers only read out, “links…links…links” (Stein). Therefore, people with visual impairments need to click on each link to find out whether that particular link leads to the information they are looking for (Loo, Lu, & Bloor, 2003).

Frames. Frames are a navigational challenge due to the necessity to address window focus to a specific frame for navigating the links via keyboard tab navigation. Even though there are features that can be accessed via frames to provide assistance in navigation, such as the use of frame titles and the NOFRAME tag, these features are seldom used, or if used, are not labeled accurately (Coonin, 2002; Hoffman & Battle, 2005; Stewart, 2002).

Tables. When tables are used in layout of text and graphics on the page, it poses a great challenge for people who are visually impaired due to the ordering in which text is read. While the majority of screen readers come with various options for reading a table by column or by row, there is still the problem of empty cells encountered in the table as well as the continual repetition of column/row headers to orient the user (Amtmann et al., 2002).

Graphical content. As the Internet evolved from the text format to the Window based multi-media format, website designers inserted pictures, video, and Macromedia flash in designing websites. Any visual elements without “alternative tags” to describe the visual information, such as pop-up messages, banners, graphic headlines and menus, buttons, icons, animations, and pictorial contents and are only identified as “image” cause screen reader programs to stop reading the Web page or to go blank (Axtell & Dixon, 2002; Lewis & Kaluber, 2002; Takagi et al., 2004). Stein (2000) reports that a screen reader program reads graphics as, “image…” rather than providing information as to what the images are about. The undefined graphics becomes problematic when the image itself contains information they are looking for (Han & Mills, 2007).

Forms. Website designers utilize forms on Web pages for the purposes of collecting information. The design of these forms can be discouraging when screen readers may not recognize that there is a form such as an online registration form. For users who are blind, poorly designed or unlabeled forms was the third-highest cause for frustration in websites (Lazar et al., 2007). When accessing the websites with screen readers, there are problems with reaching the input element, to identify the label of the form element and to reach the submit button. The major issue is that people with visual impairments do not know where to place the cursor as they cannot see to put click in each box in the online form (Han & Mills, 2007). It is difficult for computer users who are visually impaired to find the correct line, place the mouse, and click on it in order to fill out forms (Han & Mills). Therefore, individuals with visual impairments often need assistance from a sighted person to complete online forms.

Application content. It is not only images that cause problems but Java Applet and Macromedia files are also a burden. Java is an object-oriented programming language often applied to complex applications such as games, video, and animation players. Screen readers cannot read Java and Macromedia Web applications such as Flash. Sometimes, there are links or menu options embedded in Java or Flash programs, people with visual impairments cannot utilize those options as they are not recognizable by screen reader programs (Han & Mills, 2007; Hoffman & Battle, 2005; Stewart, 2002). Flash also causes screen readers to continuously restart reading a Web page (Smith, 2004). In addition, constantly changing Flash contents also cause screen readers to return to the top of the page as the reader assumes that there has been an amendment on the Web page due to signals sent by Flash to the screen reader (Smith).

Usability on the Web for People with Visual Impairments

Definition of Usability

There are many aspects of usability and the concept is somewhat subjective. Rosson and Carroll (2002) describe usability as “the quality of a system with respect to ease of learning, ease of use, and user satisfaction” (p. 9). Shackel (1991) states that “usability depends upon the design of the tool in relation to the users, the tasks and the environments, and upon the success of the user support provided” (p. 24). He proposes that usability for individual users should be judged by both the subjective assessment of the ease of the design and by the objective performance measures of effectiveness in using the product. To be more specific, evaluation should be based upon the following criteria. Shackel (1991) suggests:

- success rate in meeting the specified ranges of users, tasks and environments,
- ease of use in terms of judgments,
- effectiveness of human use in terms of performance in learning, relearning and carrying our a representative range of operations (p. 24).

Nielsen (2003) identified five core components that defines usability, these are:

- Learnability: The system should be easy to learn so that the user can rapidly start getting some work done with the system.
- Efficiency: The system should be efficient to use, so that once the user has learned the system, a high level of productivity is possible.

- Memorability: The system should be easy to remember, so that the casual user is able to return to the system after some period of not having used it, without having to learn everything all over again.
- Errors: The system should have a low error rate, so that users make few errors during the use of the system, and so that if they do make errors they can easily recover from them. Further, catastrophic errors must not occur.
- Satisfaction: The system should be pleasant to use, so that users are satisfied when using it; they like it.

Nielsen focuses more on the system and the interface itself. Although he accounts for some context of use in the sense that he argues that in order to improve usability, one should evaluate new designs with a number of actual users.

Differences between accessibility and usability. Accessibility and usability are closely related, but while accessibility is aimed at making the website open to a much wider user population, usability is aimed at making the target population of the website more efficient and satisfied (Leporini & Paterno, 2004). In practice accessibility tends to be technology led and usability tends to be user led. This has revealed some conflicts, when a web page is deemed accessible because it conforms to guidelines such as WCAG, but still presents problems to the user. This could be because their version of assistive technology does not work as well with the page as the most up-to-date version, or because the technical solution does not match the experience of the user. 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 (Brophy & Craven, 2007). The key to website usability is ensuring that the site is both useful and usable for the intended audience. Technical accessibility is a pre-condition for usability. (Leporini & Paterno, 2004). A survey of blind and visually impaired people using electronic information services in public libraries found that adherence to accessibility guidelines will not necessarily ensure that services are usable for blind and visually impaired people (Lewis, 2004).

Web Usability Problems

Even when a Web site conforms to certain accessible design standards, it is not necessarily easy to use with screen readers. Four aspects that can cause usability problems in accessible web sites for people with visual impairment who use screen readers are identified by the researcher as follows:

Links. For instance, the information on the Web page may be arranged in such a layout that blind users become frustrated in attempting to access the information. According to the study of Lazar and his colleagues (2007), many pages contained redundant links, which required a blind user to read each Web page in a line-by-line fashion. With each selection of a link, users must start from the top of the page in reading until they either reached the bottom of the page or found a desired link. The selection of a new link refreshed the screen, which generally forced screen readers to move focus to the top left-hand corner of the screen. The frustration occurred when users must listen to the same information each time they chose a new link. Craven (2003) also found that a screen reader read out each link one by one which can be very difficult to remember. The study of Byerley and Chambers (2002) revealed that placement of irrelevant links at the top of Web pages was a great inconvenience that required users to sift through a lot of “stuff” before they heard what they needed. They preferred drop-down boxes to long lists of links so that they can reformat them in alphabetical order with the screen reader. Gerber (2002b) echoed that the redundancy of main navigational links was not only annoying, it interfered with navigating because the user didn't know that a new page had loaded.

Banners. Lazar et al. (2007) found another example of layout problem was the use “banners” which caused the screen to refresh every time there was a change in the banner text. This may cause screen-reading software to lose focus and often resulted in the user hearing information that was not at the position of the cursor.

Excessive unwanted information. Han and Mills (2007) found that for users who are visually impaired there was an overload of information on busy web sites which complicated their search process making the whole experience tedious. The participants in the study of Craven (2003) felt that they were less happy with pages that provided them with too much information because such pages were time consuming and overbearing.

Website redesign. The participants in the study of Han and Mills (2007) noted that the frequent redesigning of Websites was inconvenient. Users who are visually impaired often remembered the overall structure of a website in terms of content location and which link to click on to get to desired information. However, if a website was redesigned, then a known Web structure was often no longer valid in the minds of users with visual impairments. Users with visual impairments thus had to relearn the structure of the website all over again which required them to read all the contents and click on each link before being able to utilize the website.

Auditory Learning

The learning of people who are blind or low vision is most likely to be affected by their visual impairments. Listening becomes an important learning modality that enables them to obtain cognitive, literacy, and social skills (Byrnes, 2012). Learning through listening is an essential component of the expanded core curriculum for educating students with visual impairments (Hatlen, 1996; Huebner, Merk-Adam, Stryker, & Wolffe, 2004).

Listening is frequently compared to reading since the skills developed in both processes are very similar, such as selecting main idea, sequential ordering, summarizing, making inferences (Harley, Truan, & Sanford, 1997). In the both processes of listening and reading, spoken language or words are converted to meaning in order to be understood. However, listening for some school-age students with visual impairments has proven to be a more efficient means of providing information than either braille reading or large print reading. Individuals with visual impairments read braille at about 100 words per minute (Mangold, 1982) and listening to recorded materials can be up to speeds of approximately 175 words per minute (Nolan & Morris, 1973). Nolan (1963) found that braille readers from sixth to tenth grade could be able to process information through listening at rates of one third of their braille reading time. Morris (1966), using students who are legally blind from grades 4-6 and high school, indicated that learning through listening could be 155-360 percent more efficient than through braille or large print reading.

But listening is not meant to be a substitution for reading. For people with visual impairments, listening is considered as an essential compensatory mode for increasing access to information (Jackson, 2012). When time is of concern, listening provides a means of increasing learning efficiency; thus, the level of efficiency that people with visual impairments attain in listening affects their learning (Denton & Silver, 2012). Some factors are found to have an impact on the overall process of listening and are related to determine the level of efficiency in listening. They will be examined below.

Attention and Listening Environment

Attention. The main influences on whether the information is received are the person's attention and focus levels, as well as listening environment. A person's attention and focus is a prerequisite for promoting efficient listening (Bishop, 2004; Denton & Silver, 2012). Aldrich and Parkin (1988) reported that listening to an audiotape made it much more difficult for people who are blind to control the flow of information and lead to decreased concentration. In addition, Parkin and Aldrich (1989) observed that people with visual impairments using information via audiotapes experienced more distractions than the readers. Difficulty sustaining attention and concentration affects the ability to listen and learn for people with visual impairments. Fortunately, Tadic, Pring, and Dale (2009) found that many students with visual impairments developed the ability to take control of their attention through sound or touch cues.

Listening environment. Besides a person's attention, the listening environment also affects the receipt of an auditory message. An important part in supporting an optimal listening condition is the eliminating unnecessary noise (Staples, 2012; Denton & Silver, 2012). Bischoff (1979) recommended the reduction of extraneous distractions to improve listening comprehension. To listen in environments without excessive background noises, people with visual impairments can learn more easily to focus on essential sounds (Byrnes, 2012). A simple solution to create the listening environment less of distraction is the change of a person's physical location within a room, such as seating close to the speaker or away from distractions (Denton & Silver).

From part to whole. The level of listening efficiency is sometimes influenced by a person's ability to listen and synthesize what they hear into a framework. Listening is almost entirely sequential in nature (Bishop, 2004). One can hear only one character or word at a time and is forced to wait for the next utterance. Restricted in the separate pieces of information available to them, children with visual impairments may have fragmented impressions of their world (Barclay & Staples, 2012). Children with visual impairments often have difficulty comprehending the overview or framework of an experience (Ferrell, 2000). This linear and fragmented presentation of information requires a different cognitive process. People with visual impairments often need to learn concepts from part to whole (Fazzi & Klein, 2002; Heinze, 2000). They need to synthesize the discrete pieces of information and weave them together into a whole.

Experience

Sound is transient and may be meaningless on its own and too abstract for children with visual impairments (Byrnes, 2012; Staples, 2012). Since children with visual impairments are incapable to use vision to attach meaning to sounds, they need to have meanings provided to them. Participation in real experiences provides opportunities for them to connect what they hear to what is happening, because experience provides a meaningful context for understanding (Barclay & Staples, 2012;

Postello & Barclay, 2012). Deliberately pairing listening with other sensory, hands-on experiences, such as touching the object, feeling the emotion or being in the place, allow a child to have the full contextual experience and thus enhances a child's understanding (Barclay, 2012). Listening, when paired with the opportunity to touch, is a powerful means in concept formation (Byrnes, 2012). It is most helpful for students with visual impairments to have repeated and consistent opportunities for experiences that linking listening to other sensory inputs within their daily routines and naturally occurring activities as well as specialized activities (Byrnes, 2012).

Active Listening

Active listening is a very important variable that retains the listening efficiency. Listening is not the same as hearing; it is associated with the mind rather than just the ears. Listening seeks meaning of what is being heard and requires that the listener to recognize, comprehend, and interpret information received (Postello & Barclay, 2012). Listening is an active skill in contrast to passively "hearing" auditory information. Active listening means to take in information attentively with the intention of fully understanding the meanings (Herlich, 2012). Nolan and Morris (1969) found that active listening helps to improve listening. He observed that active listening led to greater learning outcomes for literature, science and social studies at the high school level. Active listeners did much better in listening than students who sat passively. Their active listening activities consisted of note-taking, asking questions of a speaker, discussing the audio materials, and controlling the speed of taped recordings. Active listening is a foundation for academic success. To be efficient listeners, students with visual impairments at secondary school level need to be taught effective note-taking skills (Herlich).

In order to understand online information spoken out by screen readers efficiently, people with visual impairments need to apply the same listening skills in learning to online information searches, including paying attention, eliminating extraneous distractions, synthesizing information from part to whole, pairing with full contextual experience, and listening actively.

CHAPTER III

METHODS

The purpose of this study was to explore the phenomenon of the interactions between high school students with visual impairments and web sites via screen readers. Qualitative research methods and case study design were used to provide detailed descriptions of actual users' information searching behaviors and to learn about their understanding of accessibility and usability issues. This chapter describes the methods of data collection and data analysis that were used to conduct this study with a description of managing the issue of the trustworthiness and the ethical considerations.

Research Design

Qualitative Methods Design

This study employed qualitative methods and a case study design to understand the experiences of high school students with visual impairments in Taiwan when they searched information on the Web using a screen reader. This study attempted to provide an in-depth description regarding their behaviors, challenges, and coping strategies. Denzin and Lincoln (2008) defined qualitative research as "a situated activity that locates the observer in the world. It consists of a set of interpretive material practices which make the world visible" (p. 5). This research focused on the students' information searching behaviors and intended to provide a way to make this unexplored area more visible to readers and yield increased understanding.

As the main focus of this study revolved around the information searching experiences and perceptions of high school students with visual impairments, qualitative research was a valuable methodology for exploring human experiences. According to Creswell (1998), “Qualitative research is an inquiry process of understanding based on distinct methodological traditions of inquiry that explores a social or human problem. The researcher builds a complex, holistic picture, analyzes words, reports detailed views of informants, and conducts the study in a natural setting” (p. 15). A qualitative research study that the researcher proposed built a deep portrait of information searching experiences of high school students who are visually impaired in Taiwan upon data collection from the natural setting. In addition, Merriam (1998) explained qualitative research “is an umbrella concept covering several forms of inquiry that helps us understand and explain the meaning of social phenomena with as little disruption of the natural setting as possible” (p. 5). This study attempted to explore how high school students who are visually impaired made sense of information searching on the Web and how they interpreted challenges they experienced. Therefore, the qualitative approach was appropriate to obtain the participants’ perspectives.

Case Study Design

This qualitative research study utilized a case study design to explore the experiences of high school students who are visually impaired in Taiwan when they used screen readers to search information on the Web. Case study research was conducted on what is termed a bounded system. The case can be an individual, a group, an activity, an incident, or a group of organizations. Stake (1995) stated that "the case is a specific, a complex, functioning thing" and suggested that each case has "a boundary and working parts" (p. 2). In addition, Creswell (2007) shared the same concept of a bounded system by noting "case study research involves the study of an issue explored through one or more cases within a bounded system" (p. 73). In this study, the bounded system was an educational institution specialized for people who are visually impaired in Taiwan. The unit of analysis was at the individual level and is the high school students at this school.

Furthermore, case study methodology stressed the study of the unit in a situation or in context. Yin (2009) indicated that "A case study is an empirical inquiry that investigates a contemporary phenomenon in depth and within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident" (p. 18). Merriam (1998) elaborated the case study is to "gain an in-depth understanding of the situation and meaning for those involved. The interest is in process rather than outcomes, in context rather than a specific variable, in discovery rather than confirmation" (p. 19). Therefore, a case study was considered appropriate as this study concerned with the information searching process of high school students with visual impairments in Taiwan when using screen reader.

A salient characteristic of case study is that multiple data collection methods should be used. As Yin (2003) explains, "The case study inquiry copes with the technically distinctive situation in which there will be many more variables of interest than data points, and as one result relies on multiple sources of evidence, with data needing to converge in a triangulating fashion, and as another result benefits from the prior development of theoretical propositions to guide data collection and analysis" (p. 13-14). Creswell (2007) also stated "the investigator explores a bounded system of a case (or multiple cases) over time, through detailed, in-depth data collection involving multiple sources of information (e.g., observations, interviews, audiovisual material, and documents and reports), and reports a case description and case-based themes" (p. 73). This study utilized multiple data sources such as pre-task interviews, observations of online information searching activities, and post-task interviews to explore issues of Web information search using screen readers from participants' perspectives.

Role of the Researcher

Before this study, the researcher was an itinerant teacher for students with visual impairment for three years. The researcher taught students with visual impairments from first grade to 12th grade at several different schools. Besides, the researcher volunteered tutoring English for high school students after school at a special school for student with visual impairments for two years. Because of the tutoring, the researcher had contact with several school administrators, teachers and staffs. This experience at the special school for student with visual impairments was an asset for providing access to the participants and establishing the relationships needed to collect rich data. However, the researcher's teaching and tutoring experience also came with a set of biases. Exposing these biases at the beginning of the study was important to help the researcher establish credibility as a researcher (Creswell, 2007; Merriam, 1998; Stake, 1995).

Because of the researcher's experience as a teacher for students with visual impairments, the participants might have been somewhat reluctant to fully disclose their thinking during the interview. To address this concern, the researcher explained that the participants' identities would remain confidential and that the information they provided would be used purely for the purposes of research. The researcher strove to set a tone in interviews of open-minded inquiry. The goal was to explore the use of G-mouse screen reader in online information searches, not to assess their performance on information searches, nor to judge whether their effort was successful or not. The general willingness of participants to discuss sensitive topics suggested that the researcher's previous professional role was not a large barrier to data collection. Participants chose to discuss topics that could be perceived as not reflecting well on them individually, or on their teachers. For instance, some participants chose to describe an experience that was clearly a personal defeat.

As an itinerant teacher for students with visual impairments, the researcher's teaching was limited to one-on-one and there was no standard curriculum for teaching students with visual impairments. This was very different from the instructional situation of students in the special school for students with visual impairments. The students in the special school were teaching with a minimum of thirty students per class and their classes used the performance standards to guide the curriculum. Of importance to the researcher was not losing touch with understanding the students in the special school, the researcher tutored a group of high school students after school twice a week for two years. This role as both an itinerant teacher and a tutor in the special school offered the researcher a unique perspective regarding the experiences of high school students in the special school and a need to understand the experiences of their online information searches.

Data Collection

This study used a combination of pre-task interviews, observations of online information searching activities, and post-task interview to collect data. First, setting and participant selection were presented to describe where the data were collected and the process that was used to select student participants. Then the Web searching tasks that were performed by the participants and equipments were listed. Next, the pre-task interviews and the observations were discussed. Finally, post-task interviews captured the voices of the high school students with visual impairments as they reflected aloud on the online information searching process.

Findings from a Pilot Study

A pilot study of online search sessions was conducted in the Fall 2010 to determine the data collection process. The fact-based tasks and online search procedure were tested to ensure the wording of search tasks as well as the technical requirements of screen capture tools. Participants for the pilot study were two high school students who are blind from the same school as in this study. The first pilot session was with an 11th grade male student. He rated himself to be “very experienced” in using screen reader to search information on the Internet. The second pilot session was with a 12th grade female student. She considered herself to be “not experienced” in both using the Internet and the screen reader.

The pilot participants were asked to verbalize their thoughts and actions while using a screen reader to perform five search tasks online. These five fact-based tasks based on five subjects are: (1) Language arts: Find out how many stars and stripes there are on the flag of the United States; (2) Social science: Find a web site that cites evidences in what year Taiwan became Japanese colony; (3) Literature: Find the name and a complete text of a poem which describes his life in Cambridge from Chinese modern poet Chih-Mo Shiu; (4) Music: Find a downloadable music clip of native Taiwanese music; and (5) Science: Find a web site that cites recent scientific evidences about the global warming. Their web interactions were captured by a digital camcorder and observed by the researcher.

A few changes were made based on the pilot participants' feedback. The first change was the reduction in the amount of search tasks. The last two search tasks were removed from the original task list and only the first three search tasks were used because none of the pilot participants completed all five tasks due to mental exhaustion. During the pilot study, the average session per task would take the participants 30 to 60 minutes to complete and they were tired after two hours. Therefore, the pilot sessions illustrated that three tasks would be suitable for using in this study. In addition, some minor changes were made to the wording of task descriptions that confused the pilot participants.

The second change was made to drop the method of think-aloud to collect data and after-task interview was added. From the pilot session, it became clear that the think aloud would not be a useful method in practice for users of screen readers. The particularly difficult aspect of think-aloud behavior was to conduct two cognitively demanded activities at the same time. The pilot participants reported that they needed their full attention to listen to the information that the screen reader was reading aloud and had limited memory capacity left for speaking out their thoughts and actions. When pilot participants went silent and forgot to speak out, the researcher prompted questions to remind them to speak out. In several instances, the pilot participants would ask the researcher to stop because it interfered with their task performance. In the end, there were little think aloud data available for understanding what they were doing and why. Therefore, the think aloud method was removed. Since this study required deep description about online information searching behaviors from the participants, the after-task interview could satisfy in eliciting the required data through asking the participants to talk about the search tasks that they just conducted. It was crucial that after-task interview did not interrupt the participants' online information searching process.

Participants

Sample selection in this study was purposeful and non-random in order to recruit participants who were able to provide the information about issues important to the purpose of the research (Patton, 2002a). Merriam (1998) stated "Purposeful sampling is based on the assumption that the investigator wants to discover, understand, and gain insight and therefore must select a sample from which the most can be learned" (p. 61).

The final sample for this research was six students. The students from grades 10 through 12 at a school for the visually impaired in Taiwan were selected based on the following two criteria:

- Primary use (2-4 months) of screen readers for output information from a computer.
- Some experience in navigating or retrieving information from the Web.

The purposeful sampling (Creswell, 2007; Patton 2002a) was used in this qualitative study. As the information searching process of high school students with visual impairments has rarely been studied before, this study explored the characteristics of this phenomenon with a small number of cases rather than a large sample. Purposeful selection (Yin, 2003) allowed the researcher to select a small sample based on specific research criteria to obtain the most knowledgeable and experienced participants. The purposeful sample selection provided the opportunity to identify “information-rich cases” which can be studied in depth (Patton, 2002a, p. 243) rather than a random sampling of the population which ensured representativeness of the data gathered.

The study sample came from students in the school for visually impaired where the researcher previously volunteered tutoring. The participants chosen for this study were high school students with visual impairments because they possessed equivalent formal training prior to this study as this school offered a computer course starting at 10th grade. The instruction included an overview of how to use the screen reader and basic strategies in searching the Web. Thus, high school students with visual impairments had minimum experience and were knowledge in searching information on the Web using the screen reader.

Even though high school students at this school for the visually impaired all had some previous experience with the screen reader and the Web in their 10th grade computer course, the researcher sought to limit the sample to experienced students who utilized the screen reader and the Web to solve information problems for their own personal or educational purposes after school. Experienced students had the knowledge and skills necessary to search for information on the Web so that they could focus on the Web information rather than the technology.

Unlike quantitative studies where the ultimate purpose was the generalizability by using a recommended sample size, there was no defined rule as to the number of participants required in a qualitative study. The sample size cannot be predicted at the initial stage of the study. Thus, the number of required participants may become obvious as the study progresses. More than likely, determining an appropriate sample size for a qualitative study depends upon informational redundancy (Lincoln & Guba, 1985) or theoretical saturation (Glaser & Strauss, 1967). The number of participants would have increased to the point where minimal information is forthcoming from the new participants or no new themes are emerging from the data.

Participant Selection Procedures

To provide a thick description of participants' experiences, the researcher selected only six subjects. There were 100 high school students at this school for students with visual impairments. Individuals who had a virtual experience with the Web and were likely knowledgeable about screen readers in general were recruited primarily by referrals from the computer teacher and resident assistants. The participant selection procedure was described as follows:

(1) The introductory letter explaining the purpose and procedures of the study was sent to the computer teacher for students who used screen readers, and the resident assistants of the dormitory with the intent of soliciting his or her informal recommendation of qualified participants.

(2) The computer teacher of students who used screen readers was asked to identify 10th to 12th grade students whom he considered to be adequately skilled in screen readers. The computer teacher identified between twenty to thirty students who meet this criterion.

(3) Since the majority of the students lived in the dormitory during the weekdays, resident assistants of the dormitory were asked with the recommended student list from the computer teacher to indicate students who they believed engaged in the Internet activities almost daily after school. Fifteen high school students who had many hours of experience in the Internet navigation were identified after receiving advice from resident assistants.

(4) Finally, these fifteen students received an invitation to participate in this study and only those who expressed willingness to participate were chosen for the study. The first six subjects meeting all criteria who volunteered to participate were selected for the study. Signed permissions to participate from the students and their parents were collected. To ensure the confidentiality of students, a unique number was assigned to them.

Two of the first six students meeting all criteria who volunteered to participate were excluded during the study. One student was absent from school for more than one week after the pre-task interview. Unfortunately, she was sick and had no intention to return to school soon. The other student was a low vision student but he was a braille-reader and used G-mouse screen reader to search for information on the Web. However, he still could see the graphics on the computer screen. He was excluded because he relied both on the computer screen and speech output of G-mouse screen reader when searching for information online. In the end, the seventh and eighth students meeting all criteria who volunteered to participate were selected for the study. The total number of students in the study remained the same.

School Setting

The participants were recruited from a school for the visually impaired in Taiwan. This school served as a special school in the continuum of nationwide placements for students with visual impairments and multiple disabilities between the ages of 4 and 21 in Taiwan. This school had students with visual impairments and multiple disabilities in K through 12th grade. This school had a diverse student body, with students not only from the local area but also from all around Taiwan. The school's educational vision stressed that every person with visual impairments and multiple disabilities must have educational services equal to services provided to sighted students.

This school provided high school students with visual impairments and multiple disabilities with related skills necessary to be successfully involved in vocational environment, academic studies, and independent life. This school helped high school students with visual impairments and multiple disabilities to reach their goals of higher education, employment, and independence in three ways: (1) assist transition from high school to college, (2) prepare for and find a job and (3) lead an independent adult life.

There were approximately 100 high school students at this school for students with visual impairments and multiple disabilities. They were assigned to three different classes: (1) college-bound class, (2) non-college-bound class, and (3) multiple disabilities class. High school students in college-bound class and non-college bound class were offered to take two years of computer class every week during their 10th and 11th grade. It was a one-hour computer class for developing the skills needed to use computers and Internet through assistive technologies. Students could choose to have a computer class either to learn to use ZoomText screen magnification or G-mouse screen reader. The computer class for G-mouse screen reader was small and consisted of less than fifteen students so they could receive individualized attention. This class for G-mouse screen reader informally included half-hour lecture and half-hour laboratory every week. In this class students received instructions in basic computer skills with G-mouse screen reader, such as keyboarding and word processing, using email, and navigating websites.

Computer Lab and Equipment

There were three computer laboratories among school's facilities. The computer lab, which was located in the same building of the classroom area, was selected to set up as a research site for this study because of its availability to broadband Internet connections and its convenient access from student classrooms. In addition, it prevented the researcher place herself in the position of being left unsupervised with individual students.

The computer lab was composed of only one room. A digital camcorder with a built-in hard disk recorder and a built-in microphone was positioned on the computer desk for capturing video and audio data. The camcorder created video clips which can be downloaded to a computer and transferred to video files for replaying and viewing at a later time. No computer audio-video recording software or logging program was used because of compatibility issues of screen readers. The camcorder was directed at the computer screen and the participant's hands. The audio output of the screen reader was captured along with the Web activities on the computer screen and the participant's interaction with the computer. The researcher sat next to participants in order to be able to operate the equipment as well as observe participants as they worked on the computers.

Strain, Shaikh, and Boardman (2007) stated that people with visual impairments "typically have highly customized computing environments" (p. 1853). In order to provide participants with a hardware and software setup that was as natural as possible, the information about the usual setup in their school computer class was obtained from the computer teacher prior to the study. This helped participants avoid unnecessary waste of time spent familiarizing themselves with the computing systems. All tasks were performed in the computer lab equipped with a computer laptop running Windows XP, Microsoft Internet Explorer 6.0, G-mouse 4.41 screen reading software, and an external standard 101-key keyboard. A blank webpage was set up as the default home page in the browser.

G-mouse

G-mouse was chosen to be the screen reader used for this study on the basis of its availability on every computer in classrooms and the computer labs in the participating school. G-mouse was a screen reader application released in 2002 and developed by the Resource Center of Tamkang University in Taiwan. G-mouse was widespread used by students with visual impairments in Taiwan due to its low-cost. This screen reader software was available free of charge via the Internet at http://www.batol.net/gm/ and a special hardware called "keypro" had to be purchased to protect the software at the price of about $25 (Chen, 2004).

G-mouse provided both speech and braille output in English and Chinese (Lin, 2003). G-mouse worked with a speech synthesizer to read aloud Traditional Chinese characters or English words displayed on the computer screen. At the same time, G-mouse also provided Chinese/ English braille output through refreshable braille displays. However, it can only convert the information in Traditional Chinese characters to Chinese braille codes used in Taiwan and only supporedt output to popular refreshable braille displays made in Taiwan (e.g. Golden-2, Super-1, and Super-2) (Cho & Su, 2010). In addition, G-mouse facilitates bilingual braille input mechanism-- Chinese Taiwan Mandarin braille and uncontracted English braille (Research, Development and Evaluation Commission, Executive Yuan, 2010). G-mouse was not only developed for operating in a Microsoft Chinese Windows environment but also was designed for supporting standard Windows applications. Another feature of G-mouse was that it offered options which allowed users to adjust the speed and the tone of the voice to their needs.

Furthermore, G-mouse can be controlled using only an industry-standard 101-key keyboard. The basic commands were executed via the 10-key numeric keypad on the right-hand side of the standard keyboard. Besides the basic commands, G-mouse had many hotkeys commands which were advanced function commands combining a number of steps or keystrokes into one operation. In order to navigate the Web it requires these hotkeys to be used in conjunction with keyboard shortcuts of the Windows system or the Internet browser.

Tasks

The three information-seeking tasks constructed specially for this study fit into "fact-based" task category that was used in the research of Bilal (2000). The type of task seemed to have influence on the process of information searching by children (Bilal, 2000, 2001; Schachter, Chung, & Shorr, 1998). Fact-based tasks were chosen specifically based on the purpose of the study. The purpose of this study was to understand students' experiences when they interacted with the Web using screen readers rather than to test their abilities to complete information searching tasks on the Internet. Bilal (2000, 2001) found that students had less trouble with "fact-based" tasks than "research-based" tasks. Fact-based tasks ensured that participants wouldn't give up easily and they were willing to explore.

Bilal (2000) defined "A fact-based task is one that requires a single, straightforward answer. It is data-based, usually uncomplicated, and may not require research to find the answer" (p. 648). All three fact-based tasks entailed a clear goal that required participants to retrieve a single fact. Participants can easily decide the amount of information needed to complete the task. The tasks were not significantly different from one another in their level of difficulty.

These three fact-based tasks that were assigned to participants were selected and validated by school teachers in Taiwan. These tasks were new tasks and not used in their classroom prior this study. There may be a concern that a differentiation between assigned tasks and participants' choices of tasks had an effect on students' motivation. However, Bilal's studies (2001, 2002) suggested that the absence of interest in searching information for research tasks was far more an issue than for fact-based tasks.

Thus, participants were less likely to have troubles with fact-based tasks that were not their own choices.

The assigned information search tasks covered three different curricular subjects. These three subjects, language arts, social science, and literature, were chosen to reflect the real-life experiences of students. Students had been given academic assignments to find information on the Internet in these subject areas at least once prior to this study. Each teacher who taught 10th grade language arts, social science, and literature was asked to list one search task directly related to the topics in their textbooks, rather than to broad subjects. One task was representative of each of the subject areas. As the curriculum formed a ready-made subject focus, certain topics that were not age-appropriate were automatically avoided. More importantly, school related subjects helped assure that participants were likely to have sufficient subject-matter knowledge to understand the content material encountered on the web and concentrated on attempts to find information.

Prior to its use in this study, the questions of these search tasks were pre-tested in the pilot study. In Fall 2010, two students who are blind were recruited using convenient sample from this school for students with visual impairments. However, wordings of some questions proved to be somewhat difficult for high school students to understand. This helped the researcher to identify any potential misunderstanding with the language used to describe search questions. Some of the search questions were ambiguous to students and were then modified to clarify their confusion.

The three fact-based search tasks, which the participants were asked to complete in this study, were as follows: (1) Language arts: Find out how many stars and stripes there are on the flag of the United States; (2) Social science: Find a web site that cites evidence in what year Taiwan became Japanese colony; and (3) Literature: Find the name and the complete text of a poem which describes his life in Cambridge from Chinese modern poet Chih-Mo Shiu.

Each task description consisted of the type of information requested to be found on the Web. For example, the first task description is to “Find out how many stars and stripes there are on the flag of the United States” and the information required was the number of stars and stripes. A complete list of three task descriptions and the information requested for each task was presented in Appendix A.

Task Evaluation

Evaluation of each task was made during the execution of the task and following the completion of the task. Time spent on each task and the outcome of each task were recorded. A task was considered successfully completed if the participant gave information as required for the task, no matter if it was correct or incorrect. “Unsuccessful” designation was applied if a participant didn’t give any information or simply gave up. The task evaluation form was shown in Table 2.

Table 2

Task Evaluation

Student No.:

	Start time	Finish time	Successful/ Unsuccessful	Information Provided	More Specific Comments
Task 1					
Task 2					
Task 3					

Task Instruction

Prior to the tasks, the researcher provided instruction on what participants were asked to undertake, as described in Appendix B. The orientation was read aloud to guarantee the instruction to participants were given in a consistent manner. In an attempt to relieve their anxiety, the researcher emphasized that the purpose of the study was to further understand web accessibility and usability issues rather than to test their information searching skills. In addition, the participants were encouraged to ask questions or to chat with the researcher during the tasks in order to relax them. However, the researcher provided assistance to help students smooth the process of navigation. For example, the researcher manually restarted the computer when the computer found frozen.

Pre-task Interview

The pre-task interview was completed by interviewing the participants individually in the scheduled time prior to performing the online information searching tasks. A short interview was conducted with each participant to gather demographic information and the participant's experiences with the computer, the Internet and the screen reader usage.

Structured interview questions developed by the researcher were used to collect data. To have participants fill out a braille form of demographical questionnaire and then transcribed the braille writing into print would add an unnecessary complication to data collection. The initial interview allowed the researcher to avoid over-complication and gather information without major problems. The participants' verbal responses to each question were written down by the researcher. The pre-task interview took thirty minutes. The researcher assigned each participant a unique number to protect his/her anonymity and used it to identify the pre-task interview results and data from other methods.

The pre-task interview contained twenty-eight questions related to participants' background information. The questions were arranged in four parts: personal information (six questions), prior experiences with the computer (six questions), the Web (seven questions), and the screen reader (nine questions). Questions included age, grade level, the description of their visual impairment, the experience level of using the computer, the Web, and the screen reader, the places where they have access to the Internet, the number of hours per day using the screen reader to search the Web. The list of pre-task interview questions is presented in Appendix C. The pre-task interview in this study provided the detailed background and experiences of the participants that helped the researcher draw up the profile of each participant. Data gathered from the pre-task interview also assisted the researcher in interpreting data generated from the observation of search tasks and the post-task interview.

Observation

Observation was a useful method for understanding participants' online search behaviors. This method can obtain information that was not simply revealed by other techniques. According to Merriam (1998), "observational data represent a firsthand encounter with the phenomenon of interest rather than a secondhand account of the world obtained in an interview" (p. 94). As the participants performed search tasks on the Web, the researcher directly observed their search behaviors. It was important for a holistic approach to observe the process as it happened, not only the outcome of a process. The objective observation of participants' actions served to complement the data from the post-task interviews which reflected their subjective thoughts and feelings.

During observation, the researcher acted as "observer as participant" as defined by Merriam (1998, p.101). After reading each search task aloud to the participant, the researcher sat silently and watched at the searching occur naturally. The interaction between the researcher and the participant was minimal. On occasion, the researcher gave the participants assistance only if approached by the participants for technical problems of the computer that they were unable to solve, such as disconnection from the Internet. The observation of online search process took place on a one-to-one basis in the computer lab. The observation lasted two hours per participant. In addition, a digital camcorder was set up to record the search task sessions of each participant.

Furthermore, the researcher wrote field notes. The field notes were handwritten during and immediately after each observation. At the beginning of the search session, the participants were notified that the scratching sound on papers was the researcher taking notes. When observing, the researcher took descriptive notes about their behaviors on a log sheet, such as the time they started and finished the tasks, the search paths, the URLs they visited, comments, and emotion called out. The researcher recorded the significant points of their behaviors initially and later referred back to the video clips for extensive details. Following the observation, the reflective notes were documented immediately. The researcher wrote down reflections to interpret the experience from the researcher's point of view, reflections on the methods of data collection and analysis, on ethical dilemmas and conflict (Gall, Gall, & Borg, 2003).

The field notes were also used to prompt the questions for the post-task interview in order to elicit further comments from the participants regarding their behaviors.

Post-task Interview

Along with conducting search task observations, the post-task interviews with participants focused mainly on information which cannot be observed. The post-task interviews were used to complement data collected during observations and field notes. Through observation along with video clips, the researcher could understand what the participants did when searching information online using a screen reader, but cannot necessarily understand their thoughts, feelings or underling behaviors.

Lincoln and Guba (1985) explained interviews as “conversations with a purpose” (p. 286). The post-task interview gathered information about the participants’ thoughts and emotional experience associated with online search tasks in their own words. According to Patton (2002b), the purpose of interviewing was to allow the researcher to enter into another person’s perspective. The interview helped to provide insight into why the participants performed search tasks in certain ways, what they found challenged, and how they felt at that moment while searching information.

The semi-structured interview was conducted face-to-face on a one to one basis thirty minutes after online search task sessions of each participant were completed. The post-task interview allowed the participants to better recall of the recent search behaviors used and the viewpoints of online search experiences. The researcher conducted the interviews in the computer classroom and took notes during the interviews. The post-task interview lasted from thirty minutes to an hour. With permission from all participants, the interviews were digitally audio recorded and then transcribed by the researcher. The transcriptions of the interviews were provided to participants for verification and accuracy checks. Open-ended questions were developed as a guide to assist in focusing the participants on the experience of online search sessions (see Appendix D). The “why” or “how” questions was asked to elicit descriptions of their behaviors and issues in details. Further questions were added later based on data from the observations and probing questions were used based on the participants’ responses.

Procedure

Data collection took place over the period of one month at a school for the visually impaired in Taiwan. Once the parental consent forms (Appendix E) and the child assent forms (Appendix F) were received for the study to proceed, arrangements were made to administer the data collection. The Chinese language was used throughout data collection since it was the native language of the participants. The participants entered search queries in Chinese and web pages they visited were also in Chinese.

Six high school students participated in the data collection process of the pre-task interview, online information search sessions, and post-task interview. The data attached to each participant were assigned a number that was used throughout data collection. Thus there was no record connecting a named student with any particular data.

First, a short pre-task interview was conducted with each participant to gather information about their background and prior experiences. Each of the six participants was interviewed face-to-face individually at the school using structured opening questions that were developed by the researchers (Appendix C). The questions include demographic information and the participant's experiences with the computer, the Internet and the screen reader usage. The pre-task interview took thirty minutes. Participant's response to each question asked was transcribed by the researcher. Then they were scheduled an appointment for an online information search session.

Online information search sessions were held at the school's computer lab and each participant was scheduled on separate days. The participants were given a general introduction to the flow of the online search session. Three information-seeking tasks were employed that required participants to search on the Web using screen readers. Tasks were presented to participants in the same sequence order. To obtain results from natural behavior, the researcher imposed as few restrictions as possible on the participants' choice for searching the Web. The participants were allowed to choose any search engines or websites to start the search tasks. They could reformulate search queries at any time they want. In addition, the participants had two hours to search for the information to solve three tasks. The participants could choose how long to spend on each task. However, in consideration of ensuring that the participants attempted all of the tasks, when thirty minutes elapsed, the participants were given an oral prompt for the next task by stating: "You can stop and move on to the next task." It was up to the participants to determine whether to give up or not rather than the researcher.

Each task was considered completed when the participant vocally announced that they had found the information requested or they wanted to stop. Task completion times for each task were recorded individually to provide possible explanation for differences in the results. Instead of on-screen recording software, data from fact-based tasks was recorded using the digital camcorder and later transferred electronically to save in the computer. During online information search sessions, the researcher observed the participants' behaviors and took notes.

Upon completion of online information search tasks, the participant took a short break. Later, the participant came back to the computer lab and was interviewed individually using semi-structured open-ended questions (Appendix D) that were developed by the researchers to assist in eliciting their perceptions of the online information search experience. The post-task interview lasted from thirty minutes to an hour. The post-task interviews were audio-recorded and later transcribed. The Institutional Review Board at the University of Northern Colorado approved all procedures (Appendix G).

Data Analysis

This study used open, axial, and selective coding, and emergence of themes as data analysis techniques to answer the three research questions.

Coding

Data analysis of online information search videos and post-task interviews focused on rich descriptive information in which the researcher attempted to identify themes, patterns, or issues, built explanations, and interpreted what had been learned from the study. Data analysis was accomplished by following a standard format for coding to systematically analyze the data.

Open coding. Open coding was the process of systematically breaking the data down into categories and subcategories. According to Strauss and Corbin (1998), "data are broken down into discrete parts, closely examined, and compared for similarities and differences" (p. 102). Open coding was used to identify initial similarities and differences between participant experiences, grouping them into categories and subcategories of information. This process began by an initial reading of transcripts of post-task interviews to give the researcher an in-depth overall sense of the data. The transcripts were color coded to highlight words and phrases that corresponded to the research questions. In this way, numerous words and phrases were identified. Each color coded group of words and phrases were then assigned an alpha code related to the groups. In this way, the initial categories were developed around the three research questions. In the next step, sub-categories were developed by grouping similar concepts within each of the categories. The sub-categories were assigned a numerical subset. These were found in Table 3, Table 4, and Table 5.

Table 3

Open Coding Phase: Concepts of Research Question #1

Research Question 1	Making movement	1. Reading through content 2. Reading mode and typing mode 3. Stop reading through 4. Didn't stop reading through 5. Pause reading through 6. Open/close windows 7. Reading content of the new windows 8. Jump ten links 9. Open NotePad 10. Close incidentally opened Window Media Player 11. Read Web address alphabetically 12. Press Tab 13. Close typing mode right after type in search terms 14. Close typing mode only when type in English words 15. Control the reading speed by listening at a few words or listening to the entire phrase 16. Control the reading speed by adjust the speech rate 17. Think twice before following a link 18. Back to search box for next task 19. Back to search box for next search query 20. Skip navigation menu faster at second and third time

Table 3, continued

Research Question 1	Making movement	21. Skip navigation menu and related searches, but listen to every word in the result links 22. Scrolling to know the current position 23. Time taken to complete a task 24. Time spend on a result page 25. Time spend on a website
	Making decision	1. Yahoo homepage 2. Yahoo!Answers 3. The search box at the top and the bottom of the search results 4. The search box located before navigation menu 5. Get to search box by scrolling, by pressing <Home> 6. Get to search box automatically 7. Get to search box at Yahoo homepage 8. Backtracking when irrelevant terms, English words, Web address appeared 9. Assess relevance by the keywords 10. Assess relevance by the domain knowledge 11. Assess relevance by guessing 12. Change search queries after learning clues from result pages or websites 13. Jumping from link to link first, then reading through 14. Reading through only 15. Reading through with all links 16. Reading through without links

Table 4

Open Coding Phase: Concepts of Research Question #2

Research Question 2	Web	1. Difficulty in reading page title in English in the result page 2. Difficulty with page title starting with the same words 3. Unaware of a pictures embedded in text 4. Unaware of an advertisement 5. Unaware of a table 6. Unable to remember Web address 7. Unfamiliar with Yahoo!Answers 8. Unfamiliar with Wikipedia 9. Unfamiliar with a blog 10. Navigation menu at the top remain the same 11. The page cannot be displayed 12. Relevant information located at the bottom of the page

Table 4, continued

Research Question 2	G-mouse	1. Cannot listen to a certain paragraph 2. Too many paragraphs in one page 3. Cannot tell whether the page has finished loading or not 4. Slow to load a page from China 5. Wait for G-mouse to start reading 6. Trial by pressing the command of reading through 7. G-mouse suddenly start reading the different web page on another windows 8. No feedback after entering a search query
	Participants	1. Unaware of words with the same pronunciation 2. Cannot recall what they just heard a few minutes ago 3. Reiterate what they just heard 4. Listen to the same page again and again 5. Cannot distinguish between a result page and a web page 6. Unaware of search boxes at the top and at the bottom of a result page 7. Being uncertain about task description 8. Being frustrated when listen to irrelevant websites 9. Being patient at listening to the entire page 10. Being impatient at listening to links 11. Being confused by the read out after pressing commands 12. Want to abandon the task but continue searching

Table 5

Open Coding Phase: Concepts of Research Question #3

Research Question 3	1. Ask for the researcher's help with switch to typing mode 2. Ask for the researcher's help with the frozen computer 3. Ask for the researcher's help with Internet connection 4. Abandon reading through the Yahoo!Answers 5. Abandon reading through Wikipedia 6. Abandon the task after visiting eight websites 7. Abandon the website with many graphics 8. Abandon the website in simplified Chinese 9. Skip the link with a page title in English 10. Skip the link with a page title in Web address 11. Skip the navigation menu 12. Skip the link with a page title in irrelevant keywords 13. Backtracking when heard a page title in English 14. Backtracking when heard irrelevant keywords in the page title 15. Backtracking when heard a number at the bottom of the result page 16. Back to Yahoo homepage when the search terms in the search box cannot be deleted

Table 5, continued

Research Question 3	17. Back to Yahoo homepage when the search terms cannot go into the search box 18. Restart when reading mode cannot be switched to typing mode 19. Read refreshable braille display when page is loading 21. Read refreshable braille display after the search query was entered 22. Adjust the speech rate according to lesson learned from the experience of Task 1 23. Change search queries according to content clues from search result pages or websites 24. Reading through the entire page after first jumping from link to link 25. Skip the navigation menu faster at second and third time 26. Try <Backspace> or <CTRL+F4> to go back to previous page 27. Try reading through after first jumping from link to link 28. Try different ways to locate a search box 29. Copy and paste in NotePad 30. Reiterate the information 31. Bookmarking 32. Save a whole web page as a file on the desktop

Axial coding. These categories and subcategories were then assembled in new ways through the use of axial coding. According to Strauss and Corbin (1998), axial coding was used to further identify and develop new categories by linking “categories to their subcategories along the lines of their properties and dimensions. Axial coding looked at how categories crosscut and link.” (p. 124). In axial coding, sub-categories were questioned and compared to identify subcategories that were similar in the information they represented. In this manner sub-categories were collapsed, combined, and connected into new integrated axial categories, moving the focus toward themes. The categories emerged during the axial coding phase were found in Table 6.

Table 6

Axial Coding Phase: Categories

Research Question 1	Making movement	1. The keyword/phrase/sentence use to search 2. The websites visited and duration of time 3. New commands 4. Switching between reading mode and typing mode 5. Listen at high speed 6. Forwarding and Backtracking 7. Scanning 8. Scrolling within page 9. Scrolling in the search result lists 10. Scrolling in web pages 11. Scrolling to find search box
	Making decision	1. Starting point 2. Get oriented to search box 3. Use natural language in formulating first search term 4. Assess the relevance of the information on the search result lists 5. Change the search term to keywords learned from content clues 6. Reading context
Research Question 2	Web pages	1. Web pages- search engines 2. Labeling of links 3. Graphics 4. Flash 5. Advertisements 6. Tables 7. Special websites- Yahoo!Answers, 8. Navigation at the top 9. Broken links 10. Excessive information
	Screen reader	1. Select paragraphs 2. Page loading 3. Insufficient feedback
	Training	1. Choose different words from the same pronunciation 2. Short-term memory 3. Different conceptual model about the structure of result page
Research Question 3		1. Copy and paste in NotePad 2. Trial and error 3. Experiential learning 4. Read refreshable braille display 5. Back to the starting point 6. Restart 7. Backtracking 8. Avoidance 9. Skip 10. Abandon 11. Ask for help

Selective coding. Through the use of selective coding, a core category was developed, which resulted in themes or issues that could be interpreted by the researcher (Creswell, 1998; Strauss & Corbin, 1998). Selective coding was the process in which all categories were unified around a central or core category. Selective coding helped to identify poorly developed categories for which there was insufficient support in the data. The core category might emerge as one of the categories or subcategories that had already been defined or a new term may be needed to describe and explain the main phenomenon. There was a sense of hunting down a central theme. The researcher drew upon past experiences and education to interpret the data and gave meaning to the data, separating the important from that which was not in order to overcome bias. The core categories emerged during the selective coding phase were found in Table 7.

Table 7

Selective Coding Phase: Core Categories

Research Question 1	Action	1. Scanning 2. Scrolling 3. Limited use of keyboard commands of G-Mouse 4. Scope and depth of the search 5. Time
	Cognition	1. Choose a starting point for a search 2. Locate the search edit box 3. Formulate the first search query 4. Examine the search result lists 5. Modify the search queries Browse the textual content of a website
Research Question 2	Web pages	1. Graphics and Flash without text alternatives 2. Tables without linear text alternatives 3. Navigation menu at the top 4. Inappropriate labeling of links 5. The structure of a blog,Yahoo!Answers, and Wikipedia 6. Excessive information

Table 7, continued

Research Question 2	Screen reader	1. Difficulty in understanding synthesizing speech in English 2. Difficulty in telling that a web page is loading or has finishing loading 3. Insufficient feedback to verify the outcomes of keyboard commands
	Training	1. Have not formed conceptual models about how information is displayed spatially on web pages 2. Information overload
Research Question 3		1. Note-taking 2. Trial and error 3. Backtracking 4. Look for assistance 5. Skipping 6. Giving up

Emergence of Themes

Content analysis involved the identification of emerging themes and identification of their similarities and differences in data collection. The transcripts of post-task interviews and the researcher's observational notes were the basis for the content analysis in this study. The researcher detected possible themes in the transcription of post-task interviews. The researcher listened to the tapes and read the transcripts several times comparing them with observational notes. During these analysis activities the researcher marked emerging themes with different colors. These marked paragraphs were later sorted by research questions and themes. The researcher organized and analyzed the themes according to the research questions.

Trustworthiness

According to Denzin and Lincoln (2000), internal and external validity, common criteria in quantitative research, were replaced by trustworthiness in qualitative research. Trustworthiness itself is further defined in terms of the credibility, transferability, dependability and confirmability of the research (Guba & Lincoln, 1998; Shenton, 2004).

Credibility. One important way of promoting the trustworthiness of qualitative research is by establishing credibility. Credibility is defined by Lincoln and Guba (1985) as the congruence of the views of the participants and the researcher. In qualitative research, data are analyzed to investigate multiple perspectives rather than determine an absolute truth. There were a number of ways in which the researcher promoted credibility in this study. These included methodological triangulation, peer debriefing and member checking (Lincoln & Guba).

First, the researcher used multiple data collection methods: pre-task interviews, online information search tasks sessions, observations, and post-task interviews. As Shenton (2004) suggested, using different methods to collect data can compensate for the individual limitations of each and thus create a more comprehensive representation of the issues under investigation.

Second, peer debriefing was used as a way to ensure that the data are analyzed as rigorously as possible. Peer debriefing allows for a non-involved peer to interact and question the researcher, data and process to ensure that bias is acknowledged and addressed if needed. A friend who was a doctoral student in Molecular Biology was trained to be a research assistant for this study. Training in data analysis was conducted by the researcher in which techniques for coding and identifying themes was reviewed and data analysis was practiced on transcripts from the pilot study. During the process of data categorization the trained research assistant and the researcher analyzed the same data using the developed categories to allocate quotes to the categories, then we checked agreement in this analysis process. As a team we co-coded transcripts of online information search videos and post-task interviews. This co-coded process of peer debriefing increased credibility as it allowed the researcher not only to check agreement over codes but also gave the researcher an opportunity to argue for my interpretation of the data. Most importantly it drew attention to issues that minimized my bias where the researcher might overlook important themes that emerged.

Finally, member checking was a method of establishing credibility which provides participants with an opportunity to review transcripts of interviews to ensure the accuracy of statements and to verify that the information reflect their intent. Transcripts of post-task interviews were printed in braille and sent to each participant. Data from post-task interviews was added to the study only after receiving confirmation from the participants.

Transferability. A further aspect of trustworthiness related to whether the research findings were able to be transferred to other settings or contexts. To ensure transferability of findings it was important to provide sufficient information to help the reader to determine if the findings can be applied to their own settings (Shenton, 2004). Creswell (2007) stated “To make sure that the findings are transferable between the researcher and those being studied, thick description is necessary.” (p. 204). The field notes were maintained by the researcher to offer insights into more subtle clues such as the demeanor and perspective of the participants. This study offered sufficient “thick description” of the context for the reader to determine if the research findings can be transferred to similar situations.

Dependability. A third criterion for research trustworthiness is dependability. Dependability addresses the capability of future researchers to be able to trace the methodology employed and potentially recreate a similar study. One way to develop dependability in a qualitative study is through the use of an audit trail. Merriam (1998) defines an audit trail as a detailed description of data collection methods, the strategies used to analyze data, and a comprehensive written explanation of how choices and decisions were made throughout the process.

The process of data collection and analysis was thoroughly documented. This full description was provided earlier in this chapter and it gave a full audit trail, providing detailed descriptions of data collection and data analytical procedures. This establishes the dependability and credibility of this study.

Confirmability. In establishing trustworthiness, confirmability was another prominent element that strengthened the research. Confirmability refers to objectivity of the data and the fact that bias has been addressed and eliminated to the greatest extent possible, and it is the final component of trustworthiness but is similar to objectivity (Lincoln & Guba, 1985). Confirmability is related to the researcher's concern that the findings are truly drawn from the experiences of the informants (Patton, 2002a), and do not reflect the bias of the researcher. Such bias indicates a lack of ethical research conduct because the researcher only reports on data which support their viewpoints. The current study has addressed confirmability through the methods in relation to credibility. It is not possible to ensure credible outcomes without addressing researcher bias in data analysis.

Ethical consideration. As discussed above, the design and plans for research implementation attempted to consider all issues related to the quality of this research. This involved addressing its trustworthiness, and trustworthiness in turn relied on, indeed was contingent on the credibility, transferability, dependability, and confirmability of the research. Ethical considerations must also be taken into account.

Ethical considerations in all forms of research were vital as they protected research participants so that they could provide trustworthy information without causing them harm. First, the research methods were designed so as to not burden participants intentionally. Rather participants were motivated to contribute their experience without constraint. They were given clear preliminary information about the study. Willing participants were then asked to provide written consent for participation. Second, this research offered no advantage and makes no difference to the participants as compared to those who did not participate. The only implicit advantage might occur through participants articulating their experiences which could stimulate their understanding of their information search behaviors and challenges. This did not create any academic advancement compared to students in the same cohort who did not join the research, and the risk of harm was minimized. Third, the participants understood the nature of this research and were free to terminate participation at any time. They also had their right to withhold any information that they did not want to disclose. In addition, to ensure confidentiality, the participants' unique numbers was known only to the researcher. Thus they were never be identified by name on any of the data collected in this research, or in any presentation or publication arising from the research. Finally, this study did not involve any funding or grant from any organization, and it was purely for personal academic advancement. In addition, the research results were accurately reported with a balance of both negative and positive experiences and outcomes.

Summary

Chapter three described the general research approach, the research design, and the data collection techniques and analysis procedures that were used in this study to answer the following research questions:

Q1 How do high school students with visual impairments search for information on the Web to answer academic fact-based questions using G-mouse screen reader?

Q2 What challenges or barriers do high school students with visual impairments encounter during information searches on the Web using G-mouse screen reader?

Q3 How do high school students with visual impairments overcome challenges or barriers during information searches on the Web using G-mouse screen reader?

This chapter also explained the techniques that were used to establish the trustworthiness of the study. Qualitative research methods and case study design allowed for the use of multiple data sources to address the research questions. The data collection activities included pre-task interviews, online information searching sessions, observations, and post-task interviews. Chapter four will discuss the results of the study.

CHAPTER IV

RESULTS

This chapter presents the findings of the research on information searching experiences of high school students with visual impairments who access the Web with the aid of screen readers. The analyses were based on data from six high school students recruited from a school for the visually impaired in Taiwan. The data presented in this chapter were collected through pre-task interviews, observations, online information search task sessions, and post-task interviews. These four data obtained was used to answer the following research questions:

Q1 How do high school students with visual impairments search for information on the Web to answer academic fact-based questions using G-mouse screen reader?

Q2 What challenges or barriers do high school students with visual impairments encounter during information searches on the Web using G-mouse screen reader?

Q3 How do high school students with visual impairments overcome challenges or barriers during information searches on the Web using G-mouse screen reader?

Research findings are presented in four separate sections of this chapter. The first section describes the demographic characteristics of the participants and their experiences with the computer, the Internet, and the screen reader usage. The second, third, and fourth sections present themes that emerged from the data related to each of three research questions. Figure 1 outlines the themes that emerged from analysis of the data in relation to three research questions. Direct quotes of participants which were translated from Chinese into English by the researcher are presented with the findings in order to illustrate the themes.

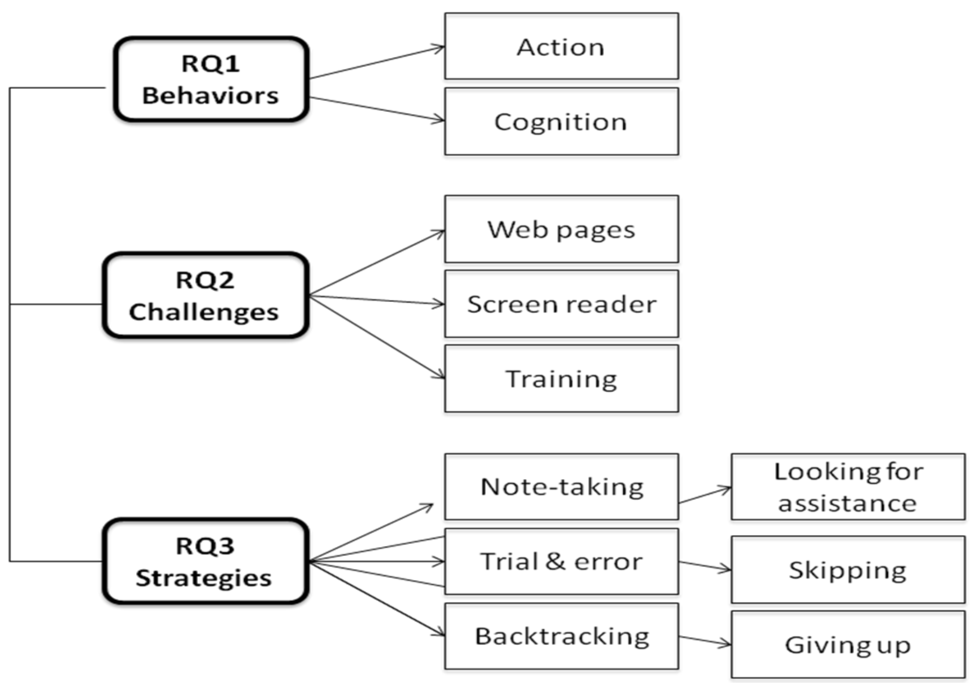

Figure 1. Themes related to three Research Questions.

Demographic Characteristics of the Participants

Data from the pre-task interview provided demographic information about six high school students with visual impairments. The participants included 2 girls and 4 boys; four participants were at the 11th grade, one participant was at the 10th grade, and another participant was at the 12th grade. With respect to degree of visual impairment, all participants identified themselves as blind, with no or some light perception. Four of them described their condition as congenital blindness (from birth) and two of them described their condition as adventitious. Eye conditions mentioned included: retinopathy of prematurity, optic atrophy, and retinal detachment. All participants were able to read braille. They all used G-Mouse screen reader as their primary assistive technology to access the computer. These participants possessed G-Mouse experience ranging from 3 to 7 years. Three participants had been using the Internet every day, and three for twice or three times a week. Daily Internet use ranged from 5 to 9 hours and weekly Internet use all for 7 hours. Three participants rated themselves as experienced users with the Internet and three as less experienced users. Figure 2 is a summary of the demographic characteristics of six participants. All information included in this demographic summary was provided by the participants.

	S1	**S2**	**S3**	**S4**	**S5**	**S6**
Level	Less experience	Less experience	Less experience	More experience	More experience	More experience
Gender	Female	Female	Male	Male	Male	Male
Grade	11th	11th	10th	11th	11th	12th
Age	17 years old	17 years old	17 years old	17 years old	18 years old	19 years old
Blindness	Birth	14 years old	Birth	9 years old	Birth	Birth
G-mouse	4 years	3 years	3 years	7 years	5 years	4 years
Internet	7 hours 2-3 times a week	7 hours 2 times a week	7 hours 2-3 times a week	5 hours daily	7 hours daily	9 hours daily

Figure 2. Demographic characteristics of participants.

The first participant, identified as S1, is seventeen years old and an 11th grade female student. She is profoundly blind with no light perception in both eyes. S1 has been blind since birth as a result of retinopathy of prematurity. She uses braille as a primary reading source. S1 has experience in working with G-Mouse screen reader for four years and searches for information online for seven hours twice or three times a week. S1 considered herself as inexperienced user.

The second participant, identified as S2, is seventeen years old and an 11th grade female student. She was low vision since she was an infant which was a condition she inherited from her mother. Her vision has deteriorated as she has grown older. S2 became totally blind at age fourteen and has been blind for three years. She has faint light perception, but is not able to recognize the shape of a hand. Although she knows and can use braille, S2 reads primarily by listening to G-Mouse screen reader when access the information on the Internet for seven hours twice a week. S2 saw herself as inexperienced user.

The third participant, identified as S3, is seventeen years old and a 10th grade male student. He became blind as an infant after contracting optic atrophy, which damaged the optic nerve. S3 has minimal light perception, but can’t see forms, hand movements, or shadows. He uses braille as his primary means of reading. For three years S3 has been involved in online activities with the aid of G-Mouse screen reader for seven hours twice or three times a week. S3 described himself as inexperienced user.

The fourth participant, identified in this study as S4, is seventeen years old and an 11th grade male student. He was diagnosed with retinal detachment at age nine and has been blind for eight years. S4 has some light perception in both eyes, but sees little more than shapes or shadows. He primarily reads through braille. S4 requires the use of G-Mouse screen reader when he is accessing web sites through his computer. He has been using G-Mouse screen reader for seven years and going online for information for five hours every day. S4 rated himself as an experienced user.

The fifth participant, identified as S5, is eighteen years old and an 11th grade male student. He is totally blind with no light perception as the result of retinal detachment, which he said resulted from his premature birth. S5 uses braille to do most of his reading. He has five years of experience in using G-Mouse screen reader and seven hours of daily usage of the Internet. S5 considered himself as experienced user.

The sixth participant, identified as S6, is nineteen years old and a 12th grade male student. He had optic atrophy as a preterm infant. Both of his eyes were completely blind, with no light sensation. S6 uses braille as his primary method of reading. He has been using G-Mouse as his learning assistive tool for four years and accesses the Web for nine hours every day. S6 identified himself as experienced user.

Research Question #1

This section describes two main themes that answer the research question: How do high school students with visual impairments search for information on the Web to answer academic fact-based questions using G-mouse screen reader? Based on the analysis of the data, two themes regarding behaviors were identified including (1) Action, and (2) Cognition. Figure 3 outlines the themes and categories related to Research Question #1.

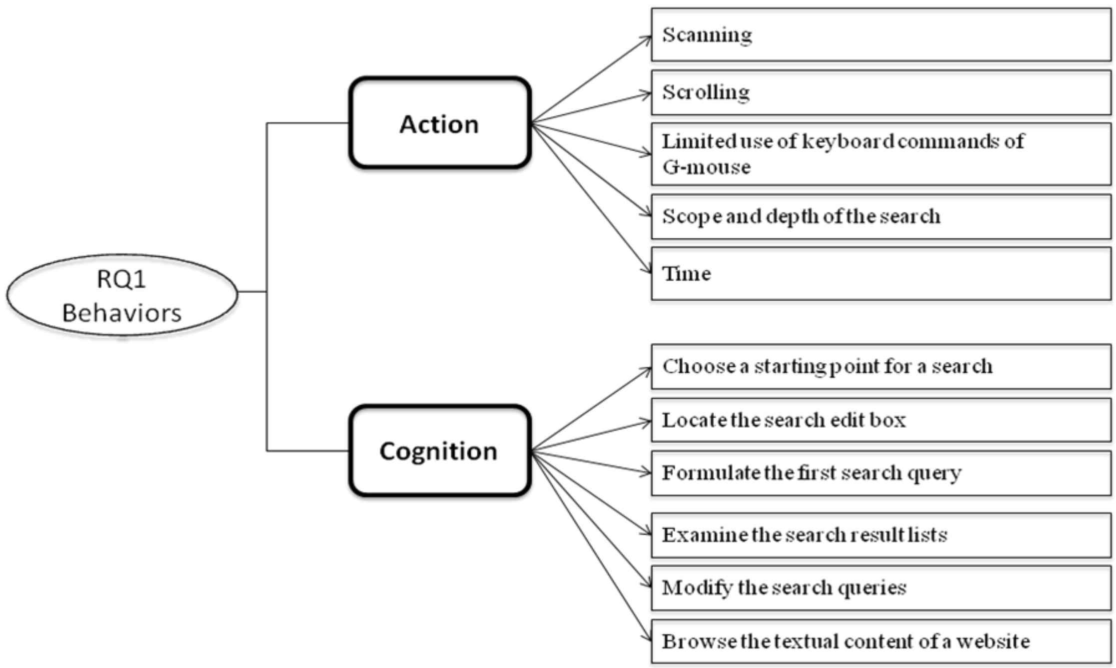

Figure 3. Themes and categories related to Research Question #1.

Action

Actions were the moves the participants made during the task completion. Actions were categorized as what Marchionini (1995) termed "physical actions." Marchionini (1995) stated that moves were manifestations of tactics and mainly system specific. Examples of actions were keyboarding, scrolling, and backtracking. Several common patterns were found in terms of the moves the participants made during their search tasks. These included (1) scanning, (2) scrolling, (3) limited use of keyboard commands of G-mouse, (4) scope and depth of the search, and (5) time.

Scanning. To accelerate reading, the participants didn't increase the speech rate of G-Mouse screen reader. Instead, the participants speeded up the reading by scanning. By scanning, the participants did not listen to an entire link but only the first few words of a link. This way they quickly got a sense of what was in the link and determined whether the link was relevant to their information needs. If the participants perceived the link as possibly irrelevant, they moved on quickly to the next link.

The participants often used scanning on the search result lists of a search engine or a web portal but not on the content of a website. Since G-Mouse screen reader didn't provide the participants information on what to skip, the purpose of scanning could serve as a glance over information on a search result page. S5 illustrated, "While searching, I spend a lot of time on listening. I have to say, most of them are irrelevant information. I just want to quickly get to the information that can be potentially useful to me." However, at the same time the participants were likely to miss important information by scanning, especially if a link started with the same words. Sometimes, keywords the participants were looking for were embedded deep in the text of a link and not at the beginning of a link. For example, when S3 listened to links with the same words twice in a row, he was uncertain whether the keyboard command was not activated or if the link was repeated.

Scrolling. When performing the search task, the participants moved around a web page by jumping from link to link. The participants often pressed the < plus> key on the numeric keypad to move down a page through the links and < minus> key on the numeric keypad to move back up a page through the links. Only S4 and S5 used the <Tab> key as an alternative key to jump through links when their right hands got tired from pressing keys.

The participants employed this tactic not only on the search result page of a search engine but also on the content page of a website. After listening to the page title of a search result announced by G-mouse screen reader, the participants often moved through links sequentially from top to bottom. However, they did not always scroll completely through a page. It was observed that they sometimes navigated the page backwards to listen to the previous links again. It was through repeated visits that allowed them to understand a link completely. In addition, the participants tried to avoid listening through navigation menus and other irrelevant content at the top of the result page. S1 stated that he memorized the number of links that had to be jumped in order to get to the beginning of the search results. On the content page of a website, the participants jumping from link to link so that they could selectively glance over the content. During reading a large volume of information, the participants strived to listen to just enough content and moved foward as quickly as possible to the section that had the information they were looking for. One drawback of jumping through links was that it was very dependent on the labeling of a link. The participants had to spend time on understanding poorly labeled links simply to find out where the links lead, such as links with the label of “more” or “click here.”

Limited use of keyboard commands of G-mouse. G-mouse screen reader offered a variety of keyboard shortcuts to navigate a web page. However, the participants used a limited number of commands. They included commands for editing Chinese words (<Spacebar+underscore> key), tabbing down links (< plus> key on the numeric keypad), tabbing up links (< minus> key on the numeric keypad), reading through the textual content word by word (CTRL+<zero> key on the numeric keypad), stopping reading through (CTRL+<minus> key on the numeric keypad), pausing reading through (CTRL+<NumLock> key on the numeric keypad), reading the current position of the cursor (<five> key on the numeric keypad), and going back to desktop (<zero> key on the numeric keypad).

Upon entering a search result page regardless of the task, all of the participants used < plus> key on the numeric keypad (tabbing down links) and < minus> key on the numeric keypad (tabbing up links) as their first command. <Spacebar+underscore> key, the command to switch from reading mode to Chinese edit mode, was commonly used by all of the participants to formulate a search query. It was also observed that the participants, S1 and S2, used <CTRL+ zero key on the numeric keypad> to read through a web page. Interestingly, some participants used different keyboard shortcuts to perform the similar functions. For examples, S4 and S5 jumped from link to link by pressing <Tab> key. On the other hand, S4 used <ALT + plus key on the numeric keypad> to jump through ten links at a time. In addition, S4, S5, and S6 used <Windows+ zero key on the numeric keypad> to read through a web page without links. Surprisingly, there was only one person who used advanced shortcuts of G-mouse screen reader that required the understanding of space. On Task 3, S5 explored the textual content of a web page with a keyboard-driven mouse. He used the commands that moved the current mouse position with the keyboard and had the content beneath the cursor read out, such as <eight> on the numeric keypad (move the cursor up), <four> on the numeric keypad (move the cursor left), and <slash> on the numeric keypad (move the cursor here).

When the participants searched information on the Web using G-mouse screen reader, they did not only use commands of G-mouse screen reader, but also relied on utilizing keyboard shortcuts of Internet Explorer and Windows system to complete the tasks. Different shortcuts from Internet Explorer and Windows used by the participants including <Backspace> key (go to the previous page), <ALT + left arrow> key (go to the previous page), <CTRL + F4> key (close the active document window), and <Windows Logo> key (display or hide the Start menu). The study revealed that the participants with less experience, S1, S2, and S3, relied heavily on commands of G-mouse screen reader, while the participants with more experience, S4, S5, and S6, took more advantage of keyboard shortcuts of Internet Explorer and Windows system. For example, S5 and S6 used Menu key (between the right Alt key and the right Control key) to check whether the software for translating simplified Chinese was available on the computer. However, it was noted that even the participants with more experience did not take advantage of all the functionality of G-mouse screen reader, Internet Explorer, and Windows. Even though all of the participants found the G-mouse easy to understand and to operate, many participants said they did not know how to use all the commands which were covered by the computer class.

Scope and depth of the search. The number of search result pages examined per query varied among participants from 1 to 5. Participants, S4, S2, S6, examined only the first results page during all the three tasks. On the other hand, S1 viewed 5 pages of the search results while S3 and S5 examined 4 pages of search result on Task 2. Only S5 viewed 3 search result pages on Task 3, whereas the other participants looked only the first result page. The majority (83%) of followed links from search results came from the first seven results. Forty-seven percent of selected links from search results came from the first three results. In general, during most of the online sessions none of the participants went further than the first result page and the first seven search results.

The number of websites visited by the participants per task ranged from 1 to 15. During the first task the participants, S1, S2, and S4, visited only one website while participants, S3, S5, and S6, viewed three websites. Three participants, S1, S5, and S6, who browsed five websites during the second task, successfully found the answer. During the third search, only S5 visited fifteen websites whereas the others viewed 2-6 websites. Generally, the participants visited more websites on Task 2 and Task 3 than on Task 1. The number of website visited might be influenced by the level of task difficulty the participants perceived. Table 8 presents the number of result pages examined per query and the number of websites visited per task by the participants.

Table 8

Result Pages Examined per Query and Websites Visited per Task

	Task 1		Task 2		Task 3	
	Result Pages	Websites	Result Pages	Websites	Result Pages	Websites
S1	1	1	5	5	1	4
S2	1	1	1	9	1	6
S3	1	3	1	3	1	3
S4	1	1	1	1	1	2
S5	1	3	4	6	3	15
S6	1	3	1	6	1	2

The number of external links visited by the participants was 2. Only two participants, S1 and S5, visited a website selected from search results and then followed an external link on that website. During the observations the participants engaged in limited exploratory behavior. They browsed only the first page on the websites they visited and thus fail to gain the benefit in visiting an external link.

Time. All of the participants believed that they had found the answer for Task 1. The time taken to complete Task 1 ranged from 3 minutes to 18 minutes, averaging about 10 minutes. Two took 10 minutes or less. Three took between 11 and 15 minutes, and one took over 15 minutes. The time taken to complete Task 2 ranged from 18 minutes to 32 minutes, averaging about 24 minutes. Three participants, S1, S5, and S6 found the answer and took 22 minutes, 25 minutes, 32 minutes, respectively to complete. The other three participants, S2, S3, and S4, chose to quit after 18, 20, and 26 minutes respectively. Five participants completed Task 3 successfully. Only S3 chose to quit after 16 minutes. The time taken to complete Task 3 ranged from 3 minutes to 29 minutes, averaging about 13 minutes. Three took less than 10 minutes. Two took between 11 and 20 minutes, and one took over 20 minutes. The amount of time taken to complete varied between tasks. On average, the participants took more time to complete Task 2 than they did to complete Task 1 and Task 3. Table 9 lists the time taken to complete each task by the participants.

Table 9

Time Taken to Complete Each Task

	Task 1	Task 2	Task 3
S1	18 minutes	32 minutes	11 minutes
S2	07 minutes	18 minutes (unsuccessful)	08 minutes
S3	13 minutes	26 minutes (unsuccessful)	16 minutes (unsuccessful)
S4	13 minutes	20 minutes (unsuccessful)	09 minutes
S5	10 minutes	25 minutes	29 minutes
S6	03 minutes	22 minutes	03 minutes
Average	10 minutes	24 minutes	13 minutes

The participants spent an average time of 1 minute 40 seconds with search result pages on Task 1, with a minimum time of 40 seconds and a maximum time of 4 minutes 30 seconds. On Task 2, the participants spent an average time of 3 minutes with search result pages, with a minimum time of 30 seconds and a maximum time of 7 minutes 30 seconds. On Task 3, the participants spent an average time of 2 minutes with search result pages, with a minimum time of 40 seconds and a maximum time of 4 minutes. On the other hand, the dwell time on the content of websites on Task 1 ranged from 2 minutes to 10 minutes, averaging 6 minutes 10 seconds. On Task 2, the dwell time on the content of websites on Task 1 ranged from 4 minutes 20 seconds to 17 minutes, averaging 12 minutes 20 seconds. On Task 3, the dwell time on the content of websites on Task 1 ranged from 2 minutes to 14 minutes, averaging 5 minutes 30 seconds. Table 10 lists the participants' dwell time on result pages per task and dwell time on websites per task.

Table 10

Dwell Time on Result Pages per Task and Dwell Time on Websites per Task

	Task 1		Task 2		Task 3	
	Result Pages	Websites	Result Pages	Websites	Result Pages	Websites
S1	04:30	10:00	07:30	12:00	01:20	07:30
S2	01:00	02:00	02:20	08:40	03:00	04:10
S3	02:30	06:00	04:00	04:20	01:30	02:00
S4	00:40	10:00	00:30	15:30	00:40	03:30
S5	00:40	06:20	01:50	16:00	04:00	14:00
S6	00:40	02:20	01:30	17:00	01:00	02:00
Average	01:40	06:10	03:00	12:20	02:00	05:30

The results showed that all of the participants spent considerably longer time with content pages of visited websites than with result pages from search engine/port. This might indicate that the participants were able to find a possibly relevant page quickly but needed to spend more time reading a page in order to locate the required information. Based on the researcher's observational notes, one possible reason was the different ways the participants read through result pages and content pages. The only way the participants navigated the search result page was to jump from link to link and scan only the first few words of a link. It took them less time to find a potential link and determine its relevance. In contrast, the participants often used a combination of two strategies to read the content of a website. They moved through links first to get an overview of a website and then read through the content words by words for the second time.

Cognition

Cognition was defined as acts related to knowledge comprehension, problem solving, and interpretation (Nahl, 1998). Examples of cognitive behaviors during information searching on the Web included formulating queries, keeping track of information, and making decisions about retrieved information. The participants' cognitive behaviors can be categorized into six groups: (1) choose a starting point for a search, (2) locate the search edit box, (3) formulate the first search query, (4) examine the search result lists, (5) modify the search queries, and (6) browse the textual content of a website.

Choose a starting point for a search. In the computer, the default webpage was a blank page on Microsoft Internet Explorer for Task 1 and at whichever webpage they ended for Task 2 and Task 3. Yahoo and Google were chosen by participants as a starting point for searching information online. Four participants, S1, S2, S3, and S4, chose to use the web portal Yahoo homepage to start their search. The reason that S3 went directly to Yahoo was that it was recommended by the computer teacher and demonstrated in the class. S3 explained, "I learned the web address of Yahoo from the computer teacher. He showed us how to search with it. I don't actually look at other way to do the search unless a teacher tells me to do so." S2 cited familiarity as a reason for choosing to use Yahoo to search. S2 commented, "I always start with Yahoo, because I've been practicing using it after I learned from the computer class. I have spent time on it and played around with it." S1 tended to stick to Yahoo with which she was familiar. S1 stated, "I have become so accustomed to using Yahoo. I am not familiar with other search engines, so I'll just stick to what the computer teacher taught us."

Only two students, S5 and S6, started looking for an answer by visiting the search engine Google. The reason that participants selected Google was the perceived easy to use which leaded to the perceived time savings in which information likely to be found over Yahoo. S6 remarked, "I guess Google where I start . . ……..I think Yahoo is not as fast as Google. Yahoo gives you hundreds of stuff that are irrelevant, for example 'Related Search' before the real search results. But Google seems to be just simple. It may not have that many stuff, but it seems to give me the information directly. So I can find what I want in less time." S5 mentioned that Google helped him to locate information faster than Yahoo on the Internet. S5 initially chose to use Yahoo homepage, but changed to Google right before finished entering the first keyword for Task 1. In the interview, when asked why he changed from Yahoo to Google, S5 explained, "It is quicker for me to go to Google…Mostly because it is easy to use. I have always just used Google because it often finds something quicker than Yahoo."

As participants started a new search for Task 2 and Task 3, S1, S2 and S3 backtracked to Yahoo homepage while S5 and S6 backtracked to the search result page of Google from Task 1. Only one participant did not return to the initial choice of search engine/portal on one of the tasks. For Task 3, S4 started by going to a specific website. S4 went directly to Yahoo!Answers to locate the full text of the certain poet asked for in the Task 3. S4 explained, "I know about this poet. I know where to start. If you have got a question and you got a good idea what you are looking for, I think Yahoo!Answers is a very good starting point. Yahoo!Answers always has something."

Locate the search edit box. After choosing a search engine/portal or a specific website, the participants needed to find a search edit box to type a search term in order to do a search. Three participants, S1, S2, and S3, pressed <Tab> key repeatedly to locate the search box on Yahoo homepage. They listened to screen reader announcement until "edit text" was read out. The other three participants, S4, S5, and S6, didn't pressed any keys and waited patiently for "edit text" to be announced. They were aware that they were taken straight to the search edit box to type in search terms.

As the participants revised search terms or started a new search, they backtracked to different places to locate a search edit box. S1, S2, and S3 went all the way back to Yahoo homepage. But S4, S5, and S6 backtracked to the search result page of Yahoo or Google. In the researcher's observation, the reason that S1, S2, and S3 returned to Yahoo homepage was that they did not seem to be aware a search edit box was also provided at the top of the search result page of Yahoo.

S1, S2, and S3 experienced difficulties in locating the search box when they backtracked to Yahoo homepage. Even when "edit text" had been announced, S1 and S2 were not certain that they located the search edit box. They pressed <Tab> key many times to make sure the cursor was right in the search edit box. At times they even pressed <Home> key or <End> key. These extra keystrokes took them longer than the other participants to begin entering a search term. S1 reflected, "I didn't know where I was. Was I there yet? I wondered if I reached the right place for typing a search term."

In the interview, S3 complained,” Why can they just give us a hotkey? So I can jump right to the search field by pressing a key?”

In contrast, S5 and S6 were very successful at locating the search edit box at the top of the search result page of Google. S4 not only found the search edit box at the top of the search result page of Yahoo, he was able to tab down the page to locate the search edit box at the bottom. S4 confidently stated, “It is easy. I can find the search field on any website, as long as there is one on the webpage. You just tab down to find it. There will be “edit text”. That’ it! That’s where you can type in a search term.” Although the search edit box was hidden among the other links, S6 had a strategy to find it. S6 remembered the order of navigation bar, the search edit box and the search results on Google. By using the order as a point of reference, S6 could navigate to the search edit box from any part of search result page of Google. S6 described, “I know the search field is at the very beginning. I have to go down a few times to reach the search field. I don’t remember exactly where the search field is. Maybe on the 5th? However, I can feel I am almost there. If I hear something like a search result, I know I go beyond it. So I just need to go back to find it.”

Formulate the first search query. The first search query participants formulated for the three fact-based tasks contained question type queries from the task statement. They relied on keywords that were already in task description instead of their own terms. The first search query used for the first search task included: “flag of the United States,” “flag of the United States stars stripes,” and “how many stars and stripes on flag of the United States.” For the second search task participants used the following as their first search query: “when Taiwan became Japanese colony +,” “when

Taiwan became Japanese colony," and "when Taiwan ceded." The first search query used for the third search task included: "Chih-Mo Shiu," "Information about Chih-Mo Shiu," "Chih-Mo Shiu describes Cambridge," and "Cambridge poem and complete text."

In terms of first search query entered by the participants, most of them contained long, complex, and very specific queries. The number of Chinese words typed in per query was from 3 to 21. When asked why 17 Chinese words were used in the first query on Task 2, S3 commented that if he submitted long specific queries, he would bring up the most relevant results and thus make the search easier for him. Unfortunately, the use of long precise terms often resulted in many more hits which were not relevant to the information the participants were looking for. Although the first search query from most of the participants were long and specific queries, only one of the participants used advanced query operators <plus> to be more precise in his query. S4 explained, "Because then I got not only the search terms I entered but also those terms with more words followed them. <plus> which meant that hopefully I wouldn't miss anything."

The majority of participants did not seem to plan in advance which keywords might be useful. Instead, they typed in the exact phrases from the task description. Only one participant, S1, take time in choosing her first search query on Task 2. She came up with completely different terms "when Taiwan ceded" from others. S1 explained that she knew more appropriate terms based on her domain knowledge of the history. The domain knowledge could help the participants with less experience formulate exact keywords to carry out their search.

During the observation, none of the participants used query support features such as automatic term suggestions while typing in the search terms. As the participants typed, a list of suggested terms that most closely matched what the participants had typed appeared visually on the screen. The list of suggested terms continued to narrow or broaden based on the participant’s input. G-mouse screen reader didn’t give any indication of automatic term suggestions. The term suggestions can be only accessed and read out through entering the <arrow down> key.

Examine the search result lists. Since a search engine/portal returns a huge amount of search results, determining the relevance of the retrieved results to information need is required before the results become useful. The search results were displayed as an ordered list of items and ranked according to their relevance to the query. Each list item contained web page title, web address and text excerpt with highlighted query keywords. However, when the participants processed search result pages using G-mouse screen reader, navigating from link to link was the only method they employed to move through result lists. Thus, the web page title was the primary piece of information the participants used to make decisions about whether to explore a web site or not.

Three patterns were observed when the participants selected a relevant result from a result list based on the information included in the web page title. The first pattern was selecting based on keywords of the page title. The most common way of selecting a relevant result was achieved by examining keywords of the page title. On Task 2, S1 focused her search on the keyword ‘cession’ in evaluating results. She stated that a particular web page was unlikely to be relevant because it contained the keyword 'navigation'. S1 explained, "I mostly looked at the keywords here. If not 100%, but close to 90%. I was not interested in 'navigation'. But the page title 'Taiwan cessions and East Asia situation', that was what I was interested in because it contained the keyword." Similarly, keywords of the page title were also used by S5 to decide whether or not to read a web site in detail on Task 2. S5 stated, "I started by just looking at the keyword. I could see the page title 'Taiwan cession and anti-Japanese' that it was going to be what I wanted."

The second pattern was selecting based on query terms mentioned in the page title. Another way of selecting a relevant result was performed by looking at the query terms mentioned in the page title. When asked how he decided which sites to examine more closely, S6 responded, "If you just listened to the titles, you couldn't always tell from them if something was going to be relevant. I tended to just go down the page and listened to see if any term I typed in the box were mentioned." This assertion was echoed by S2. Another example provided by S2 was to read at how many search query terms were mentioned in the page title on Task 2. S2 elaborated, "When I was trying to see the relevance from the title, I would just see if what I was looking at was relevant to my search terms. For example, if there was only one search term mentioned and I would skip it. Say this one 'Taiwan! Japan!', for example, that looked relevant. You see there were two search terms mentioned. I took a look at that."

The third pattern was selecting based on page title with detailed description. The final way of selecting a relevant result was performed by examining how descriptive the page title was. Sometimes search results were displayed as a list of page title started with the same description. It might be difficult for the participants to know what they would get by pursuing a link. On Task 3, S3 selected a result to read in more detail by reading the page title which contained more words. He remarked, “I would look mainly at the page title to see whether or not it was what I was looking for. So I would basically just start with the one with detailed description. It was obviously a good indication. For example, the titles with just ‘Saying goodbye to Cambridge again’ were not necessarily relevant. However, ‘Modern poem- Saying goodbye to Cambridge again’ looked like it would be more relevant.”

Modify the search queries. If the search results from the first search query did not lead directly to an answer, a return to a search engine/portal or a specific website for further queries was observed. The participants often refined their search queries before they were satisfied with results. Of six participants, four submitted two search queries on Task 1. However, no query modification was performed by S1 and S2 on Task 1. On Task 2, five participants submitted two search queries and only S4 made use of one query. On Task 3, four participants submitted two search queries and three search queries were generated by two participants, S3 and S5. Table 11 presents the search queries submitted per task by the participants.

Table 11

Search Queries Submitted per Task

	Task 1	Task 2	Task 3
S1	1	2	2
S2	1	2	2
S3	2	2	3
S4	2	1	2
S5	2	2	3
S6	2	2	2

There were differences between the ways in which the participants edited their search queries. Query modification methods included adding words to an existing query, removing words from an existing query, and submitting a new query. One method that the participants demonstrated in editing a query involved adding words to an existing query. The reason for this query reformulation was to narrow the scope of the search. On Task 1, two participants, S3 and S5, started with a more general query "flag of the United States." It generated hundreds of hits, many of which were not relevant to the information intended. After struggling to find information, S3 and S5 added words to the existing query. The refined query became longer as "how many stars and stripes on flag of the United States." Eventually, they found the information they needed. In the case of S1, after obtaining too many irrelevant results on Task 3, S1 restricted the scope of the search by adding words "Cambridge" to the initial query "Chih-Mo Shiu". S1 explained, "That had brought back too many irrelevant results. So that's too much for me. So I try to add another keyword, which was 'Cambridge'. So 'Chih-Mo Shiu' and 'Cambridge'." This approach was a success and the information she was looking for was provided.

Another way that the participants demonstrated editing a query involved removing words from an existing query. Opposite to adding words, removing words from an existing query was in an attempt to increase the volume of the results. On Task 1, two participants, S4 and S6, started with the long specific queries such as "how many stars and stripes on flag of the United States," "flag of the United States stars stripes." After the long specific queries failed to give them any useful results, S4 and S6 removed "how many," "stars," and "stripes" from the initial queries. As illustrated by S6, "I quickly jumped down the first page. I think it got about ten results. But the thing that I was looking for didn't even come up. So what I did next was to look under a short keyword 'flag of the United States'." Both of them successfully found the information for answering the question. In the case of S3 on Task 2, he started with the question-type query "when was Taiwan occupied by Japan and became Japanese colony" but received poor results. So he tried removing words and broadened the scope of the search by using the query "when was Taiwan occupied by Japan." This approach would have been a success if he was aware of his misspelling.

The other way that the participants demonstrated editing a query was to submit a totally new query. In order to get better results, this approach was very common among the participants on Task 2 and Task 3. However, the participants didn't reformulate their search queries by creating their original search queries. Instead, they often used terms that were found in the result pages retrieved from the previous queries or in the content of web pages they visited. On Task 2, four participants, S1, S2, S5, and S6, modified their search queries after exploring one or more pages of search results and web pages. In fact, S1 rewrote her queries to “the treaty of Maguan,“ after she extracted bits and pieces of information from the retrieved result pages and web pages. In her interview, S1 described, “I was trying to find when Taiwan was ceded to Japan. Those web pages talked about the history of Taiwan were pretty long. At the same time I tried to recall what I knew about Taiwan history. When I heard ‘the treaty of Maguan’, I kind of felt this might be right. So I decided to give it a try. Fortunately, I found this was exactly the treaty that Taiwan was ceded to Japan. If I didn’t hear those pages which reminded me about it, I wouldn’t have remembered it. And I wouldn’t have used this useful keyword.” On Task 3, five participants, S2, S3, S4, S5 and S6, found the name of the poem to be a more specific term to use after looking through the first few pages of search results. They refined their search queries to “saying good-bye to Cambridge again.” An example of choosing a new query by picked up clues and hints from search result pages was illustrated by S5: “My first search came up with quite a lot of information about life stories of Chih-Mo Shiu. I realized that this search was not going anywhere. After I read a few results, I found a name of a poem repeatedly appeared. At that point, I realized this might be the term related to what I was looking for. And yes, it brought up exactly the information I was looking for.”

Browsing the textual content of a website. After a result was considered possibly relevant to the information need at hand, the participants would follow the link to explore the content of the retrieved website in detail. The participants developed some strategies for website exploration, including navigating from link to link, reading through the whole page, and a combination of both strategies.

The first strategy was navigating from link to link within a website. When browsing the possibly relevant results, the participants jumped from link to link and from top to bottom by using the <tab> key. They listened to the links so they could get a general overview of the web site to decide whether or not the page was actually useful. As described by S6 who navigated one of web sites on Task 1 and only read the links: “I would look to see if there was an article about American flag in this website and at this stage I would just skim through. Sometimes it was easier to go through and read at some of the links to see if anything was in it.” It turned out that that website was no use to him because it only offered in simplified Chinese which G-mouse screen reader couldn’t understand.

The second strategy was reading through the textual content of a website. When browsing the highly relevant results, the participants would read through the entire textual content of a website as opposed to move through the links. By using <Ctrl + Numpad 0> key, the participants had the entire page read out to them in attempt to develop a full comprehension of a web page. When they wanted to listen to the whole page without menu links or advertisement links, <Windows + Numpad 0> key was used instead. Although reading through the entirety of a website was a time-consuming strategy, the participants prefer longer reading times to potentially missing information that could be useful for the task at hand. On Task 2, S1 read through the entire text of a website in order to make inferences about when a historical event occurred. S1 explained, “When you read a history, you should read them properly. Moving through links is not sufficient. If you just pick parts out of the history, then you run the risk of misunderstanding what they are saying.”

The third strategy was a combination of both strategies. A majority of the participants used a combination of both strategies to get a better idea about the content of a website. The strategy of navigating from link to link can work hand-in-hand with the strategy of reading through the textual content. For example, many participants first browsed the page through the links to get a gist of the website. If they couldn’t pinpoint the information they need using this strategy, they resorted to reading word by word through the entire page. In order to answer the question on Task 1, S3 jumped from link to link within a web page titled ‘Globe flag- United States’ and locate the parts such as ‘Flag changed’ and ‘Flag explanation’. So he returned to read through the full text that helped him answer the question. S3 noted, “I had sort of skimmed through and looked at the links to see what it was about and I could see that that page was mainly about flags. There were bits relevant here. I thought I would give a try by reading the text fully.”

Research Question #2

This section describes three main themes that answer the research question: What challenges or barriers do high school students with visual impairments encounter during information searches on the Web using G-mouse screen reader? When using screen readers to search for information on the Web, the participants encountered many challenges and barriers. Based on the analysis of the data, three themes related to challenges were identified including (1) Web pages, (2) Screen reader, and (3) Training. Figure 4 outlines the themes and categories related to Research Question #2.

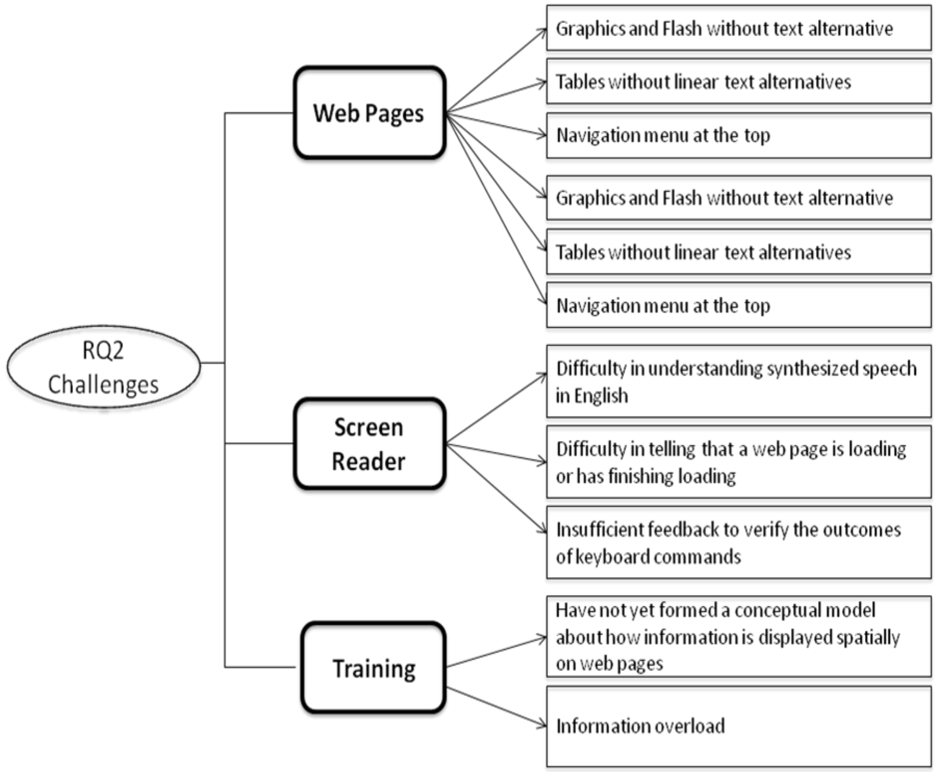

Figure 4. Themes and categories related to Research Question #2.

Web Pages

There were a number of accessibility and usability problems that posed challenges for the participants when they looked for information on the Internet through G-mouse screen reader. These problems included (1) graphics and Flash without text alternatives, (2) tables without linear text alternatives, (3) navigation menu at the top, (4) inappropriate labeling of links, (5) the structure of a blog, Yahoo!Answers, and Wikipedia, and (6) excessive information.

Graphics and Flash without text alternatives. Usually graphics such as photos are provided on a web site in order to present much more detailed features than simple text. However, in web sites there were far too many images that lack descriptive text. In some cases, the alternative text was missing. In other cases, the alterative text was present but non-descriptive such as “image”. During the interview, S6 stated that he noticed sometimes G-Mouse screen reader stop reading the Web page for a few seconds. But he didn’t know what happened until the researcher informed him that there were pictures. G-mouse screen reader did not state that it had found a graphic. Therefore it was completely invisible to the participants. When the image itself contains information, S6 didn’t know that he had missed the information he was looking for. The researcher observed that it was not only images that caused problems but also Java and Macromedia graphics were also a burden. G-Mouse screen readers could not read Java and Macromedia graphics such as Flash. Therefore, if the Java or the Flash included any links within, the participants could not utilize them as they were not recognizable by G-Mouse screen reader. In addition, constantly changing Flash contents also caused G-Mouse screen readers to return to the top of the page as G-Mouse screen reader assumed that there had been an amendment on the Web page due to signals sent by Flash to the G-Mouse screen reader. Interestingly, P6 didn’t know what happened and she felt a little strange when she heard “question mark” eight times repeatedly in the screen reader announcement.

Tables without linear text alternatives. The G-Mouse screen reader read the text from left to right, and when the information was presented in tables, the information was linearized by the G-Mouse screen reader. As a result the participants had difficulty comprehending the information. The biggest block to reading tabular material resulted from the fact that G-Mouse screen reader did not allow the students to read columns of data. It was only possible to read each row of data as a line of text. In the video of Task 1, when S1 read a row of numeric entries, it was difficult to know when one number stops and another begins. A row of 4 numbers such as 1777-1795 13 1859-1861 33 was read by the G-Mouse screen reader as 1777 1795 13 1859 1861 33.

Navigation menu at the top. The navigation menu at the top represented a source of delay and inefficiency for the participants. Since navigation menu appeared on each page, the students who were forced to read the contents in an almost sequential way were always compelled to skim them before they could identify the main content of the current page. S2 mentioned that the placement of irrelevant links at the top of a web page was a great inconvenience, requiring her to sift through a lot of stuff before she heard what she need. Similarly, S3 suggested that the navigation menu at the top of the page would be better placed at the bottom since it was not particularly important. Although S1 had no trouble completing three tasks, the researcher observed that because of the navigation menu at the top, she had to listen to the G-Mouse screen reader read through all the links before reaching the most significant information on the center of the web page.

Inappropriate labeling of links. Using G-Mouse screen reader, the participants accessed a list of links which are presented without context. However, links could be difficult to interpret when separated from the surrounding context. The participants might not be able to see the overall context, such as text appearing before and after a link. This increased the problem of link labels that were confusing or unclear. Links such as "click here," "more..." do not give the participants any clue for understanding the function of the link itself. In the situation that link labels were not descriptive, the participants couldn’t determine whether or not to follow a link because the link label does not contain sufficient information. S6 stated that a majority of links were misleading because the label did not accurately describe where the link would take him. On Task 3, when all the links started with the same words, he felt that he needed to click on each link to find out whether particular links contained information that he was looking for. Likewise, when a link the participants were looking for was there but it didn't start with the keywords they were thinking of, they might not find it.

The structure of a blog, Yahoo!Answers, and Wikipedia. Of the 74 websites the participants visited after following the links in the search results, 8 were from Yahoo!Answers, 5 were from Wikipedia, 2 were from blogs. The participants were unsure about interacting with websites that they were unfamiliar with. In terms of content arrangement, the content on Yahoo!Answers, Wikipedia, and blogs was consistently placed in the middle of a page. This could be problematic if the participants were not familiar with the page as their mental model of the content was broken. S2 followed a potential link to Wikipedia. As she never used Wikipedia before, she was unfamiliar with the structure of Wikipedia and unable to identify any elements or information. She described the navigation menu as irrelevant information. The fact was that the main content was displayed half way down the screen. She left the website before reaching the main content area on the page. In addition, S1 found it was difficult to interact with the Yahoo!Answers as all the navigation links had to be read aloud in order to reach the main content. In particular S1 commented on the fact that there was no easy way to go and also it was difficult to tell when G-mouse screen reader had reached the main content. A lack of familiarity meant that the participants required additional time to establish where the heading ended and where the text began in order to provide the answer to the task.

Excessive information. Searching through large quantities of information presents greater challenges to those who relied on a screen reader. Abundant information limited the participants from acquiring desired and needed information promptly. The participants were forced to listen to all the presented information from the top of the web page regardless of whether it was relevant to their needs. S6 noted that abundant information hindered his search and delayed his information gathering process. S5 commented that searching for information was not really a problem, but it was a time consuming process. When attempting to recall the information for answering question on Task 2, S4 had difficulty in remembering the information he was just listening to ten minutes ago. He forgot the year even when he had been successfully identified it. After listening to one page for 15 minutes, S4 had difficulties recalling the year that Taiwan became Japanese colony and confused the year with other historical events.

Screen reader

In addition to web accessibility and usability issues, the difficulties were observed in cases where the search was interrupted by technical problems or other factors originating from the screen reader. These were problems that are caused by difficulty in understanding synthesized speech in English, difficulty in telling that a web page is loading or has finished loading, and insufficient feedback to verify the outcomes of keyboard commands.

Difficulty in understanding synthesized speech in English. The ability to understanding synthesized speech in a web page is crucial to a speedy listening to the information being read. The G-Mouse screen reader was unable to correctly pronounce certain English words found in a web page, especially unusual words, acronyms, and abbreviation. Participants were confused by listening to improper, though phonetically accurate, pronunciation of English. S3 commented that in some respects he found the speech of English a little confusing. For example, G-Mouse screen reader pronounced “Yahoo” like “Volume”. Participants complained about the accuracy of the speech sound in English alphabets. S1 found the pronunciation of English was poor. She remarked that this had made practice tests difficult. As she read the answer to the multiple choice question for practice exams, it was very important to hear English alphabets a, b, c, and d clearly. Similarly, S2 stated that the speech of English was incomprehensible and that it had felt as though she was listening to an alien language. It was observed she skipped all those links labeling with English words.

Difficulty in telling that a web page is loading or has finished loading. Another challenge that bothered all the participants was time waiting for the G-mouse screen reader to respond, such as loading a new web page. In this study, participants relied exclusively on the audio feedback. Participants commented that G-mouse screen reader lacked the feedback needed to understand a page was still loading or had finished loading. When asked how he knew the web page has finished loading, S5 stated that the audio clue was that the G-Mouse screen reader started reading from the top of the web page. However, when the web page which participants were linking to was still loading, they could not be sure that the computer or G-Mouse screen reader was still working. On the other hand, when S2 could not identify whether the web page had finished loading, she probed with a keystroke and consequently caused the task to be executed twice. Similarly, S1 would blame herself because she thought she had not performed the right action. Interestingly, S6 mentioned that he usually preferred to use G-Mouse screen reader and refreshable braille display together. The reason was that he would know the loading percentage of the web page by reading the last four cells at the right hand side of the refreshable braille display. Surprisingly, S4 knew that G-Mouse screen read had a keyboard command that could read out the percent of the web page as it loaded, but according to his experience it didn't work sometimes. Therefore, he didn't use it at all.

Insufficient feedback to verify the outcomes of keyboard commands. One feedback-related problem that bothered all the participants was insufficient feedback to inform that a keyboard command has had an effect. The participants had difficulty translating their goals into actions when feedback was difficult to perceive and was not inconsistent with the participants' expectation. Consequently, the participants executed the task twice or blamed themselves because they thought they have not performed the right action.

One example of this type of problem was nothing appeared to happen upon activating the link. Specifically, there was no audio feedback that a change had taken place. It was not always obvious if there were any new content displayed. The participants were not sure whether they had successfully activated the link or it was a broken link. S1 commented, "G-mouse give no indication of any changes to the site. I am not sure if results are there, the top of the page is the same as the last one". Actually, the new content could only be discovered by a deliberate read. The other example of this type of problem was when the participants followed a link and a new window was generated without warning. In this situation, the participants did not realize that the active window was new and became disoriented among windows. They were unable to use the <Backspace> as expected. Sometimes, they tried to close a window but did not realize it was the last window in stack, accidentally closing the browser instead. S2 illustrated the problem by saying, " In fact, if you work out how to use it, it is perfectly accessible, but G-mouse, as usual, is rather rude and doesn't tell you when it is a new window. You just have to presume it is the same page. If <Backspace> doesn't work, I will try commands that close a window."

Training

The participants' insufficient search competence could have contributed to the participant's difficulty in searching information on the Web. The result highlighted two main problems specific to the participants' training including (1) have not yet formed a conceptual model about how information is displayed spatially on web pages, and (2) information overload.

Have not yet formed a conceptual model about how information is displayed spatially on web pages. When using G-Mouse screen reader, the participants' perception of what a web page was substantially varied. Some participants seemed to see a web page as a sequential list of links and texts. The linear presentation of information was found to limit their perception of the spatial representation of a web page. These participants would retain the linear presentation in their mind and navigate using this concept to a certain extent. They apparently didn't think about the structure or layout of a web site at all. Through the use of G-Mouse keyboard commands, S6 felt that he could gain a clearer representation, as he could perceive where elements such as links and other attributes were located. S6, who was blind since birth, was able to remember important features such as links and was therefore able to count through the links, without fully hearing them, to get to the one he wished to activate. S6 remarked, “I memorized a link which was the fourth one down from the beginning of the page.”

Interestingly, there was evidence that some participants attempted to understand the layout of a web site and they formed a mental map of how the web site was laid out and how the information was organized. S4, who became blind after age 9, described he learned the “pattern” of a web site because he applied patterns learned from using the Windows desktop and the file structure to web navigation using Internet Explorer. On the other hand, S2, who was able to see the screen before age 14 but now relies mostly on a G-Mouse screen reader, provided a different aspect. She explained that she did not have the same mental image as a blind person, as she was interacting with the Internet using a completely different system. S2 stated, “I know what Windows and web pages looked like before. I can visualize what’s being read.”

Information overload. Another aspect that might make the participants feel challenged was the content of a web page that was retrieved. First, they might be too long for the participants to read and comprehend in a limited amount of time. The content of the individual web page which included many segments of information was often too long for the participants to read online. Furthermore, if a web page contained more information blocks, in order to read a specific block, the participants also had to read the previous ones. As re-find information is relatively more taxing, some participants developed some forms of note-taking, such as using word processors such as Notepad, reiterating the screen reader announcement, bookmarking, or saving the entire web page as a file on the computer. All these different strategies had the common goal of serving as memory aids to allow the participants to get back to specific information which had previously been useful.

Second, they may not cover the exact information that the participants needed. G-mouse screen reader obliged the participants to follow the page content sequentially. The static portions of the page such as navigation menu and banner at the top might overload the reading because the participants had to read the same items over and over for every page. For example, the participants submitted a query in a search edit box of a search engine. Often the search result generated by a search engine was visualized in the middle of the page among other content. At the top of result pages, there were several links, advertisements, the search fields and buttons. Therefore, it might take the participants a long time to find it because the information that precedes the results has to be read, even if it was still the same as the previous page. Some participants used the strategy of skipping to avoid processing the repeated irrelevant information. For example, S4 used <Alt+ plus on the numeric pad> to jump ten links at a time.

Research Question #3

This section presents six main themes that answer the research question: How do high school students with visual impairments overcome challenges or barriers during information searches on the Web using G-mouse screen reader? Searching for information on the Web was a challenge for the participants who struggled with complex and poorly designed web pages. Based on the analysis of the data, six strategies were identified which the participants developed in an attempt to cope with the difficulties of accessing the Web, including (1) note-taking, (2) trial and error, (3) backtracking, (4) looking for assistance, (5) skipping, and (6) giving up.

Note-Taking

Note-taking is a common strategy used by the participants to keep track of information they read. When the participants were trying to find information within the page, they were easily overwhelmed by the significant amount of content. To avoid getting lost within a large amount of text, the participants performed some kinds of note-taking activities. They took notes electronically using word processors such as Notepad, reiterating the screen reader announcement, bookmarking, or saving the entire web page as a file on the computer. The participants took notes of different types of text, such as paragraphs, keywords, or web addresses.

For example, during the search process S4 tried to manage the information he found without braille note taking devices. On Task 2, S4 found a web site might contain information he needed, but it took him seven minutes to read through the entire page word by word. He didn’t want to listen to the whole page again. The solution for him was to copy the content and paste it to Notepad. In this way, S4 could skim through the content by listening to the first few words of each line. On the other hand, S2 reiterate what the screen reader read out, so that she could memorize the important parts of the content page without revisiting the web site. For the participants the search process took a long time to complete, therefore, they developed different ways of remembering the information they encountered. When asked how she shared the web address of a website with her friends, S1 responded, “A web address is too long to remember. No way I can memorize so many English words. I simply save the entire web page as a file. Then I copy the file to a disk. My friend can read the disk.” As opposite to S1, S6 reported simply using bookmarks to save the web address.

Trial and Error

A trial-and-error event occurred when the participants took a move and then quickly gave different commands for the same purpose. The participants often exhibited a trail-and-error behavior as a method of exploration when they were unsure why the first move failed but took another move right away. Trial and error was mostly employed under situations of locating the search edit box, switching reading mode to edit mode, selecting potential relevant links, discovering when a page had finished loading, finding the main content, and returning to previous page or homepage.

For example, S2 wanted to find the search edit box on Yahoo homepage. She used the key <plus> on the numeric pad to go forward several times and then went backwards several times by using the key <minus> on the numeric pad. Likewise, S1 failed to enter text in a search edit box for the first time. She turned the screen reader into “edit mode” before typing any text but turned to “reading mode” right after finishing enter text in the search edit box. Moreover, S3 was confused by links starting with the same words. He explored the links by following the links simply in the hope that it went to useful information. In addition, S6 pressed <Ctrl + zero on the numeric pad> to force the screen reader to start reading through the entire page without links. He listened to the screen reader and waited for it to start reading. This would only happen when the page had finished loading. Similarly, S5 pressed < tab> key to have all the links read aloud first and then pressed <Ctrl + zero on the numeric pad> to listen to all the information on a page to find the desired information. Furthermore, S2 pressed <Backspace> first and then <Alt + left arrow> until something happened. These were pressed in the hope that she could return to previous page.

Backtracking

When browsing web pages, the participants occasionally got lost within the page. This could occur either because the student clicked a wrong link or because the page at the destination of a link did not contain information that was expected. The backtracking strategy was used when the participants wanted to recover from situations where they were lost within the Web. Instead of going backwards to the point at which the confusion began, the participants went back to a safe situation, typically the homepage of the search engine. This occurred until the participants reached the point at which they became lost and then a different decision was taken. In the videos this strategy was observed on Task 2 where S1 was using Yahoo to find search results. She was trying to find links to the history of Taiwan and clicked on a link she thought was appropriate. On the new page, she had to use a combo box to choose the location. By accident she chose China. Rather than went backwards one page to select a different location, S1 returned to the Yahoo home page and retraced some of her steps.

Looking for Assistance

Active coping was the most common strategy, however, there were some participants who also turned to another person when faced with a problem. The participants reported that they were more likely to look for assistance from those who were always readily available to them including sighted family members and their peers with low vision. At school, classmates were used for seeking assistance. At home, family members were more typically asked first and if they did not know an answer, other sources were consulted.

In comparison, peers and friends who are blind were more likely to be the sources of screen reader problems whereas sighted peers and family members were used as the sources of Internet-related problems. The participants stated that they looked specifically to the more experienced and knowledgeable peers and friends who are blind for help. These individuals have a better understanding of their needs. Compared with more experienced participants, less experienced participants S1, S2, and S3 were more inclined to ask for help from a sighted person with Internet-related problems. They sought the help from sighted people who happened to be around them when they accessed the Internet, such as teachers, classmates, friends, and family members. More experienced participants S4, S5, and S6 tended to use trial and error first and preferred to solve technical problems independently. Sometimes they submitted requests for help to discussion groups or bulletin boards to find the solution to computer related issues. Under certain situations such as forms and picture verification boxes in online booking processes, however, it was necessary to rely on the help of sighted people. When both less experienced and more experienced participants encountered problems with the physical computer, they were more likely to ask for help from a sighted person. For example, if the computer was found frozen, or the Internet connection went down.

Skipping

The participants encountered many web sites and search result pages that had the page header, the banner, and the navigation bar at the top of the page. The page header was typically the same for every page and contained the banner, which informs the participants what the web site was, and the navigation bar. The strategy of skipping allowed students to avoid the frustration of listening to the page header repeated for every page when they visited the same web site. In the videos this strategy was observed in every task when the participant S2 was trying to reach the Yahoo search results. She immediately pressed the <plus> key on the numeric pad several times to avoid the banner and the navigation bar. She stopped just after she had reached the first search results. However, the participants still had to skip through irrelevant links, advertisements, and lists of related articles or products that were positioned in between the title and the rest of the content. Even worse, irrelevant content was sometimes placed right in the middle of main content, forcing the participants to guess if it represented the end of the content or just some annoying interruption. While the participants often ended up reading through the advertisements for fear of skipping relevant information, sometime they skipped the irrelevant content.

Giving Up

Giving up was the strategy by which the participants surrendered to coping. It was a last resort strategy when other strategies had been exhausted. There were occasions that the participants became so tired after several trials with one task that they could no longer deal with the frustration and stress of browsing the Web. Under such circumstances, the participants typically became exhausted and resigned themselves to not being able to succeed in their task and gave up.It often occurred after having difficulty locating the desired information or coming across content inaccessible beyond the skill of the participants. In the videos this strategy was observed on Task 2 when the participant S3 was typing his third keyword in the search edit box of Yahoo. His keywords were lost during the typing process, possibly due to the wrong procedure of keyboard commands, and as S3 was unable to retrieve the keyword without typing again, he simply just gave up on searching. When S2 managed to escape from a loop of pages, the next visited page was a broken link, she gave up her task. The key situation that made the participants gave up was not the type of problem found, as most of the problems were common to other problematic situations, but a sequence of failures and unsuccessful interactions

Summary

This chapter presented the findings of the data collected from six high school students with visual impairments. Multiple sources of data from pre-task interviews, observations, video recordings, and post-task interviews were used for the triangulation analysis to answer the three research questions of the study. The demographic characteristics of the participants, including descriptions of their experiences with the computer, the Internet and the screen reader usage were presented. Three key findings were identified related to information searching experiences of high school students with visual impairments who access the Web with the aid of screen readers.

The first main finding is about how the participants search for information on the Web. Regarding the participants' actions, the participants skimmed through a web page by jumping from link to link and scanning the first few words of a link, rarely reading through an entire page. By using limited of use of G-mouse keyboard commands, the participants only looked at the first page of search results but visited more than one website per task. In relation to the participants' cognition, they chose a search engine/port or a specific website to search for information. After the participants got oriented to the search edit box automatically or by tabbing to it, they formulated the first search query from the task description and then modified the search queries with new terms found from retrieved result pages or web pages. The participants examined the search result lists based on the page title and browsed the textual content of a website by jumping through links and reading through the entire page.

The second important finding is about challenges the participants encountered during searches on the Web. In terms of web pages, the participants faced six accessibility and usability problems that obstructed their progress to varying degrees during online information search. The six problems included graphics and Flash without text alternative, tables without text alternative, navigation menu at the top, inappropriate labeling of links, the structure of specific websites, and excessive information. In relation to G-mouse screen reader, searching information on the Web became a challenge for the participants when G-mouse screen reader failed to pronounce English in an understandable way, to give indication when a web page had finished loading, and to provide sufficient feedback to verify the participants' actions. Regarding the participants' training, the obstacles encountered by the participants could be caused by individual's insufficient search competence, including not having the conceptual model of a web page's layout and strategies to deal with information overload.

The third major finding is about the participants' strategies to overcome challenges during information searches on the Web. When the participants experienced problems on the Web, they employed six strategies, including note-taking, trial and error, backtracking, looking for assistance, skipping, and giving up. The participants employed these strategies to overcome challenges and barriers throughout the whole search process, not just at a particular stage of a search.

CHAPTER V

DISCUSSION, RECOMMENDATIONS, AND CONCLUSION

In previous chapter, three main findings were identified regarding to information searching experiences of high school students with visual impairments who access the Web with the aid of screen readers. This chapter presents the discussion of these findings related to the three research questions. The chapter also offers practical applications of the findings, explore the limitations of this study, and propose some areas of future research suggested by the findings.

Discussion

This study echoed the findings from some research focused on Web searching behaviors of adults with visual impairments (Craven, 2003; Jones et al., 2005; Lazar et al., 2007; Theofanos & Redish, 2003) and online information searching behaviors of adolescents with visual impairments (Shimomura et al., 2010), but this study was not simply a qualitative confirmation of previous results. This study also revealed behaviors that previous research had not mentioned or examined.

Factors Affecting Action

Experience. In this study the differences between the participants who considered themselves as more experienced users and those as less experienced users were found in relation to the type of keyboard commands, the choice of search engines, and the orientation of the search edit box. From the findings it could be seen that the experience of the participants helped determine their behaviors. Sound is transient and may be meaningless on its own. Participation in real experiences provides opportunities for them to connect what they hear to what is happening, because experience provides a meaningful context for understanding (Barclay & Staples, 2012; Postello & Barclay, 2012).

Experienced participants started with Google, while the less experienced participants were inclined to stick with Yahoo. Experienced participants found easy to use and time savings were crucial for them to make the choice. This concurred with findings in the Berry's (1998) report where more experienced users tended to acquire a more efficient and systematic approach to maximize use. It was a successful experience for experienced participants to locate the search edit box on Yahoo or Google. They were aware that the cursor was automatically set in the search box. Participants with less experience found it difficult to locate the search edit box. They didn't realize there was a search edit box at the top of the search result page. Familiarization with the web pages was important for participants to understand a page and navigate a site. These findings were in line with those of Gerber's (2002b) study that people with visual impairments re-visit sites because they are familiar with their layout and therefore can navigate more easily.

Users experience with assistive technology played an important role in determining how successful they could finish the task. This study revealed that the participants with less experience relied heavily on commands of G-mouse screen reader, while the participants with more experience took more advantage of keyboard shortcuts of Internet Explorer and Windows system. Experience could involve familiarity with the web page or familiarity with the functionality of the system and the assistive technology. This finding is congruent with prior research (Lunn et al., 2011) that found users who used screen readers became more familiar with the technology and they also became more familiar with the pages that they were visiting.

Scrolling. The findings of this study showed that the participants skimmed through a web page by jumping from link to link, rarely reading through an entire page. Using the screen reader, the participants might lose the overall context of the current page and read only small portions of texts. For example, when jumping from link to link with the tab key, the participants read the link text, but did not know what was written before and after the link. This result was consistent with the findings of previous research (Barnicle, 1999) indicating that people who used screen readers listened to a single item at a time rather than see multiple items simultaneously was that they were deprived of access to supporting contextual information.

Scanning. This study found that the participants speeded up the reading by scanning and did not listen to an entire link but only the first few words of a link. There were several factors that influence how people with visual impairments approached a web site, including whether they were already familiar with the site—its layout and content, how much time they had at a particular moment, whether the content really caught their interest, and their level of expertise (Gerber, 2002b). Web sites might be more or less usable, depending on which approach was used. Navigation could be further divided into goal-oriented navigation and browsing. Browsing was characterized by its exploratory nature and absence of planning and goals.

Goal-oriented navigation was looking for specific information to fulfill specific information needs. Most of the participants seemed to use browsing for navigating web sites as they scanned though the page by jumping from link to link. The participants with more experience tended to search with targets in mind. It was hard for the participants to find information embedded deep into the audio output of the screen reader. This was similar to that described by Zeng (2004) that the users' abilities to find the exact information they needed was more important than to gain the completeness of information available to them.

Keyboard commands. This study identified that the participants did not take advantage of all the functionality of G-mouse screen reader. The command structure of screen readers focused upon keyboard input and required the participants to remember a large number of keystrokes in order to interact efficiently with web pages. The use of keyboard commands demanded much recall memory. The requirement created a cognitive overload on the participants. This study confirmed in this respect the results of the studies by Theofanos and Redish (2003) and Chen, Tremaine, Lutz, Chung, and Lacsina (2006). Thus the users who used screen readers split their cognitive resources three ways in trying to understand the interaction between the screen reader, the web browser, and the web site. In addition, advanced shortcuts required the understanding of the web page structure. While most of the participants relied heavily on link by link scanning, only one participant who considered himself as more experienced user, took advantage of commands related to the space of a web page. He used the keyboard-driven mouse to move the current mouse position and read out the content beneath the cursor so that he could access content that was not accessible using only standard keyboard commands.

The depth of the search. The results of this study showed that all of the participants looked at the first page of search results only and rarely went past the first seven results during most of the online sessions. With regard to the depth of the search, the participants tended to stop more readily once they had found at least one relevant link and did not look further. The reason for this might be due to the fact that the participants were listening link by link and might not have been aware that ten other possible relevant items were displayed. This aligns with the findings of Craven and Brophy (2003) that for people who used screen readers it might have been useful to hear the total number of estimated results found during a search which was visually displayed before the first result.

Factors Affecting Search Procedures

Query formulation. The findings of this study showed that the participants expressed their complete information need in a long precise query and as a result, their queries were more expressive. Query formulation was a critical stage in the search process as the participants try to express the mental model of their information need using a query. They wanted to access the most relevant information immediately. This behavior could be readily understood when one takes into account the fact that, as shown by the findings, many aspects of the search process were time-consuming for the participants. This result was consistent with the findings of previous researches (Craven, 2004) indicating that providing an initial search request, which was specific enough that it reduced the number of interactions required from submitting that query to reaching the required results. It was one of the effective strategies a people who use screen readers could employ to try to reduce the overall search time.

Despite link-to-link navigation, the participants still had to linearly process the results list before they could decide whether their search was going in the right direction and whether their choice of queries was correct. These findings showed that the beginning of the search process could be challenging for the participants and that they should be supported during query formulation especially for longer queries. Therefore, the participants could benefit from an awareness of such alternative search strategies to increase the effectiveness of their search activities.

In addition, the participants did not benefit from visual cues on search engine that could help their query formulation strategy. For example, automatic term suggestions, which appeared in a drop down box in real time as a query was being typed. In order to access it, the participants had to type at a relatively slow pace and navigate away from their focus, listen to the suggestions, and navigate back again. This interferes with the way the participants interacted with search systems, making the cost of using automatic term suggestions higher than the benefits they could provide. Therefore, automatic term suggestions were most often ignored among the participants. Despite being accessible, automatic term suggestions were not usable. The lack of awareness and use of search support features highlighted the importance for search engine features to be both accessible and usable because if potential benefits did not exceed required efforts, they would remain unpopular with people who used screen readers. Therefore, it was essential to ensure that support features were designed to be accessible with screen readers, but they should also be usable and easy to integrate with the mode of interaction.

Search result lists. When exploring search results, the participants based their assessment of relevance mainly on the content of the page rather than its structure or layout. Using screen readers, the participants took a longer time to acquire the content of the web page as they needed to build their mental model of the web page from the pieces of information being read to them by the screen reader. The findings showed that the participants progressed slowly during the search process and they submitted a low number of queries and viewed only the first page of search results. Given the time and effort required by the participants to explore search results, there is a need to make this process more efficient. Bigham, Cavender, Brudvik, Wobbrock, and Lander (2007) suggested that alternative presentation methods should be evaluated to enhance browsing behaviors of people who used screen readers in order to increase the efficiency of the search process.

The lack of information impacts the search behavior of people with visual impairments the most as additional information conveyed by visual cues are not accessible. Hence, due to this lack of contextual information, the participants displayed a limited exploratory behavior in the video and visited a low number of external links. This behavior could be explained by the fact that when visiting web pages from the search results list, people with visual impairments failed to grasp the benefit that external pages could have on their search process (Craven & Brophy, 2003). Therefore, Bigham et al. (2007) suggested that unless there was a clear benefit in visiting an external link, people who used screen readers were discouraged from doing so as the costs associated with visiting and understanding a new page was high.

Reading the textual content. The results showed that at the stage of reading through textual content of a web page, the strategy displayed by the participants to keep track of encountered information was note taking. The participants relied on external applications such as word processors to take notes during their search process. While this was an effective strategy to relieve the load on working memory and to reduce the time-consuming need to revisit web pages, it also required the participants to constantly switch between applications which could be inconvenient and contribute to cognitive load. The screen reader already required significant cognitive effort from the participants and when reading through content of web pages, the participants were faced with a high level of cognitive load while comprehending and analyzing information. Therefore, the participants developed strategies such as bookmarking and note taking to make relevant web pages more persistent and to make them easier to re-find in the future. Note taking was not popular among sighted people as they found it relatively easy and effortless to re-find results of interest either by searching for them again or by keeping them open in multiple tabs and windows (Bigham et al., 2007). This implies that, unlike sighted searchers, people who used the screen reader needed to be supported by search systems to manage the information they found during the search process as re-finding was relatively more taxing.

Factors Affecting Listening Process

Information overload. As screen readers processed Web pages sequentially and read through everything, Web browsing became time-consuming. To address this problem, the participants read at speed by scanning only the first few words of a link and jumped from link to link. They tended to spend less time, however, they were not able to give a comprehensive idea on the information encountered. This linear and fragmented presentation of information requires a different cognitive process. Students with visual impairments often need to learn concepts from part to whole (Fazzi & Klein, 2002; Heinze, 2000). They need to synthesize the discrete pieces of information and weave them together into a whole. In addition, by quickly scanning information that was not actually used in the decision making process increased. This information only added to a participant's information overload. In many cases, they still had to start from the beginning of the page and listen to a substantial part of page content before they got to the information. The problem of information overload still remained. This finding confirmed the observation of Chen et al. (2006) who had recognized one of challenges that people with visual impairments encountered: people with visual impairments needed to go through much unwanted information sequentially, before reaching the desired content. Leporini and Paterno (2004) pointed out that one of the main navigational problems was excessive sequencing in reading information and that instead of directly accessing a certain paragraph, the user who are blind needed to listen first to the preceding paragraphs.

Mental models. Information search behavior was impacted by the way the participants interacted with the search system. This aligns with the concept of Andronico et al. (2005) that the screen reader played a significant role in how web pages were perceived for people with visual impairments. The screen reader processed pages and produced output to the participants in a sequential order, from left to right and from top to bottom, presenting the content word by word and line by line until the end of the page was reached. This is similar to that described by Takagi et al. (2004). Using screen reader, people with visual impairments could only get one-dimensional string of content fragments.

The mental model created from the screen reader output did not include two-dimensional layout. Without the information provided by the layout, it was confusing for the participants to interpret the pages. This echoes the research of Murphy et al. (2008) that people with visual impairments did not know where they should focus their attention on since they did not have the spatial awareness of the elements' position on the screen. The most straight-forward model for one-dimensional information was a string of text, and this representation was used when reading a book or listening to the news on the radio. The problem with a string of text was that they were hard to navigate because there was no structure.

Similar to findings by Craven (2004), impressions of web pages for people who used the screen reader were largely dependent on content while sighted people placed a strong emphasis on layout. Therefore, the participants received the content of the page in small portions and had to make connections between these pieces of information to construct their mental model and to get an overview of the page. Participants would retain this mental image and navigate using this conceptual model to a certain extent. If they could remember that a link was the fourth one down from the beginning, they would make use of their memory. As a result, Murphy et al. (2008) arrived at a similar conclusion that people who used the screen reader would try to remember the sequence of the interested items. A considerable demand was found to be placed upon short and long-term memory usage, which had the drawback of reducing the quality of the interaction experience for people who used screen readers.

Factor Affecting Strategies

When using G-mouse screen reader to search information on the Web, the participants seldom navigated without difficulties. They often encountered accessibility barriers and problems caused by the G-mouse screen reader and their search competence. The results showed that the goal of strategies employed to overcome challenges was to enable the participants to remove themselves from these challenging situations rather than pursuing their goal.

In situations of confusion, the participants asked for assistance as long as it allowed them to remove themselves from such situations. The participants looked for assistance to reassure themselves by asking confirmation about what was happening. The idea of escaping from situations of uncertainty was also employed by backtracking to a previous page or the homepage. The participants consciously went all the way back to the homepage even though they knew would not lead them to their goal. They deliberately backtracked to a safer location rather than followed a different link. As a result of employing these strategies, the participants felt more confident about what surrounded them. The notion of escaping from the problem was also reinforced by the strategies employed under information overload. The goal of these strategies was to increase the participants' autonomy: skipping and note-taking. The use of these strategies entails the move to a safer place which enabled the participants to browse without any obstacle. As a last resort strategy, giving up was also considered as a strategy to gain more freedom. In light of the above, it was apparent that escaping strategies were employed at every navigation stage: at result selection level, at page exploration level and at page navigation level.

This means that in situations of uncertainty, and overload, the participants were driven by the need of overcoming the situation and to do so, they escape from the current path rather than looking for their goals. The findings suggested that cost of accessing information was minimized at the expense of gaining low quality information. This entailed that the participants would skip information if by doing so their problems were avoided. Alternatively, this phenomenon could be explained that in challenging situations any information was good enough.

Recommendations for Practice

Students with visual impairments still face many challenges and barriers when using screen readers to search for information on the Web. The findings of this study have recommendations for screen reader developers who want to help improve online task performance of students with visual impairments, for web designers who are interested in making their web more accessible and usable, and for educators who teach high school students with visual impairments.

Recommendations for Screen Reader Developers

Screen readers have great potential and are useful in many situations, but the technologies have still not reached a level adequate for helping students with visual impairments to complete most tasks online. Three recommendations for screen reader developers are to: (1) support automatic term suggestions, (2) provide the overview of content arrangement, (3) provide a non-speech notification for a content change.

Support automatic term suggestions. One of findings indicated that when the participants formulated their search queries, they were unaware of the feature of automatic term suggestions provided by search engines. The screen reader should be enhanced to cope with the automatic term suggestions that are provided by the search engine. The automatic term suggestions are not directly relevant to the user's task but might be useful for the completion of the task. The automatic term suggestions should be accessed in more usable ways to allow students with visual impairments to navigate effectively. The screen reader developers should ensure that the screen readers are compatible with the feature of automatic term suggestions and do not affect the way students with visual impairments interact with it.

Provide the overview of content arrangement. The results showed that the participants had not yet formed a conceptual model about how information was displayed spatially on web pages. Current screen readers had limited capability to interpret complex two-dimensional layouts. Information about the visual layout of the web page can help students with visual impairments understand how it operated. Simply providing a description of the layout alone, without changing the interaction model, is not enough. students with visual impairments may be unable to navigate to the main content, despite having an awareness of its layout. Moreover, retaining the precise layout of a number of items in memory imposes a significant cognitive load. What may be needed is the overview of how the content is arranged.

Provide a non-speech notification for a content change. This study identified one of the challenges the participants encountered was that they could not tell a page was still loading or had finished loading. Typical screen readers are not designed with the Web in mind and offer only limited functionality in generating a reading order from documents. Especially the interactive nature of the Web is not very well addressed in those products. Non-speech sounds like the beep alert students with visual impairments that some events that occur in the environment, such as a page has finished loading and when content on the page has changed. The apparent advantage non-speech sounds is that they can convey simple information in a quicker and less distracting way than might be possible through speech.

Recommendations for Web Designers

Searching for information on the web is quite a complex task, since students with visual impairments frequently need to refine their search before finding what they are looking for or before they are satisfied with the results. If a web page is incomprehensible or not usable to students with visual impairments, they may explore alternative pages. While many research projects have tried to improve screen readers, much more effort is needed for Web designers to tackle the problems experienced by students with visual impairments when they searching and browsing the web. Two recommendations for web designers are offered and they are to: (1) include auditory previews and overviews for search engines, (2) provide support in keeping track of information.

Include auditory previews and overviews for search engines. Results suggested that the participants only used the page title to predict search result relevance. There is a need to incorporate additional page details. Students with visual impairments would benefit from the use of auditory previews and overviews. Previews act as a surrogate for individual result and overviews represent a complete results set. Previews and overviews of search results on the search engine would help students with visual impairments to speed up their search process by allowing them to manage their time more efficiently. Providing previews and overviews of the search result give students with visual impairments the opportunity to understand whether or not the web site contains the information they require. Thus, students with visual impairments could spend more time viewing content that they are interested in and avoid viewing retrieved results that are not relevant to their information need.

Provide support in keeping track of information. The results showed that the participants had difficulties in remembering and managing encountered information because of the information overload. Students with visual impairments have to rely tremendously on their memory when searching since speech output is momentary and fleeting. Therefore, search engine designers should support students with visual impairments in managing their search results so that they can make sense of encountered information. They should ensure that they provide students with visual impairments with an integrated solution to keep track of the information they encounter. Also, the search process of students who use screen readers is likely to be completed over multiple search sessions, and students with visual impairments should be supported to record their progress with their search task, especially for complex search tasks where they may be uncertain about the search domain or the task itself.

Recommendations for Educators

A holistic approach should be adopted in providing accessibility and usability for students with visual impairments, addressing not only technologies, but also methods of learning. The intervention of educators may remedy the fact that online information is not accessible and usable. The intervention of educators is required to ensure that students receive useful guidance at early stages of the learning process. The recommendations for educators are to: (1) provide training in formulating effective search queries, (2) provide training in overcoming information overload, (3) provide training in building mental models, and (4) provide students with opportunities to share experience.

Provide training in formulating effective search queries. The findings showed that the participants failed to use multiple keywords to search. Although search engines, including Google, provide an "automatic term suggestion" feature, the participants easily overlooked this feature during information search process. To more successfully use search engines, students with visual impairments should be equipped with better digital literacy skills including, but not limited to, formulating effective search queries. In addition, students with visual impairments have to understand to some extent the mechanics of how a search engine works, in order to formulate effective queries. Current systems encourage their users to type in short queries to express their information need. Thus, there is a need for intervention by educators to teach students with visual impairments in formulating search queries that can lead to a successful experience.

Provide training in overcoming information overload. This study indicated that one of challenges the participants encountered was information overload. Educators may introduce students with new strategies and techniques to cope with information overload. A strategy like reading in parts may help to reduce the problem of information overload. Since auditory information is transient, reading in parts may help students to decompose the problem into sections. A technique like note-taking in word processors provides external memory to students with visual impairments may help them recall information more easily.

Provide training in building mental models. The results showed that the participants had not yet formed a conceptual model about how information was displayed spatially on web pages. Students with visual impairments can substitute hearing, touch, or multimodalities for vision to explore the information online. However, current assistive technology has limited capability to interpret complex two-dimensional layouts. When auditory mode is not available, students with visual impairments can build a mental model of the web page with haptic device or tactile materials. So they will form a mental map of how the site is laid out and how the information is organized. When students with visual impairments have a mental map, they can quickly return to a point where they make a wrong turn and try a different route.

Provide students with opportunities to share experience. The participants with more experience use domain knowledge, system knowledge, and individual information seeking knowledge to solve information needs. They have developed distinct patterns of searching and used a variety of strategies, tactics, and moves in their information seeking process. The participants with more experience implemented problem solving techniques such as electronic note taking through their information seeking process. These participants need to have opportunities in a face-to-face class to share their techniques with other students. Educators can reinforce the effective behaviors and techniques by bringing them into the screen reader instruction in order to assist all students in developing their information search process.

Recommendations for Future Study

In this study tasks were imposed by the researcher and performed in a controlled environment. Students with visual impairments might behave differently when the tasks are based on real information needs or when they are embedded in a setting more meaningful to them. In addition, students should have been more motivated to conduct the search to find the information for their personal use. In order to gain as realistic an insight of their search behaviors as possible, it might be useful in the future to conduct a study in a natural setting such as at home or in a real class and with tasks initiated by the students themselves that will create their own motivations to search information.

In addition, it would be interesting to analyze the differences between more experienced students and less experienced students. This study exposed some differences in search behaviors and search strategies between participants who considered themselves as more experienced users of the Internet and those with less experience. Future studies could explore in more detail the habits of students with visual impairments who are more experienced in using screen readers to search for information on the Web and the influence that experience with Internet searching has on students' success.

Limitations

There were some limitations to this study. In this study, the purposeful sample was used and its size was also limited. Although students in different grades of high school were studied, all participants were from one school. The online information searching process of only six students were studied in depth. With a case study focused on a small and specific population, results cannot be generalized to the larger, general population. In addition, students performed online information search tasks under a prepared setting. Although the tasks were selected and validated by school teachers for this study and not used in their classroom prior this study, the tasks were imposed and only simulated possible academic information needs. In the actual search for a real class assignment, students may have more freedom in pursuing the tasks and without time constraints. Although the participants were asked to search as naturally as possible while searching for answers in the given tasks, it was obvious that the search behavior might be different in the real life situations. Moreover, because all participants volunteered to participate in this study, they might have more interest in using screen readers to perform online information searches than the average high school students with visual impairments.

Conclusion

This study provided insights regarding how high school students with visual impairments conduct information searching on the Web using screen readers from a user-experience perspective. Regarding the participants' actions, the participants skimmed through a web page by jumping from link to link and scanning the first few words of a link, rarely reading through an entire page. By using limited of use of G-mouse keyboard commands, the participants only looked at the first page of search results but visited more than one website per task. They wanted to avoid the irrelevant information and quickly get to the information that potentially useful to them, even though this resulted in taking the risk of missing important information. In relation to the participants' cognition, they chose a search engine/port or a specific website to search for information. After the participants got oriented to the search edit box automatically or by tabbing to it, they formulated the first search query from the task description and then modified the search queries with new terms found from retrieved result pages or web pages. The participants examined the search result lists based on the page title and browsed the textual content of a website by jumping through links and reading through the entire page. It depended on how the participants perceived the relevance of the website to fulfill their information needs.

Accessibility and usability issues of web sites, technical problems of G-mouse screen reader, and the individual's insufficient search competence can actually limit their pursuit of benefit from Internet which can provide opportunities for their success in education, employment, and independent living. In terms of web pages, the participants faced six accessibility and usability problems that obstructed their progress to varying degrees during online information search. The six problems included graphics and Flash without text alternative, tables without text alternative, navigation menu at the top, inappropriate labeling of links, the structure of specific websites (Yahoo!Answers, Wikipedia, a blog), and excessive information. It was noteworthy that the participants were sometimes completely unaware about the existence of these problematic content of information. This caused the participants to gain no new information and to possibly miss important information.

Searching information on the Web became a challenge for the participants when G-mouse screen reader failed to pronounce English in an understandable way, to give indication when a web page had finished loading, and to provide sufficient feedback to verify the participants' actions. When using G-mouse screen reader to search information online, the obstacles encountered by the participants could be caused by individual's insufficient search competence, including not having the conceptual model of a web page's layout and strategies to deal with information overload. The lack of the two dimensional information in the mental models of people who used the screen reader was the main obstacle for them to search information on the Web effectively.

Six major strategies were identified which were employed by the participants when they experienced problems on the Web, including note-taking, trial and error, backtracking, looking for assistance, skipping, and giving up. In addition to strategies, the problematic situations were uncovered where these strategies tend to be exhibited, such as exploring a web page, navigating across different web pages, selecting links, and detailed reading. It indicated that strategies which the participants employed to overcome challenges and barriers were found throughout the whole search process, not just at a particular stage of a search. The results showed that the goal of strategies employed to overcome challenges was to enable the participants to remove themselves from these challenging situations rather than pursuing their goal.

A rich data set about the behaviors, challenges, and strategies involved can guide educators, Web designers, and screen reader developers toward improvement of the Web navigation experiences for students with visual impairments.

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APPENDIX A

TASK DESCRIPTION AND INFORMATION REQUESTED

Task Description and Information Requested

The list of three fact-based tasks each participant was asked to complete is presented, including the task description, the information requested, the curricular subject they belonged to, and their order.

Task order	Subject	Task descriptions	Information requested
1	Language arts	Find out how many stars and stripes there are on the flag of the United States.	Provide the number of stars and stripes
2	Social Science	Find a web site that cites evidence in what year Taiwan became Japanese colony.	Provide an URL
3	Literature	Find the name and a complete text of poem which describe his life in Cambridge from Chinese modern poet Chih-Mo Shiu.	Provide the name and full text of the poem

APPENDIX B

TASK INSTRUCTION

Task Instruction

- This is not a test or a competition. I just want to observe how you search for information on the Web and to learn from you.
- I will sit next to you to observe you and I will take notes. However, I don’t want you to think I am grading your work.
- I will read all tasks aloud to you first, and then I want you to search them using the Internet. These tasks include information you need to find on the Web. If you don’t understand the task, I am glad to read the whole task as many times as you need at any time.
- There is no limit in your choices for searching the Web. Please search the way as you would normally do. When you think you have found enough information to complete the task, please tell me. Then you can stop and give me the information.
- When you finish one, you will move on to the next task. After all tasks, I will ask you some questions.
- I want to repeat that you are not taking an examination. I just want to observe how you search and understand what may challenge you.
- Do you want to ask me any questions before we start?
- Here are your tasks. Please complete them

APPENDIX C
PRE-TASK INTERVIEW QUESTIONS

Pre-task Interview Questions

Part 1: Personal information

1. How old are you?
2. What grade are you?
3. What is your primary diagnosis for establishing disability?
4. Can you describe what you can see?
5. When did you lose your vision?
6. What is the name of your eye condition?

Part 2: The Computer

1. How long have you been using computers? When did you start to use computer?
2. How many hours per week do you spend using a computer?
3. What type of computer do you use?
4. What operating system do you use most of the time?
5. Where are the computers that you can use located?
6. How do you rate your experience in using the computer?

Part 3: The Web

1. How long have you been using the Web? When did you start to access the Web?
2. Where do you access the Web?
3. In a typical week, how often do you access the Web?
4. On a day you use the Web, about how long do you use it?

5. What web browser do you use most of the time? What other web browser do you use?
6. What activities do you typically do when you use the Web?
7. How do you rate your experience in using the Web?

Part 4: The screen reader

1. What kind of screen reader do you use? What version of it do you use?
2. How long have you worked with this screen reader? When did you start to use it?
3. In a typical week, how many hours do you use this screen reader?
4. What kind of tasks do you frequently carry out with this screen reader?
5. How do you rate your overall knowledge in the screen reader?
6. How did you learn to use this screen reader?
7. How much time did it take you to learn to use this screen reader?
8. Have you received any training with this screen reader?
9. Did you find the training adequate? If not, what changes would you like to see?

APPENDIX D

POST-TASK INTERVIEW QUESTIONS

Post-task Interview Questions

1. Physically, how do you feel right now?
2. Mentally, how did you feel while working online?
3. While performing these tasks, how did you feel ?
4. How do you feel now that these tasks are over?
5. Compared to what you expected, how did these tasks go?
6. How confident are you that you found the answer?
7. How do you find something you are searching for on the Internet?
8. How do you think about these tasks? How easy or difficult was it for you to find information for this study? why the task was easy or difficult?
9. What did you like about your session? What did you not like about your session? Why?
10. When would you use a Web site and when would you use a search engine?
11. How did you tell a page is loading or has finished loading?
12. How was it for you to locate where the hypertext links and the search box are? Why?
13. You got a search result that returns a 100 hits. How did you know which of those sites to actually look at? How did you know which sites to ignore and which sites to examine more closely?
14. How well organized was the Web sites you were using? What was the most helpful or useful element of the design of the Web site? Describe what would have helped you find the information faster or more easily?

15. Can you describe any problems you encounter on the Web? How could this be improved?
16. What were the main challenges while searching for information? How did you cope with the challenges?
17. Is there anything else about searching information on the Web that I haven't asked? Is there something you need to tell me?

APPENDIX E

INFORMED CONSENT FORM

UNIVERSITY of NORTHERN COLORADO

CONSENT FORM FOR HUMAN PARTICIPANTS IN RESEARCH
UNIVERSITY OF NORTHERN COLORADO

Project Title: A Case Study of Information Searching Experiences of High School Students with Visual Impairments in Taiwan

Researcher: Hui-fen Chen, graduate student at UNC, School of Special Education
Phone Number: (04) 2522-3668 E-mail: chen7069@bears.unco.edu
Advisor: Dr. Harvey Rude, Professor at UNC, School of Special Education
Phone Number: (970) 351-1659 E-mail: Harvey.Rude@ unco.edu

My name is Hui-fen Chen and I am a doctoral student in School of Special Education at University of Northern Colorado. I am conducting a research on how high school students with visual impairments perform information searches on the Web through G-mouse screen reader and what challenges high school students encounter during the information searching process as well as how they overcome the challenges.

If you decide to allow your child to participate, your child will be asked to participate in the pre-task interview to answer 28 questions related to personal information and prior experiences with the computer, the Internet and the screen reader usage for 30 minutes in the computer lab at the school.

A week later, your child will be scheduled to perform 2-hour online information search tasks using screen readers. There will be three tasks developed and validated by school teachers. Right after the online information session, your child will participate in 1-hour post-task interview with the researcher individually in the computer lab at the school. Your child will be asked to answer questions about the recent search behaviors used and the viewpoints of online search experiences. I will ask your child to describe why he/she performed search tasks in certain ways, what he/she found challenged, and how he/she overcome the challenges.

(Parent’s Initials here________)

With your permission, the pre-task interview and the post-task interview will be digitally audiotaped, while the online information search sessions will be digitally videotaped. All research activities will be conducted after school hours and monitored and checked every 10 minutes by a resident assistant of the dormitory who is on duty.

All of the information that I obtain from your child during the research will be kept confidential in a locked file cabinet and be erased after this research is completed. In addition, I will replace your child's name with a code number. No one other than me will know who your child is in my notes. Your child's name and other identifying information about your child will not be used in any reports of the research.

The risks to your child from taking part in this research are no greater than those normally encountered during regular classroom participation. There is no foreseeable direct benefit to your child in the study. The potential benefit is that your child is given an opportunity to talk freely about his/her perceptions.

If you have any special needs or issues relating to your child's participation in this research, please feel free to contact me to discuss your concerns.

Sincerely,

Hui-fen Chen

Participation is voluntary. You may decide to stop and withdraw your child's participation at any time. Your decision will be respected and will not result in loss of benefits to which your child is otherwise entitled. Having read the above and having had an opportunity to ask any questions, please sign below if you would like to allow your child to participate in this research. A copy of this form will be given to you to retain for future reference. If you have any concerns about your child's selection or treatment as a research participant, please contact the Office of Sponsored Programs, Kepner Hall, University of Northern Colorado Greeley, CO 80639; 970-351-2161.

____
Child's Full Name (please print)

____
Parent/Guardian's Signature Date

____
Researcher's Signature Date

APPENDIX F

INFORMED ASSENT FORM

UNIVERSITY of NORTHERN COLORADO

ASSENT FORM FOR HUMAN PARTICIPANTS IN RESEARCH
UNIVERSITY OF NORTHERN COLORADO

Dear Student,

My name is Hui-fen Chen and I'm a doctoral student at the University of Northern Colorado. I am doing a research study to find out how people with visual impairments use screen readers to search for information on the Web and how they deal with the problems during the search. I would like to ask a few high school students to show me how they search and to talk with me about how they do it. If you want, you can be one of the students.

If you agree to be in my study, I will ask you to do several things. First, I will ask you some questions about your experience with computers, screen readers, and the Internet. A week later, I will ask you to show me how you use the G-mouse screen reader to search for information on the Web at the school's computer lab after school hours. I will sit next to you and write down what I see. This will not be a test and there won't be any score for your searches. Last, I will ask you to talk with me about your thoughts and feeling about the searches you have done. If you decide at any point not to finish, you can ask me to stop without a problem.

With your permission, all of the talks with me will be audiotaped and the searches on the Internet will be videotaped. The recording of our talks and your searches will be securely stored and erased after the study is completed. You will have the opportunity to read the written copy of our talks to make sure that what is written is what you wanted to say. In order to protect your privacy, I will not use your name when writing about your experiences.

If you want to be in this study, please sign your name and date below.

Student Date

Researcher Date

APPENDIX G

INSTITUTIONAL REVIEW BOARD APPROVAL

UNIVERSITY *of*
NORTHERN COLORADO

Institutional Review Board

May 9, 2012

TO: Mark Smith
School of Sport and Exercise Science

FROM: Gary Heise, Co-Chair GDH
UNC Institutional Review Board

RE: Expedited Review of Proposal, *A Case Study on Understanding Information Searching Experiences of High School Students with Visual Impairments During Web Interaction with the G-Mouse Screen Reader in Taiwan,* submitted by Hui-fen Chen (Research Advisor: Harvey Rude)

First Consultant: The above proposal is being submitted to you for an expedited review. Please review the proposal in light of the Committee's charge and direct requests for changes directly to the researcher or researcher's advisor. If you have any unresolved concerns, please contact Gary Heise, School of Sport and Exercise Science, Campus Box 39, (x1738). When you are ready to recommend approval, sign this form and return to me.

I recommend approval as is. ______________________ 5/30/12
Signature of First Consultant Date

The above referenced prospectus has been reviewed for compliance with HHS guidelines for ethical principles in human subjects research. The decision of the Institutional Review Board is that the project is approved as proposed for a period of one year: 6/21/2012 to 6/21/2013.

______________________ 6/21/2012
Gary D. Heise, Co-Chair Date

Comments: emailed Qs - 6/18/2012

- CHANGES MADE AS DIRECTED
- NEW PROPOSAL + DOCS included