



UNIVERSITY OF NAIROBI

**A GENERIC MODEL FOR UN-INTERFERED ACCESS TO
STREAMING AUDIO FILES BY THE VISUALLY IMPAIRED**

BY

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(P56/61306/2010)

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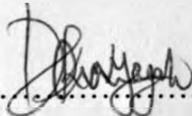
MSC – INFORMATION SYSTEMS

**PROJECT REPORT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD
OF AN M.SC DEGREE IN INFORMATION SYSTEMS (M SC-I.S.)**

JULY 2012

Declaration

I declare that this research project is my original work and has not been presented for any other university award.

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This research project has been submitted as partial fulfillment of the requirements for the award of M.SC degree in Information Systems at the University Of Nairobi with my approval as the university supervisor.

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Abstract

The use of multimedia content has increased dramatically over the last few years, but people with limited or no vision have not been able to fully enjoy the benefits of these advances because most of the content has been developed with intricate structures strongly optimized for sighted users, while the assistive technologies designed are not able to fully assist them to access all the content.

The study aimed to identify technologies used by the visually impaired in accessing information especially through the Internet, the challenges that they encounter and identify suitable ways to overcome these challenges. This has involved reviewing how the visually impaired access computers and ultimately the Internet, while understanding the concept of non-visual browsing and the user interfaces which assist them. Various Web navigation strategies as highlighted by previous researchers using screen readers and other assistive mechanisms have also been analyzed together with the possible solutions which they have tried to implement.

The research has resulted in the design of an interactive model aimed at improving information accessibility and providing people with visual impairments a level of control more comparable to a sighted person while accessing multimedia information in form of streaming audio. Users are able to listen to different sound sources without losing track of the screen-reading software because of the sound of the streaming video. This will ultimately lead to increased access to many kinds of files by the visually impaired including streaming multimedia audio with minimal or no interference of speech from screen readers. Included also are suggestions for further exploratory works that would further enhance information access.

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Dedication

This research study is dedicated to my wife Charity, our son Adrian and our mum Anne, who have tirelessly supported me through prayers, morally and other means to achieve my academic dreams. Without them, I could not have come this far.

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Abbreviations and Definitions

Accessibility: making resources usable by the largest number of people possible which includes people with disabilities. It is a human right recognized in the UN Convention on the Rights of Persons with Disabilities (CRPD).

Assistive technology: Software or hardware that has been specifically designed to assist people with disabilities in carrying out daily activities. This includes wheelchairs, reading machines, devices for grasping, etc. In the area of Web Accessibility, common software-based assistive technologies include screen readers, screen magnifiers, speech synthesizers, and voice input software that operate in conjunction with graphical desktop browsers. Hardware assistive technologies include alternative keyboards and pointing devices.

Braille display: commonly referred to as a "dynamic Braille display," raises or lowers dot patterns on command from an electronic device, usually a computer. The result is a line of Braille that can change from moment to moment. Current dynamic Braille displays range in size from one cell (six or eight dots) to an eighty-cell line, most having between twelve and twenty cells per line.

E-symposiums: conference for the public discussion of some topic especially one in which the participants form an audience and make presentations and done through the Web.

HTML: Hyper-Text Markup language- This refers to the language in which web pages are usually in.

Internet: A computer network consisting of a worldwide network of computer networks that use the TCP/IP network protocols to facilitate data transmission and exchange

IP Address: An Internet Protocol address (IP address) is a numerical label assigned to a device (computer, printer) participating in a computer network that uses the Internet Protocol for communication. It provides host or network interface identification and location addressing.

Operating system (OS): software that controls the execution of computer programs and provides various services.

Podcast: A multimedia file that is distributed by over the Internet for playback on a mobile device or a personal computer.

Webinar: this is a seminar that is held over the Internet and run using Web pages.

Webcast: Live video made available over the Internet.

CHAPTER ONE: INTRODUCTION

1.1. Background of the study

1.1.1. The Emerging role of the Internet.

Rapid advances in information technology have dramatically transformed the world during the past several decades. Access to computers and the internet is increasingly required for communication, education, employment, as well as for many activities of daily living. Universal access and effective use of ICTs are goals at national and global levels in the context of the resolutions of the World Summit on Information Society (WSIS, 2004).

There is considerable discussion about the fact that the Internet and other online services are new technologies that open up windows of opportunity for everyone to participate in the new information age, and that there are particular benefits and potentialities for people with disabilities including the visually impaired, where opportunities for communication and information acquisition by them are likely to be significantly expanded.

Advances in technology have enabled users to access resources in a variety of ways to suit their needs and requirements. This is particularly true in educational institutions and places of work. For the visually impaired people, the Internet is a challenge, it is vital, however, to ensure access is provided fully. Access can have several meanings, including physical access to hardware and software as well as ensuring users can not only access or 'read' what is on the screen (be it using magnification, speech output or Braille output) but they can also interact with resources and services. A lack of understanding of different groups of users, such as the visually impaired people reinforces social and economic exclusion and will be of even greater significance in the future as the information society develops.

Since the Internet was introduced it has grown rapidly and is expected to continue. It began in the 1960s as a networking project started by the United States Department of Defense to allow security agents and researchers at institutions across the country to communicate with each other with ease in what was called as the ARPANET (Advanced Research Projects Agency Network), in addition to network support for distributed social interactions (**Chiang et al, 2004**).

Since then, the Internet has evolved into a complex information network of networks where web documents are identified by a unique Uniform Resource Locator (URL) address, and are based on the notion of hypertext, in which certain words and phrases are represented by links that connect to another location in the same or a different document. Web pages are hosted on computers known as servers, and are accessed by users from other computers through programs known as browsers with the help of IP addresses which helps in routing in identifying the location of the servers on the network (Stallings, 1997).

In 1992, the Internet Society was chartered and World Wide Web (WWW) was released by the Corporation for Research and Educational Networking (CREN). The WWW, commonly referred to as the Web, became accessible to the general public following the 1993 release of the user-friendly graphical Mosaic browser, which led to the development of commercial applications and a user base of several million people by the following year.

In 1994, the international World Wide Web Consortium (W3C) was founded to organize and establish standards for the Web. These W3C standards allow individuals and organizations to develop their own servers, browsers and hypertext content independently, which will work together and be universally available. One such standard is the Hypertext Markup Language (HTML), the notation which Web pages are traditionally written in, allowing programmers to specify the look and feel of a document.

The major driver of this growth has been the Web and computer use. There are several possible reasons for this growth which include: ease of publishing; low cost of owning a web site; ease of updating; and the potential to reach a wide audience. There is one group of users, however, that have been largely ignored in the rush to use the Web and computers, and these are the visually impaired users, who have particular problems in accessing web material.

There are various ways through which Internet can be accessed, varying from personal computers, laptops and mobile phones which could be at places of work, cybercafés, at home or any other convenient place. This is further influenced by whether a user has sense of sight, has reduced vision or has none, where the sighted can exploit all the options available. Those who have reduced vision or have none require assistive technologies to access the Internet.

1.1.2. The visually impaired and Computer Access.

The visually impaired refers to persons who have reduced sense of sight and incorporates those who have low vision and the blind. This can also be differentiated into congenital and resultant. Congenital visual impairment refers to impairment which has existed from birth while resultant is the impairment which has developed after birth.

The increase in computer advancement and Internet usage has seen the triumph of rich graphical desktop, full of colourful icons, controls and buttons all around the screen, controlled by the mouse pointer moving about the screen clicking and dragging. This of course is not a usable environment for the visually impaired but they must learn to use and live with it. For those with some degree of residual vision, there exist assistive technology solutions for them which include **screen magnifier** applications. These magnify a small area of the display, potentially filling the entire computer screen and the user can move the area being magnified around the desktop. This allows the user to control the computer interface directly, and is a good solution for people with gradually-degrading vision.

However, for those with a significant visual impairment or complete blindness, there are different two options (King et al, 2008).

The first is to use a screen reader. This is a software application that attempts to figure out and describe to the visually impaired user in speech, what the graphical user interface is displaying on the screen. It does this through a speech synthesizer which works via a computer's sound card and announces every word on a page, line by line, sequentially. A screen reader is the interface between the computer's operating system, its applications, and the user and acts almost as a sighted companion to the visually impaired user, reading out what is happening on the screen including command buttons, menu items, and text. Microsoft have included a basic screen reader in the operating system, called Narrator found in Windows 2000 or XP.

The second way for a blind person to use a computer is to take advantage of **self-voicing** applications. These are usually applications written specifically for the visually impaired that provide their output through synthesized or recorded speech. The obvious advantage is that the

application designer can ensure that what is communicated to the user is exactly what the designer wants communicated - although this assumes that the designer's conception of what the user needs or wants to hear is correct. Aside from the extra design and development required to produce a self-voicing application, the main drawback is that the application cannot be used at the same time as the user's screen reader. With a self-voicing application, the user may even have to switch off their screen reader, which is most undesirable if they want to use another non-self-voicing application at the same time.

From the above, whether using a screen reader or a self-voicing application, the use of the sense of hearing in computer access, rather than vision has great implications for the design of the interface. The visual sense has an enormous capacity for communicating information quickly and easily. This is because by looking at an application on the computer display, one immediately notices the menus, icons, buttons and other interface controls arrayed about screen. Each represents a function that is available to the user and a quick glance allows one to locate the function one want and is immediately activated with the mouse. Thus the need to enhance interface design for the visually impaired in computer access and usage.

1.1.3. The visually impaired and Internet Access.

After knowing how the visually impaired access computers in general, then comes in the issue of how they access the wonders of the World Wide Web in particular. Websites vary enormously, but with a quick browse around the most popular sites one quickly notices a common characteristic: a very heavily visual graphical interface, images, including animated advertising banners; non-linear page layouts, like a newspaper front page with items and indices arranged around the screen; navigation menus and input controls for search functions and user input, and streaming media.

Whilst accessibility issues to sighted users may be a matter of response time, getting lost in cyberspace, or poor performance of search engine retrieval, these are issues that may be inconvenient, but they are not insurmountable problems. The considerations are not the same for the visually impaired user trying to access the same information. A problem of accessibility to a person who is visually impaired covers all those for sighted users, plus a number that are unique

to this group of users. These include the issue of screen design, the use of font size, colour, the use of patterns in screen backgrounds that make the text difficult to read and an excess of graphics. These features, designed to be appealing to the sighted user, may make Internet pages inaccessible to a visually impaired user. More so computers and web navigation paradigms are dependent on graphical interfaces with visual cues for inputs and outputs which may inhibit use by the visually impaired.

The issues faced by people with visual impairments in accessing the Web are wide and diverse and the techniques used to make it accessible range from the simple to highly complex ones. While many of the changes have improved society in many respects, they present an obstacle for visually impaired who may have significant difficulty processing the visual cues presented by modern graphical user interfaces, hardware designs, website designs, software interfaces and other input/output (I/O) subsystem devices. Thus the developments in Internet use do not always translate to accessibility due to poor design of information infrastructures, products and services, and means of dissemination in relation to social and economic development variables.

It is important to realize that not only are web pages full of rich features, but that their arrangement in the pages are completely non-standard. Every web page has a different user interface which must be explored and understood to use it, which places great demands on the visually impaired to make the necessary effort. So, how does a blind user start to get to grips with these pages? The immediate response might be to use the user's screen reader to access a conventional browser like Internet Explorer. The problem with this is that each application makes different demands on the screen reader, and the heavily-visual and non-standard interfaces of web pages pose considerable difficulties to a screen reader.

Sighted users can simply glance at a different area to change their focus, but screen reader users need to move the focus of the screen reader to the area of interest, and this is normally done by moving the caret. Browser windows, however, do not have carets - you can only scroll the whole page up and down and look for the text of interest. The only items you can select individually are links or form items. A screen reader could simply choose to read a web page displayed in Internet Explorer from the very top of the page to the bottom, but this would be immensely time-

consuming for the user. Tables and frames and forms further complicate a web page though advanced screen readers do provide special navigation modes for web pages with a great deal of success. After all, web browsing is one of the common applications which a screen reader developer will try to support. Web access is a general, not specialist need, and needs to support a general, non-specialist group of users.

The design of various tools can help the visually impaired access resources, communicate with others, and perform academic tasks independently. Guided design of such tools are required if individuals with disabilities are to compete with their non-disabled peers. For all students and employees, the ability to perform tasks efficiently and professionally can earn the respect of educators, employers, and peers alike. The ability to control powerful technological tools can thus contribute to the acceptance of a person with a disability as an equal partner in learning and working situations.

The current growth in Internet use is providing unprecedented opportunity and prospect for people to communicate, share and exchange information with others around the globe. At the same time, those without the means, skills or resources are at a disadvantage in social, educational and employment situations (Gunderson, 1994). This has the potential to enlarge the existing economic and cultural gaps between the “haves” and “have-nots” in our society, and threatens to create major difficulties for visually disabled patients. An important challenge will be to ensure that the visually impaired have mechanisms for universal access to these emerging technologies.

A preliminary study and review of internet use by the visually impaired revealed the following;

- i. A review of cyber cafes within Nairobi revealed that none had assistive facilities to aid the visually impaired in accessing the Web.
- ii. A special report, titled ‘Tough luck being blind at university’, appearing in the Daily Nation on the 24th January 2011 by Gisesa, N. & Kirigha, M., indicates that in many instances, the blind students require extra time for someone trusted to read lecture notes to them loudly and to help them chose the appropriate books, bringing the difficulty of

maintaining a permanent reader in addition to being expensive to maintain. This is due to the overwhelming mass of text printed material and inaccessibility of the internet.

- iii. Kenya Society for the blind (Ksb) 2010 Annual report indicates that at present, most visually impaired people have to depend on radio, television or information which is read to them either on cassette or by reader, and cannot readily go out and buy a newspaper, magazine or browse through the bookshelves or browse the Web to access the required information.

Chiang et al, 2004, notes that the Web has evolved rapidly in recent years, providing the public with access to vast store of information though this creates potential difficulties for visually impaired patients noting that;

- i. Hypertext Web documents are nonlinear, allowing users to link quickly to other pages that may have a completely different design and layout. This may cause confusion for those who cannot easily follow visual cues.
- ii. The Web now revolves around video, multimedia, real-time collaboration, and interactive documents, all of which are heavily visually-based thus inhibiting use by the visually impaired.
- iii. Some of the available text readers sometimes fail to read everything displayed and thus not able to communicate to the visually impaired.

This indicates that there is low Web access by the visually impaired which is also noted by Kaye, 2000, who states that despite the putative benefits of Internet for people with disabilities, their access is well below that of people without disabilities.

In addition, the following problems are also noted;

- i. The visually impaired are constrained into examining one thing at a time in an order not of their making since they do not know the structure of things before they explore them and this occurs due to the problem of unfamiliar, rich, new interfaces.
- ii. They also have to listen to a surprisingly large amount of text to give them the same amount of information as a sighted user might be able to gain in a quick glance. Sighted

users might be able to glance through a large document, scanning the chapter and paragraph headings for a key word or phrase, because they can see the headings instantly distinct from the body text and what words they contain. A visually impaired user has to wait for assistive technology to speak the heading which might be slower.

1.1.4. The visually impaired and Multimedia files access.

With the continued expanding usage of the Internet, the use of multimedia content in rich internet applications (RIAs) is rapidly increasing providing richer and more satisfying user experiences by using dynamic HTML (DHTML) and adobe flash, e.g. YouTube files, Webinars Webcasts, podcasts and e-symposiums.

The RIA multimedia content involves streaming media e.g. videos and audios and dynamic changes controlled by scripts. Streaming media is unique among other media types, such as static images and documents, in the sense that it delivers transient sounds and images, in addition to dynamically changing in response to various inputs, based on programmability of some script.

1.2. Problem Statement

The accessibility of multimedia files especially streaming media by visually impaired users is hard or even nearly impossible to deal with due to audio interference with the speech from screen readers. This is because multimedia content often plays streaming audio that blind users cannot hear together with the synthesized speech from their assistive software. This happens since there is only one physical volume control available in the typical user environment and therefore the users cannot control the volume of the multimedia content separately, thus the interference from the two sources.

1.3. Study Objectives

From the foregoing, it can be established that there exists barriers that prevent access of some information through Internet and these are caused by factors like interface design and the interpretation of speech synthesis to convey the content of the page which are currently not solved by existing technologies. These obstacles can largely be overcome with a little

forethought in the design process since many designers are generally more concerned with the 'look' of the page to sighted people than accessibility to all including the minority of users.

One major access technology that has been developed to help address the emerging divide between the sighted and the visually impaired is the screen reading and synthesizing technologies. With these in place visually impaired people can use the computer to access much of the information including through the Internet by using standard keyboard shortcuts, but this is not enough due to the problems highlighted above where the screen readers are not able to access all the information.

Thus the objectives of the study were;

- i. To carry out an investigation to find out the technologies used by the visually impaired in using computers and in accessing information through the Internet and challenges that they encounter.
- ii. Design a model that facilitates un-interfered access to streaming audio from the Internet and other sources.
- iii. Develop and validate the model designed.

1.4. Research Questions

The following research questions were used to ascertain the main barriers encountered by visually impaired Internet users, with a view to developing guidelines and interfaces to assist them;

- i. What are the current ways in which people who are visually impaired find information from the Internet for their everyday lives?
- ii. Which navigation strategies are employed using assistive screen reading technologies for visually impaired users and whether the available text/ Web readers are able to assist in accessing all the information contained in Web pages?
- iii. What are the main challenges faced by visually impaired screen reader users when accessing the web and using computers?

- iv. Which features and information on the Internet are particularly inaccessible by the visually impaired using such assistive technologies?

1.5. Scope of the Study

The study primarily focused on studying the various speech output systems (text/Web readers), evaluating them to check on how effective they are for use by the visually impaired in accessing information from the Internet and develop designs and interfaces needed to improve on them to ensure accessibility of some non-accessible files.

Respondents were chosen from learning institutions for the blind and organizations that advocate for the rights of the visually impaired which include Kenya Society for the Blind and Kenya Institute for the blind and included the blind and those who assist them.

1.6. Purpose of the Study.

The low levels of Web access imply there is something that must be done to avoid the continued discrimination and isolation of the visually impaired. This is because if the Internet growth continues being the major source of dissemination of information then it will have negative impacts for those who are unable to access it. As highlighted by Williamson et al, 2001, though the Internet's dazzling technical wizardry has suddenly increased people's ability to communicate and to obtain information, it is still in the fledgling stage despite recent improvements. Computer software and hardware designers' "cool" tips, tricks and buttons might have plenty of dash, splash and panache, but they have not yet focused on all users' real needs. People who are blind and visually impaired are a 'niche' market; they have particular requirements which have largely been ignored by software and hardware developers.

For a person who is blind, and cannot read Braille, access to printed material has traditionally been mediated through others, particularly a family member or friend, or perhaps a helper, or an organization. Apart from assisted access to print, radio, audio cassettes and telephones have provided the ways in which the visually impaired have accessed information, although radio has the general disadvantage of requiring its listeners to wait for information to come to them. In terms of access to print, Braille users are also disadvantaged since by the time a news bulletin is brailled, it's previous day's news, it's old news and often out-of-date. Though they are pretty well

served in (brailled) magazine articles, but it is the immediate news and commentary that they tend to miss out on.

A study by Penney and Associates, 1996 found that the biggest barrier to Internet connection was access to the basic equipment needed to get connected. The next greatest barrier was the cost of the adaptive equipment. The study also found that lack of appropriate and accessible training, attitudinal problems, language, and the design and rapid pace of change on the web were significant barriers. This is because people with disabilities are in the disadvantageous position of having to pay more for adaptive equipment in order to access mainstream equipment, as the adaptive equipment caters to a much smaller percentage of the population than mainstream equipment.

Thus from the foregoing, a study in this area is significant since it will assist in the design of accessible interfaces which will be of assistance in helping the visually impaired in increasing their Internet adoption, usage and more so accessing information currently non-accessible. As noted by the inventor of the WWW, Tim Berners-Lee, "The power of the Web is in its universality where access by everyone regardless of disability is an essential part" (<http://www.w3.org/WAI>).

1.7. Significance to Key Audiences

- i. It gives the visually impaired independence once they've got over the initial hurdle of knowing how to use it and being able to participate in the new virtual landscape which the Internet provides.
- ii. There is also interest in being able to access unprecedented amounts of information that was previously inaccessible, e.g. being able to read a newspaper where you can just go in and open up a page through the Internet that says the different newspapers available and you decide which one to browse through till you find what you want. As opposed to someone reading for you and only read certain pages
- iii. Another possible benefit is the potential to provide a social connection to the outside world through improved communicative abilities for those who are socially isolated, i.e. it sort of enlarges their world.

- iv. The study will also help in identifying the best commercial practices for designers, manufacturers, suppliers and service providers of various ICT goods and services to ensure accessibility by the “niche” market.

Thus not only does Web readers usage in Internet access increase access to information for the visually impaired, but it also allows them to participate in a new information and communication format which has the potential to become a primary source for all people. In this way, they will not see themselves differently from the rest of the population.

1.8. Assumptions

For the purposes of this study, the visually impaired are considered as the ones who cannot access a visual display unit even with the help of screen magnification techniques. This study reports on research with users who are visually impaired and use screen reader technology to interact with Web sites. There are many ways to use the Web depending on an individual’s specific disability and that vision-impairment is only one of many disabilities.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This involved surveying and evaluating the screen readers in use, highlighting their designs and usage in relation to the visually impaired, while noting inherent weaknesses. The focus was to understand how the visually impaired users work with computers and how they access the Web content taking into consideration previous related and coherent studies.

2.2. Review of Past Studies

2.2.1. Challenges highlighted in past studies.

As per the World Wide Web Consortium, making Web sites accessible for people with disabilities is an integral part of high quality Web sites, and in some cases a legal requirement. This is enhanced through the consortium's Web Accessibility Initiative (WAI). Despite the initiatives, most Web specialists, developers and manufacturers don't know about design issues for people with disabilities. This has henceforth given rise to challenges as discussed below.

An inquiry by Murphy et al, 2007, indicates that due to the highly visual nature of web pages, changes in font style, text sizes and formatting are not immediately obvious to those using screen readers. Valuable context may be lost due to the inability of screen readers to extract these subtle cues. This can lead to feelings of confusion and time being wasted trying to locate sections of text. He enumerates that since a mouse offers a predominantly visual-centric approach to exploring a web page, many blind users make use of tab and arrow keys in addition to other screen reader shortcut commands as a preferred alternative to a mouse. Screen reading technologies synthesize the main body of text available on each page, outputting a linear rather than spatial representation of information on a page. They often fail to convey the natural ordering of elements on a web page, which were originally designed to be perceived through sight. By default, screen readers adopt a top-left to bottom-right approach. On web pages containing a large amount of information, task completion time can increase due to additional complexity. This indicates some of the challenges that are faced by the visually impaired in their course of web access.

A survey carried out by the Disability Rights Commission in 2004 has reported that 81% of web sites tested failed to meet even the most basic accessibility criteria. Barriers to access highlighted by the report include the shortcomings of assistive technologies and the inadequate presentation of web content. Web pages are often difficult to interpret using assistive aids, such as text-to-speech synthesizers and Braille output devices. Assistive devices inadequately handle graphics, moving images, frames, tables, use of scripting languages and streaming audio and video. In addition, web designers do not consider and prioritize the needs of visually impaired users when developing sites. As a result, inaccurate or non-existent labelling of hyperlinks, a lack of alternative text descriptions on images, and cluttered and complex page structures can lead to confusion for blind and partially sighted users when exploring a web page.

Some visually impaired Internet users often close the browser and then re-launch it, rather than using the navigation buttons provided, this is due to the tedious process involved especially by novice users. Moving through a sequence of pages such as a flight booking process, as explained by Petri et al, 2001 can also prove to be complex for users. It is noted that navigating the Internet using a screen reader to be a frustrating experience due to the lack of feedback received. Less experienced users tended to explore the Web in a linear fashion from top-to-bottom, and perceived all web pages to be in a single column-like structure. Concerns with regards to becoming lost whilst navigating between pages were also noted where users tend to close the application if they become lost within a page or over a number of pages. Some of the less experienced users are reported to have even shut down their computer and restart, if they became "lost on the Internet". These problems can be attributed to the visually oriented presentation of information via the computer interface, and restrictions imposed by assistive devices.

A study by Andronico et al 2006 indicates that in web page access, the following problems can be experienced;

- a. Lack of context. The user accesses only a small portion of the text and may lose the overall context of the current page. The process of normalizing text is rarely straightforward; there are many spellings in English which are pronounced differently based on context. For example, "My latest project is to learn how to better project my voice".

- b. Information overload. Portions of the site which do not vary (index, frames, banners) may overload the “reading” since the user hears the same items over and over for every page.
- c. Keyboard navigation. Since blind users do not use the mouse functions (i.e., pointing, scrolling, selecting, etc.), they move around the page using keyboard commands, such as tab key and arrow keys, that are slower.
- d. Excessive sequencing in reading the information. Basic screen reader commands for navigation and reading only enable the user to explore page contents just sequentially.
- e. Screen reader interpretation. The screen reader deals with web page content in a very different way from visual rendering. This requires a certain expertise in understanding advanced screen reader and browser commands, as well as orientation within the page itself, and both require considerable effort by the end user.

These drawbacks, they explain, slow down navigation, annoying the user and often provoking great frustration. This is one of the reasons why some blind people do not like interacting with the Internet.

Furthermore Web pages are created from HyperText Markup Language (HTML) code. HTML incorporates an increasing number of multimedia elements and multimedia presentation can be further enhanced by incorporating Java Applets. Screen readers rely on HTML code being written in a standard and accessible manner and must run alongside the Internet Browser and intercept the HTML code to ‘interpret’ it for speech output. Unfortunately, many Web sites provide code which is far from accessible as described in O’Brien 1996. It is argued that Web sites should be legally bound to provide only standard accessible HTML in the same way that buildings must be accessible for disabled people.

As highlighted by Yu et al, 2006, limitations of current assistive technology and inaccessible Web design prevent blind and visually impaired users from experiencing the full potential of the Internet, in comparison to their sighted counterparts. Barriers to accessibility on the Web can be attributed to the predominantly visual nature of information presented to users via computer interfaces. The situation is further compounded by the limitations posed by assistive devices, such as screen readers and Braille displays. These assistive tools force blind users to browse the

Web in a linear and time-consuming fashion, rendering graphs, animations and busy Web pages inaccessible.

Alternative text descriptions are helpful, but the intention that the original image is trying to convey may not be immediately obvious to the user, thus rendering some pages difficult to interpret. The position of hyperlinks on a Web page also presents a challenge to locate. Links themselves may not provide meaningful cues to the user. The URL that the link would follow may not offer a description of the intended target. By removing structural and contextual information concerning objects on a Web page, additional time and attention must be spent on a page as the user tries to derive the meaning lost through the use of assistive technologies.

The widespread use of graphical user interfaces, however, increasingly bars visually handicapped people from using such material. Internet access, coupled with graphical user interfaces (GUI) and browsers, as highlighted by Roth et al, 1998, has become common in education, business, and at home. However, due to the widespread use of GUIs, the so-called enabling technologies for sighted have become disabling technologies for the visually-impaired. Blind users are less and less able to benefit from the enormous wealth of archived digital multimedia that is offered over Internet. The development of electronic aids for visually-impaired persons has been ongoing for several decades, such as for reading, facilitating mobility, and for educational and occupational activities. The major difficulty in designing Internet browsers for blind people stems from the essentially *bidimensional* layout and nature of the textual and pictorial information that has to be presented. This is to be contrasted with the essentially "one-dimensional" nature of existing output devices such as Braille lines or text-to-speech converters.

Another difficulty in presenting digital information to blind people users, they note, arises from the presence of embedded images; they often bear essential information, and should be suitably presented to users. Current browsers for blind users typically transform the bidimensional content of the Web documents into spoken text. These browsers often have difficulties in presenting the global layout of documents, and usually remove all pictorial information.

2.2.2. Possible solutions highlighted in past studies.

Some studies have shown that extracting semantic information and reformatting pages, can promote levels of accessibility. Semantic Web Accessibility has been discussed by Seeman, 2004, as an enabler to assist users to orientate themselves on a page, scan and access the sections that interest them the most, while leaving out sections that are not of immediate importance at the moment. In recognizing how to overcome the challenges, Harper et al., 2001, have applied real-world mobility concepts to extend accessibility guidelines and design methods in an attempt to address the limitations of current online assistive technologies for visually impaired users. These ideas were further developed using semantic web technologies in the form of virtual travel ontology. As a result, visually impaired users are provided with an overview of web page content and thus able to comprehend what a page is all about without having to undergo the rigorous process of scanning through the whole page looking for an item.

Repetitive information present on a page is also eliminated, enhancing the user experience. Standalone browser applications such as pwWebSpeak as enumerated by Hakkinen, 1996, provide a speech-based representation of page content. PwWebSpeak provides fully keyboard based navigation of web pages. Any page's structure and content will be spoken using pwWebSpeak's built-in software synthesizers or one of the user's choosing. It also supports simultaneous large print on- screen display with full control of size, foreground and background colors. The user is able to navigate through the structure of a document based on its contents: links, headings and paragraphs, rather than having to deal with scrolling and interpreting a complex screen layout.

Other tools that have previously been used to demystify web access by the visually impaired are the IBM Home Page Reader (HPR) and the Brookestalk. The HPR, (http://www.ibm.com/able/solution_offerings/hpr.html), has provided access to structural information such as tables, frames and form elements. The application uses different voices, allowing the user to differentiate between text and links to aid understanding of the page. Zajicek et al, 1998, in their 'Web Navigation Tool for the Blind' study have discussed Brookestalk and indicated that it allows the user to select from a list of headings, hyperlinks and keywords, to assist in the navigation process where summaries can be generated to provide an overview of contents, helping the user decide whether the page would be of benefit or not.

While the sighted use mouse driven GUI (graphical user interfaces), visually impaired must rely on command line, keyboard shortcuts and screen readers. Learning and interaction is slowed by screen readers which do not interact well with web pages. Many screen readers claim to have ways to untangle web pages for ease of use, but they continue encountering major problems with websites. Guercio et al, 2011 discusses a tool called WAVES (Web Accessible for Visually-impaired Extraction System), for the fast retrieval of information in a web page for blind and visually impaired people page through restructuring of web pages for faster web navigation. It uses visual cues to filter web pages and produces an excerpt of information that helps the user to decide if a page is worth reading. Data from the webpage are presented to the reader in a concise and sorted-by-weight format which reduces the access time of the screen reader to specific information.

A blind or visually impaired user can get lost in hyperspace on one single World-Wide-Web (W3)-page as opposed to a sighted user who can get an overview of the structure of a World-Wide-Web (W3) page with a quick glance at the computer screen and quickly scans the titles and links visually to find what he is looking for. Arising from this, visually impaired persons access computers using a screen reader, however structure and meta information is hard to recognize and to find (Kennel,et al, 2006). This, they highlight, is due to problems in recognizing and finding titles, links, non-textual elements, navigating from title to title and from link to link and handling input elements.

They thus suggest Web Access for Blind users (WAB), a working system which makes web-surfing easier for blind persons. This transforms structure and meta information into a form that can be more easily read by visually handicapped people. Titles, links and form elements are described textually since structure and meta information in HTML documents are normally displayed visually and are difficult for blind users to recognize. This system works with any World-Wide-Web-browser and any screen reader. No additional software has to be installed on the user's computer. The WAB-modified HTML-document has three parts:

- i. The requested document, with some modifications,
- ii. A list of all the links in the document,
- iii. A nested list of all titles.

The two lists give an overview of the document and allow the user to navigate easily through it. Throughout the modified document, a new class of link-type connections, which we call references, is inserted. References are always local to one document and are only used to navigate inside it.

2.3 Analysis of Screen Readers.

As described above, a screen reader is the interface between the computer's operating system, its applications, and the user and acts almost as a sighted companion to the visually impaired user, reading out what is happening on the screen. It attempts to figure out and describe to the visually impaired user in speech, what the graphical user interface is displaying on the screen. It does this through a speech synthesizer which works via a computer's sound card and announces every word on a page, line by line, sequentially.

The following illustrates a screen reader's architectural diagram and where each process occurs.

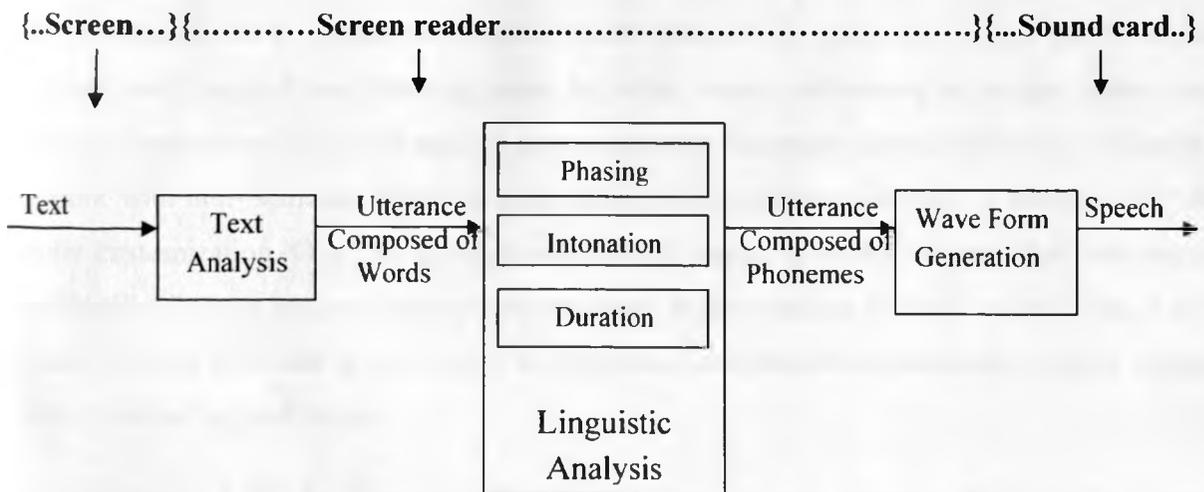


Figure 2.1: Architectural Diagram of a screen reader

2.3.1. Job Access With Speech (JAWS).

JAWS for Windows is a powerful accessibility solution developed by Freedom Scientific (<http://www.freedom-scientific.com>), which reads information on the screen using synthesized speech. It provides many useful commands that make it easier to use programs, edit documents, and read Web pages. With a refreshable Braille display, JAWS can also provide Braille output in addition to, or instead of, speech. An array of versatile features and customizable options lets you tailor JAWS for your individual needs and preferences.

It provides speech technology that works with windows OS to access today's popular software applications and the internet. It uses an integrated voice synthesizer and the computers sound card to output the screens content to the speakers. Jaws also outputs to refreshable Braille displays. This technology provides access to a wide variety of information, education and job related applications. It reads web pages using internet explorer as if they were a word processing document and supports standard Windows applications with special enhanced functionality for the most popular applications used at home, in school and in business today.

Jaws outputs to most popular refreshable Braille displays in computer. It also has extensive customization capabilities allowing users to define many preferences in single system and network environments. Additionally, a unique scripting language allows Jaws to be customized to work with non- standard Windows applications and proprietary software. It has new tools for easier customization. One tool gives users control to assign or modify prompts for both speech and Braille. It even assigns custom tutor messages without having to write scripts. And, a new Frame Viewer gives all users control to customize complicated applications without writing scripts, this is fast and simple.

In web access, JAWS for Windows will read each frame in turn, including the title of the frame, if the web designer had remembered to give each frame a title. This is when used with Microsoft Internet Explorer since any screen reader used with a browser other than Internet Explorer, will be unable to get structural information about the web page. So, a navigation frame down the left side of your page will not be distinguished from the article in the main frame. A screen reader used with Netscape, for example, will read the page left to right, top to bottom, the way it reads

e-mail or word-processed documents. So, the navigation links are mixed together with the text of the article.

Web access, as emphasized by Theofanos, 2003, is also facilitated by the use of keyboard shortcuts called keystrokes or commands which are keyboard key combinations which provide quick and effective access to the entire scope of Windows features, examples;

- i. Links List (Insert-F7).
- ii. Headings List (Insert-F6) or moved from heading to heading by pressing H inside a document. JAWS now allows them to skim through a document as sighted users do, moving from heading to heading by pressing H or using Insert-F6 to get a Headings List (just like a Links List).
- iii. JAWS allows users to find out if there is a form on the page (with the Virtual Viewer) and to jump to the form by pressing F on the page
- iv. JAWS command, N, to skip links, even if the Web site developer did not include a Skip Navigation tag.
- v. Use the Virtual Viewer (Insert-F1), a JAWS feature that displays a description of a Web page, so that the user can immediately find out how many headers, tables, links, and other screen elements are on a page, i.e. JAWS allows users to get a sense of the Web page with this Virtual Viewer.

On clicking an anchor link, a page briefly jumps to the correct place, but then reverts to the top of the page and JAWS would start to read the page again from the top. It turns out that the culprit is the time and date stamp, because the page is stamped for a continuously updated time and date, it refreshes with each click on an anchor link. For a sighted user, this quick refresh is hardly noticeable. For the screen-reading software, it makes the page unusable. The screen reader interprets the refresh as a new page.

Weaknesses

- i. The Find feature does not cycle through the page, JAWS find box (CTRL-F) only searches either down the page or up the page from wherever the cursor is on the page. It does not cycle through the page.
- ii. Another problem is that Find cannot read what is in an image
- iii. Problem of frequent refreshing a page, e.g., when reverting back from an anchor link or when filling out a field makes the page refresh.
- iv. Just as with the Links List, however, if many of the headings start with the same words, screen reader users will be frustrated trying to scan the headings with their ears. If the keywords they are looking for are not at the beginning of the heading, they won't find the right heading by jumping through the list with first letters.

2.3.2. Windows Eye.

Window-Eyes is a software application for the visually impaired, which converts components of the Windows operating system into synthesized speech allowing for access to Windows based computer systems and also includes enhanced Braille support. It is developed by Gw-micro (<http://www.gwmicro.com/window-eyes/>). Window-Eyes is primarily controlled and manipulated via a series of keyboard commands called hot keys. Some of these are;

- i. Read entire window: Control-Shift-W. This hot key is especially helpful when you are in a dialog or message box and you want Window-Eyes to repeat any text the box displays.
- ii. Read title bar: Control-Shift-T. Window-Eyes will announce the title of the active window along with the window's state. If Window-Eyes says "normal," then the window is its normal size. If Window-Eyes says "maximized," then the window is as large as possible and takes up the majority of your screen.
- iii. Read status line: Control-Insert-S. This causes Window-Eyes to read the lowest line on your computer screen. This is typically a line of text that contains general status

information for the active program such as page number, column number, disk space remaining, etc.

- iv. **Speak summary:** Control-Shift-S. This hot key causes Window-Eyes to announce the highlighted portion of the control that has your keyboard focus. For example, if you are in a list of items, a speak summary will tell you which item in the list is highlighted. If you are in a menu, the speak summary hot key will cause Window-Eyes to read the selected menu item. If you are on a website, this hot key will cause Window-Eyes to provide details about the current webpage. The speak summary hot key will always give appropriate information for the type of control with which you are working.
- v. **Read highlighted block:** Control-Shift-M. This keystroke will cause Window-Eyes to read any text that has been selected inside the active window. Window-Eyes will alert you if no text has been selected.

Window-Eyes speaks with three different voices. These are the screen, keyboard, and mouse voices. The screen voice is heard whenever activity occurs on the screen. For example, a dialog box opens, your cursor moves through a document, you move through a menu, etc. The keyboard voice speaks whenever you type text or press keys on your keyboard. The mouse voice likewise speaks whenever the mouse moves, buttons are clicked, or the shape of the mouse pointer changes.

For web access, Window-Eyes provides user definable hot keys and customizable verbosity options. These tools provide the user with a powerful and flexible environment for navigating even web pages and just like JAWS for Windows, it will read each frame in turn, including the title of the frame, if the web designer had remembered to give each frame a title.

Weaknesses

- i. The Find feature, like in Jaws, does not cycle through the page, window-eyes find box (CTRL-Shift-F) only searches either down the page or up the page from wherever the cursor is on the page. It does not cycle through the page.

- ii. Windows eye is not able to skim through a document moving from heading to heading, which could be useful to screen reader users to access just the section that has the information that they need.
- iii. Window-Eyes has no quick way to jump to a form, and thus users have to listen (scan with their ears) to the page until they get to the form. This becomes time consuming and difficult especially when there is a lot of text on a page or the form is far down the page.

2.3.3. ACE-HIGH Text To Speech Reader (ATTSR)

This is a system that lets you listen to text instead of reading on screen it on the screen. It uses 'Text to Speech' technology to synthesize natural sounding speech from ordinary text. It involves copying text to the clipboard or importing from text files and listening as the screen reader reads it back. It also allows one to output synthesized speech to speakers or to audio files in form of MP3 or WAV audio files. Control tags can be embedded in the source text to improve the prosody (patterns of intonation in a language) of text-to-speech translation (<http://www.textreader.net>).

The ATTSR allows one to define their favorite global hotkeys to control ATTSR even in other program. This feature is very useful for weak-eyed users. It has a pronunciation manager which allows users to edit the phonetics of mispronounced words and load or unload personal exception dictionaries.

Weakness

The major weakness is in web access, since it works by copying text to be read and pasting to the reader, which is cumbersome.

2.3.4. IwebReader

IWebReader is a web reader based on IVONA Text-To-Speech technology and reads the content of a website aloud. It can be used on any website, making it more attractive and accessible to all (including the visually impaired, partially sighted, elderly or dyslectic-impaired ability to comprehend written words). IWebReader is compatible with most popular browsers. With

iWebReader, one can get access to all the voices and languages available in the IVONA suite of Internet services while the intuitive user interface and amazingly natural voices intensify the visitor's experience of the website.

This is a tool for use by web developers who want to have contents of their websites accessed through audio means. It involves a step by step configuration process in order to meet the sites service requirements. After entering all the configuration data and choosing the elements of the website to be voiced-over, a ready-to-use JavaScript code will be generated to be embedded on the website. Whenever a user clicks to listen on the player, the web reader servers' immediately download the web content and simultaneously prepare the appropriate text-to-speech file. (<http://www.iwebreader.com/?href=ivona>)

2.3.5. Kurtzweil reader.

This was developed by Ray Kurtzweil and transforms text to synthesized speech. Xerox Imaging Systems, which continues to market the successor to the original Kurtzweil reader, offers a family of products for the blind and visually impaired. The reading machines process text in three steps;

First, printed material is electronically scanned [using an optical scanner], capturing each page as an image.

Second, characters are 'recognized,' and

Finally, they are converted to speech and read aloud using a synthesizer" or printed out in Braille.

2.4. Analysis

In analyzing the discussion, ways of Web access through screen readers are highlighted and challenges encountered. In addition to the mentioned weaknesses specific to individual screen readers, the following concerns indicates shortcomings at a larger level;

- i. Assistive devices inadequately handle graphics, moving images, frames, tables and embedded images.

- ii. Use of scripting languages and streaming audio and video challenges a problem to the users due to audio interference with the speech from screen readers and intricate structures strongly optimized for sighted users.
- iii. Most of the screen readers force the blind users to browse the web in a linear manner and thus renders graphs and animations inaccessible.
- iv. The bi-dimensional layout and nature of the textual and pictorial information is not compatible with most screen readers which are mostly one (1) dimensional.

To truly meet the needs of all users and overcome the weaknesses noted, it is not enough to have assistive technology but it is necessary to understand the visually impaired users and how they work with the assistive technology. For example, just realizing that vision-impaired users do not listen to the entire page is critical for designing usable pages for them. In the absence of detailed information, guidelines and models, many designers and manufacturers work from assumptions about who the user is, what he or she does, and what type of system would meet his or her needs and following these assumptions, they tend to design for themselves, not for other people including the visually impaired.

2.5 Summary

From the above, there needs to be developed interfaces for bringing web accessibility and usability together based on observing, listening to, and talking with the visually impaired users and those who work with them, as they work with Web sites and screen readers. This is intended to extend the previous investigatory works in the area, by probing deeper into accessibility issues encountered by screen reader users on the Web, identifying new issues not covered by past literature, guidelines and models.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

Methodology refers to the practice of analyzing procedures and different methods, implying a set or system of methods, principles, and rules for regulating a given discipline. Research methodology involves coming up with the most relevant, appropriate, systematic and viable way of gathering information in the form of a research design which will assist in adequately covering the study area and answer the research questions as unambiguously as possible, i.e. the organized approach to problem-solving.

3.2 Research Approach

To fulfill the objectives of the study, field survey and model design were used. A survey is a means of gathering information about characteristics, actions or opinions of a large group referred to as a population and involve the examination of a phenomenon in a wide variety of natural settings. Field survey study involves individuals, groups, organizations, or communities where the data collection is by asking people structured and predefined questions (**Choudrie & Dwivedi, 2005**). Model design is the process of putting together user requirements with the purpose of coming up with a working model meant to solve some problem.

Survey was preferred for this study since it involved understanding web access strategies by the visually impaired and screen readers' use, for persons in various settings, individually or as a group and favourable to provide data on emotions, feelings and experience. While model design was used since it could help in coming up with the user interface for use by the blind after evaluating existing systems and getting user inputs and requirements.

3.3 Data Collection

3.3.1 Data Sources

The target population was the visually impaired, with information being derived from the blind in institutions of learning and groups that advocate and support services provision to the visually impaired which were Kenya Society for the blind and Kenya Institute of the blind. The study also covered getting information from the visually impaired persons who are in working environments.

Data was collected from 44 respondents which represented the questionnaires and interviews undertaken, of which 39 were visually impaired while 5 were those assists them. This was scrutinized to ensure selection of viable data that had all the required variables and complete by all standards.

This helped in providing data to assist in understanding the study area and the conduct of the visually impaired in particular situations by getting their perspectives, behavior, and web accessibility in these situations and their overall experience navigating around the resource and the context within which they are within, while understanding how the they work with computers, how they access the Web and challenges they encounter.

3.3.2 Data Collection Methods and Tools

For the researcher to be able to understand the research area in detail, relevant, reliable and sufficient data must be collected since inaccurate data collection can impact the results of a study and ultimately lead to invalid results. There are normally two types of data that can be collected, that is, primary and secondary data (Yin, 2003). Primary data is the type of data a researcher collects on his own and with a specific purpose, while secondary data type supplements or gives more details to support the primary data. To collect data that is reliable and representative, both types of data were used.

In this research study, observation, questionnaires, interviews and document reviews were the data collection methods that were used to be able to achieve the intended objectives.

In observation, the tool that was used is the observation guide (Appendix IV). This was necessary in finding out, through viewing and witnessing, how the visually impaired access computers and ultimately how they get information through the Internet and the technologies that they use in the access. This also facilitated the evaluation of their experience and the challenges that they encounter when using the screen readers in navigating computers and the Web and also their emotions, feelings and experience and how to tell a page is loading, initial comments about the interfaces and the type of information accessed.

Questionnaires and interviews were conducted based on the questionnaires in appendices II, III. These were utilized in facilitating in-depth understanding of the technologies in use by the visually impaired, challenges that they face and ways that they use to overcome some of the challenges. This was also to understand whether any of the blind was sighted at any one time and whether during this time any computing skills were acquired. Findings from these provided the basis on which the model interface was designed and developed in solving the problem highlighted of non- accessibility of streaming multimedia files. The advantage of using questionnaires in this study was the cost effectiveness involved with minimal biasness since respondents received the same set of questions in exactly the same way, therefore yielding comparable data. Interviews allowed for prompt feedback and higher response rate. It also provided the interviewer with an opportunity to get deeper meanings of responses given thus unlocking and clarifying areas that are not clear to the interviewer. Telephone interviews were also conducted after getting references from those whom the researcher had interacted with.

Document review was used to corroborate the information derived from others data collection methods and was aimed at identifying computers and Internet access by the visually impaired, the technologies they use and challenges they encounter. This involved the analysis of literature review section of the study. This considers opinions of other researchers and was useful in this study since it helped draw from their experiences in enriching the researcher and assists in checking and re-checking for clarity and reliability.

3.4 Data Analysis

Data analysis is the practice in which unorganized or unfinished data is ordered and organized so that utile information can be highlighted from it. It involves processing and working on data, so that meaning and information to merit decision making can be derived from it.

The data collected was coded for analysis, by having score values attached to the responses to the questions in the questionnaire and in order to get a descriptive overview of the data in this study, descriptive statistics were used to summarize the data through a number of meaningful statistical indicators. Each variable was studied separately to evaluate each individual respondent score and shows the variable name and description, frequency counts for each value of the variable and percentages associated with a variable.

The analysis was done using SPSS software version 11.5. Data was edited by checking and adjusting for errors, omissions, legibility and consistency in order to ensure completeness, consistency, and readability of the data. A coding sheet was used to keep information about how each variable was coded. It comprised a list of all variables in the questionnaire, the abbreviated variable names that were used in SPSS and the way in which the responses were coded.

This was preferred due to its ease of analysis and simplicity since it is predominantly a menu based interface with command selections easily available as opposed to others like STATA which has command based interface. It also integrates the output and graphs together into a single unified output, which can be easily exported.

The analyzed data was studied and conclusions drawn there from which recommendations and design interfaces derived.

3.5 Model Design

3.5.1 Introduction

From the findings of the field survey conducted, it was found that;

- i. The blind are able to access computers and information through the Internet using assistive technologies.
- ii. In using the computers, there are some inherent challenges that the blind encounter in their furtherance of technological knowledge, which include problems in accessing graphical information, lack of screen readers having local dialects, access to streaming multimedia files among others.

In trying to solve one of the challenges encountered by the visually impaired, the research endeavored to act on the challenge of accessing streaming multimedia files. To enhance the access, the researcher resulted to the design of a model interface to facilitate this. The design involved understanding that a screen reader by default is designed to be always running on machines used by the blind and thus the challenge of streaming multimedia files because there is only one physical volume control available in the typical user environment and therefore the users cannot control the volume of the multimedia content separately.

From this understanding, a visually impaired user using the interactive interface is able to access contents from the Internet using the screen reader normally, and deactivate the screen reader application when he/she wants to access streaming multimedia content, and then activate it back when required. Thus the purpose of the model interface is to activate the screen reader application when required.

3.5.2 Analysis

This involved the analysis of the literature review on the screen readers to find out how they convert text into synthesized speech, then synthesizing the findings with data collected from the visually impaired and those who work with them. It was noted that screen readers perform their work by gathering data from the operating system and applications, hooking onto the information flow by monitoring the screen buffer, govern the data in an internal data structure (off-screen model), and provide the information in an appropriate format to output devices.

From these analyses, it was found that the blind lack clear access to streaming multimedia files, since it was being interfered with by speech from the screen readers.

3.5.3 The Design

The researcher resulted to the design of a model interface in the form of a plug-in to provide a way to re- activate the screen reader after de-activating to enable access to the streaming multimedia files. A plug-in is a set of software components that adds specific abilities to another software application.

The plug-in is designed using JavaScript to allow it upon execution to activate the screen reader application. This plug-in is designed that once opened, it displays an activation button that once clicked calls the reader. The JavaScript code calls the reader by initializing the windows shell which allows calling the reader application from its root shell by use of ActiveX interface, which allows interactive content. For the interface to be useful to the blind, the size of the button is set to be large almost covering the whole screen thus making it easier for them to activate it. (The JavaScript is at appendix I).

3.5.4 The Model Implementation

This refers to the description of how the designed model interface works, showing its interaction with the screen reader application, the files being accessed and the user. This is through various diagrams and illustrations as shown below.

i. Illustration of how the model works

As is the practice, the screen reader is by default already running and the user may decide to access streaming audio files, if he opts not to, then no need to use the plug-in, otherwise he proceeds and opens the plug-in, then activates the streaming media required, upon which on loading and getting the audio from the media, exits the reader application. After accessing the audio files and exiting, clicks the button on the opened window of the plug-in to activate the screen reader.

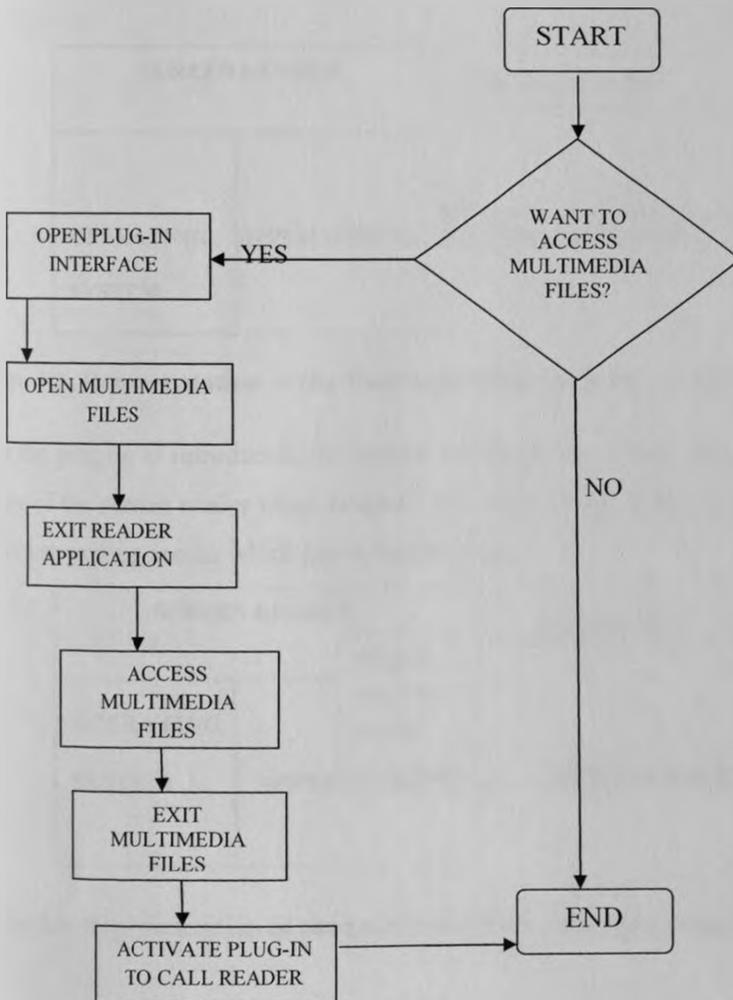


Figure 3.1): Flowchart showing how the model interface works

ii. Architectural Diagram

The diagram below (fig. 3.2) shows how the screen reader normally works without the plug-in, where it interfaces between the user (blind) and the computer's operating system (OS) and applications. It does this by gathering data from the OS and applications, hooking onto the information flow and monitoring the screen buffer to convert the text received into speech/voice. The output/ voice in this case is from the screen reader or voice from the screen reader having interference from streaming audio.

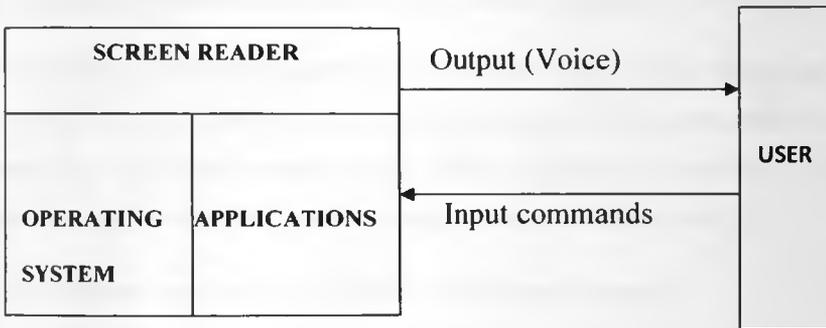


Figure 3.2: Representation of the User's Interface with the screen reader.

After the plug-in is introduced, the layout will be as the figure below. The interface allows the calling of the screen reader when needed. The output voice in this case is from the screen reader or from streaming media which has no interference.

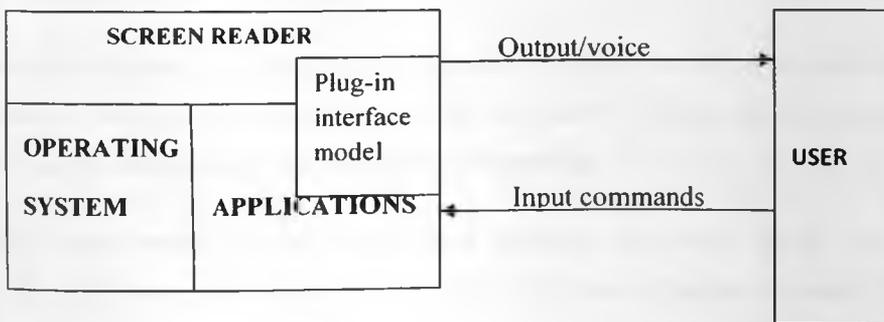


Figure 3.3: Representation of the user's interface with the reader having the plug-in.

3.6 Evaluating and Validating the Model

This involved checking the designed model to evaluate whether it is able to facilitate the blind to access multimedia files in form of streaming audio without interference of speech from screen readers. It involved conducting the following tests and using the feedback and opinions to enhance it;

3.6.1 Usability Tests

This involved having the users confirm whether the model interface is working adequately to necessitate access of streaming multimedia files without interference as was previously the case.

The test involved use of existing guidelines to evaluate the interface design and its use. As per Shneiderman (1998), each type of user expects an interface to accommodate their desires while at the same time accessing whatever they want as quickly as possible. From his study he enumerates some golden rules of interface design used to evaluate usability.

These guidelines/tests were used to evaluate the interface designed;

- i. Strive for consistency in use; this implies that consistent sequence of actions should be required in similar situations while having consistent layout.
- ii. Offer informative feedback; for every user action, the system should respond in some way, to show that something has happened.
- iii. Design dialogs to yield closure; the sequence of actions should be organized into groups having a start, middle and an end, i.e. the informative feedback at the end should show the user that their activity has completed successfully.
- iv. Offer error prevention and simple error handling; the design should have adequate controls to detect, prevent and correct errors. This ensures no time is wasted in repeating a tedious long process.
- v. Reduce short term memory load; the design should ensure that users are not overburdened by instructions which can be provided interactively.

The evaluation was done using nine (9) blind persons from various backgrounds and in their day to day environment. The persons were familiar with the use of screen readers since it's what they use to access computers. All of them had post-secondary education and some training on use of assistive technologies. This involved first introducing them to how the interface operates, letting them operate for some time and then interviewing and observing them later to get their views in line with the above guidelines. This was done with the assistance of the questionnaire attached (Appendix V). The data collected was analyzed using SPSS software version 11.5 and results interpreted as indicated in section 4.6 of the report.

3.6.2 Control Test

This was done in one of the institutions training the visually impaired and involved having the users access the same multimedia file. The control test involved eleven (11) visually impaired persons being divided into two groups; group one having five (5) persons while group two having the rest six (6), where the first group accessed the sample file without the plug-in interface while the second was having the interface.

The experiment was randomly set and the subjects being divided by the sessions they came to the institution for their classes. The first group of users, 5, came to the institution in the morning hours (between 9am and 11am) while the second group in the afternoon hours (12 noon to 2pm).

The file being accessed was from; <http://www.youtube.com/watch?v=SG0RuHUQ8pE>, being a video clip from citizen TV entitled: ICT Development in Kenya.

The participants in the two groups were similar in the following ways;

- a. They were all blind and could not read the contents of a screen even with the help of a magnifier and thus they all relied on a screen reader.
- b. They all had the minimum skills and exposure necessary to access computers and the Internet without assistance.

The first group accessed the clip from the Internet without the Interface and was left to proceed listening to it at the same time having the screen reader on and reading the contents on the

screen. Later questions were asked to them concerning the contents of the clip to check on the extent to which they comprehend the clips contents with the screen reader's interference on. The questions asked are as per appendix VI.

The second group had the plug-in interface installed, introduced how it works, guided to do some practice and left to access the clip having managed to control the screen reader's voice from interfering with the clip's voice. Later, similar questions to those of the first group were asked to check on the extent of comprehending the clip's contents. The data collected was analyzed using SPSS software version 11.5 and results interpreted as indicated in section 4.6 of the report.

3.6.3 Comparing usability of the interface with several screen readers.

This involved testing the usability of the plug-in interface with several screen readers to confirm whether the interface model is generic, i.e. it can be used with a wide variety of screen readers in use by the blind.

CHAPTER FOUR: RESULTS AND ANALYSIS OF FINDINGS

4.1 Introduction

This chapter involves analysing the respondents' field survey findings through various methods like descriptive statistics and content analysis. Content analysis is used to determine the presence of certain words or concepts within texts or sets of texts. This involved quantifying and analyzing the presence, meanings and relationships of such words and concepts, then making inferences about the messages within the texts.

4.2 Research Findings

The analysis of the data from the respondents yielded the following results;

4.2.1 Demographic information

4.2.1.1 Respondents Age

Table 4.1 Respondents Age

| AGE | Frequency | Percent |
|----------------|-----------|---------|
| BELOW 15 YEARS | 0 | 0 |
| 15 - 20 YEARS | 16 | 41 |
| 21 - 30 YEARS | 20 | 51 |
| OVER 30 YEARS | 3 | 8 |
| Total | 39 | 100 |

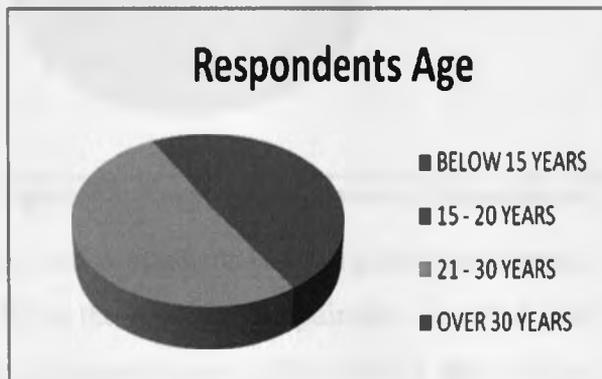


Figure4.1: Figure showing respondents Age

4.2.1.2 Level of Education

Table 4.2 Level of Education

| | Frequency | Percent |
|--------------------|-----------|---------|
| HIGH SCHOOL | 16 | 41 |
| COLLEGE/UNIVERSITY | 23 | 59 |
| Total | 39 | 100 |

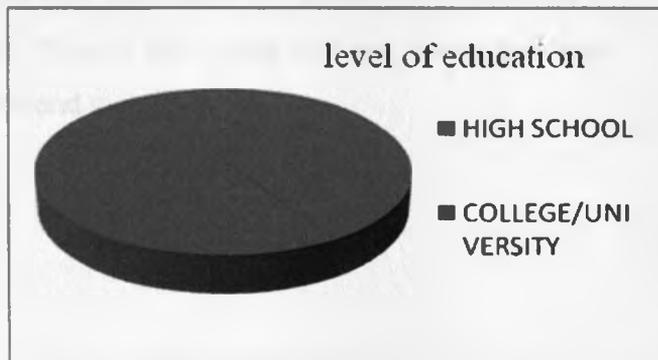


Figure 4.2 Respondents Education level

The above two parameters, respondents' age and level of education, shows that majority of the respondents (59%) were those who had or were pursuing college and university education as opposed to those in high schools (41%). This indicates that the data collected will be adequate to bring out interface designs required for the blind since those having post-secondary education are deemed to have had adequate exposure in using screen readers that those in secondary schools.

4.2.1.3 Level and Nature of Visual Impairment.

Table 4.3 NATURE OF VISUAL IMPAIRMENT

| | Frequency | Percent |
|--------------|-----------|---------|
| CONGENITAL | 26 | 67 |
| ADVENTITIOUS | 13 | 33 |
| Total | 39 | 100 |

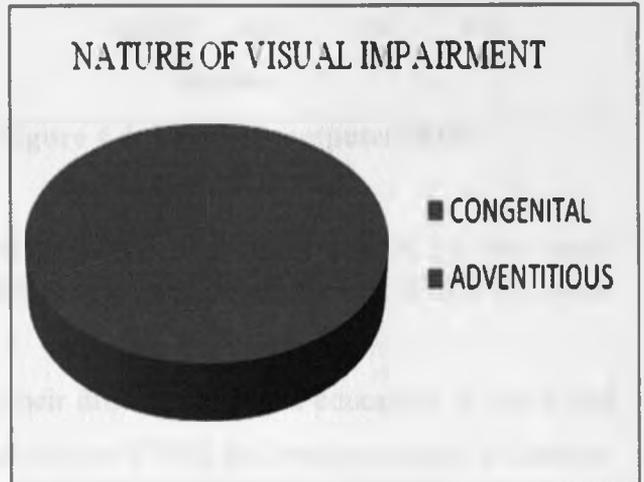


Figure 4.3: Respondents' nature of impairment.

An analysis shows that sixty seven percent (67%) of the respondents had congenital impairment, which means that blindness occurred from birth while the rest, their impairment occurred later after birth. From the interviews of those whose impairment occurred after birth, it was realized that blindness came during childhood during which none had interactions with a computer. Thus from this analysis, all the computer skills and knowledge has been acquired while being blind.

All the respondents' were fully impaired, meaning that they could not access the contents of a screen even with the assistance of a magnifier. This is the group that the researcher was interested in determining their Web access methods and tools.

4.2.2 Review of Internet experience

4.2.2.1 Level of Computer skills

Table 4.4 Level of Computer skills

| | Frequency | Percent |
|-----------|-----------|---------|
| EXCELLENT | 0 | 0 |
| GOOD | 17 | 44 |
| FAIR | 9 | 23 |
| POOR | 13 | 33 |
| Total | 39 | 100 |

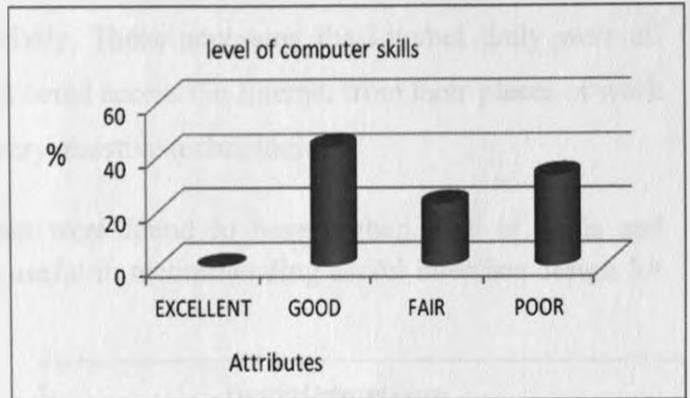


Figure 4.4: Level of computer skills

This shows that only 44% of the respondents had good level of computers skills, i.e. they could be able to access computers and their functionalities with ease, while the rest (56%) had some form of difficulties with the same.

Analyzing those having good computer skills in their different levels of education, it was found that only 25% were from secondary schools and the rest (75%) had post-secondary education. Respondents having poor computer skills were those pursuing secondary education. This can be explained as due the lack of necessary skills, knowledge and assistive technologies among students in secondary schools.

4.2.2.2 Frequency of Accessing the Internet

Table 4.5: Frequency of Internet Access

| | Frequency | Percent |
|--------------|-----------|---------|
| DAILY | 9 | 22 |
| MONTHLY | 4 | 11 |
| OCCASIONALLY | 26 | 67 |
| Total | 39 | 100 |

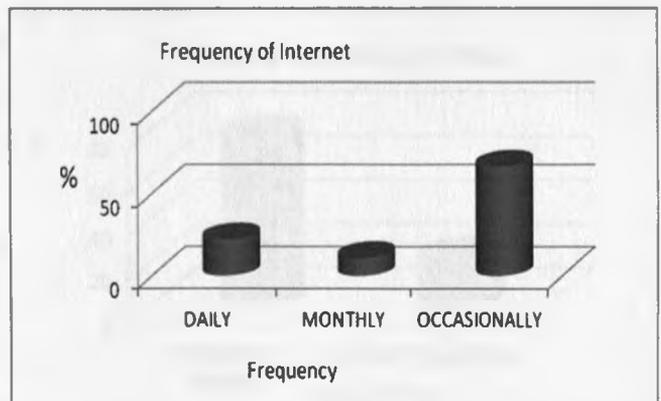


Figure 4.5: Frequency of Internet access

This analysis shows only 22% of the respondents is able to access the Internet daily, while the rest (78%) had various time lengths before access which was influenced by the availability of necessary technologies and Internet connectivity. Those accessing the Internet daily were all (100%) having post- secondary education and could access the Internet from their places of work or had a personal computer having the necessary assistive technologies.

Those having frequent access to the Internet were found to have higher level of skills and knowledge in usage of the computers hence useful in recommending useful interface design for effective Web access.

4.2.2.3 Length of Internet Usage

Table 4.6: Length of Internet usage

| | Frequency | Percent |
|------------------|-----------|---------|
| MORE THAN 4 YRS | 4 | 11 |
| 2 - 3 YEARS | 9 | 22 |
| AROUND 1 YR | 4 | 11 |
| LESS THAN 1 YEAR | 22 | 56 |
| Total | 39 | 100 |

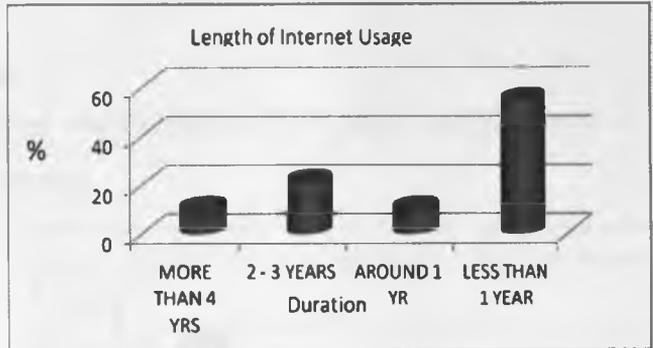


Figure 4.6: Internet Usage Length

For those who had used the Internet for more than 2 years (33% of all respondents), 75% were having post-secondary qualifications and opposed to 25% for the rest. This shows that those who had the necessary skills and technology had the chance of having accessed the Internet for a longer duration of time and thus better placed to recommend useful Web access designs.

4.2.2.4: Mode of Accessing Web pages

Table 4.7:MODE OF ACCESSING WEB PAGES

| | Frequency | Percent |
|---------------------|-----------|---------|
| SECTION OF INTEREST | 30 | 78 |
| SEQUENTIAL ACCESS | 9 | 22 |
| Total | 39 | 100 |

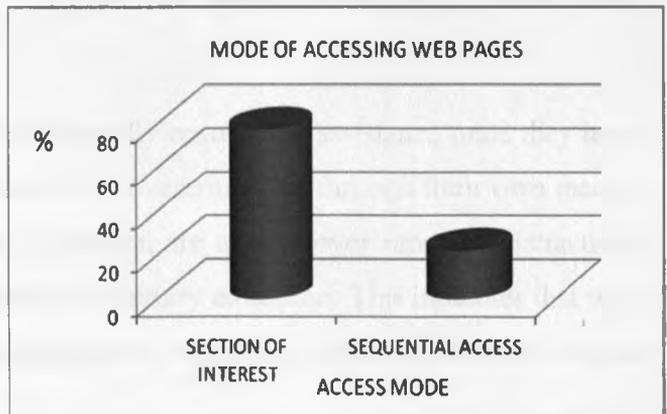


Figure 4.7: Web Access modes

This indicates that 78% of the respondents were able to access Web pages by moving to sections of interest without having to listen to the screen reader to read everything sequentially as opposed to 22 % who could not. This shows that majority of the blind are able to use the screen readers' functionality to access Web pages.

Further, all (100%) respondents having post-secondary education, were able to access the Web by moving to the sections of interest in comparison to 60% of those pursuing secondary school education. This implies that with exposure and training, the blind are able to learn how to access Web pages with ease.

4.2.2.5: Distractions while accessing Web pages.

The study highlighted that there occurs distractions when accessing Web pages, analysis on how these are overcome by the blind yielded the following;

Table 4.8: OVERCOMING DISTRACTIONS

| | Frequency | Percent |
|------------------------|-----------|---------|
| ASK FOR ASSISTANCE | 12 | 31 |
| KEYBOARD SHORTCUTS | 9 | 23 |
| WEB PAGE FEATURES | 9 | 23 |
| SCREEN READER FEATURES | 9 | 23 |
| Total | 39 | 100 |

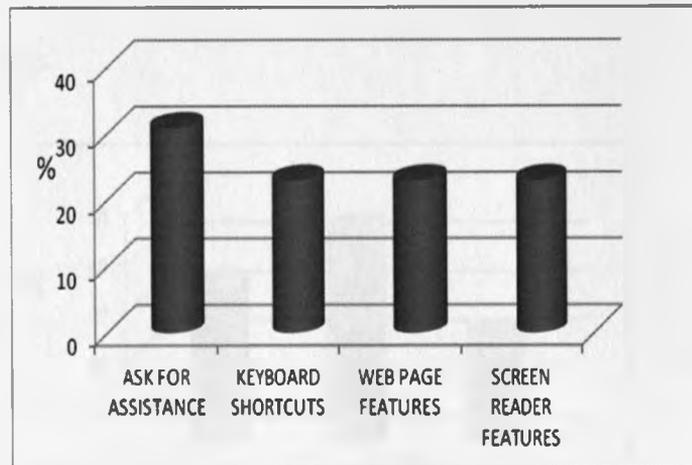


Figure 4.8: Ways of overcoming distractions

This analysis indicates that 31% of the respondent usually request for assistance once they have encountered distractions while the rest 69% are able to overcome this through their own means. All (100%) respondents having post-secondary education are able to overcome the distractions by their own as compared to 40% of those pursuing secondary education. This indicates that with wide spread acquisition of skills, knowledge and presence of assistive technologies the blind can become self reliant.

4.2.2.6: Accessing Hypertext links on Web pages

Table 4.9: ACCESSING HYPERTEXT LINKS

| | Frequency | Percent |
|-----------------|-----------|---------|
| QUITE EASY | 13 | 33 |
| PARTIALLY EASY | 13 | 33 |
| WITH ASSISTANCE | 9 | 23 |
| NOT EASY | 4 | 11 |
| Total | 39 | 100 |

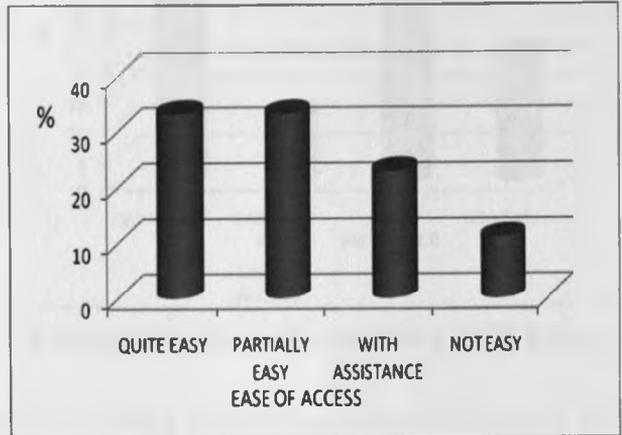


Figure 4.9: Ease of accessing hyperlinks

4.2.2.7: Ease of Navigating Hyperlinks and Headings

Table 4.10 Navigating Hyperlinks and Headings

| | Frequency | Percent |
|-----------------|-----------|---------|
| QUITE EASY | 13 | 33 |
| PARTIALLY EASY | 17 | 44 |
| WITH ASSISTANCE | 9 | 23 |
| Total | 39 | 100 |

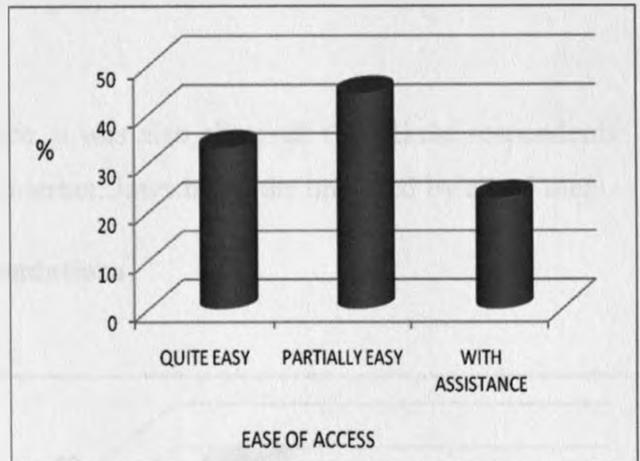


Figure 4.10: Ease of accessing hyperlinks

4.2.2.8: Ease of Navigating and Filling Web Forms

Table 4.11: NAVIGATING AND FILLING WEB FORMS

| | Frequency | Percent |
|-----------------|-----------|---------|
| QUITE EASY | 13 | 33 |
| PARTIALLY EASY | 4 | 11 |
| WITH ASSISTANCE | 13 | 33 |
| NOT EASY | 9 | 23 |
| Total | 39 | 100 |

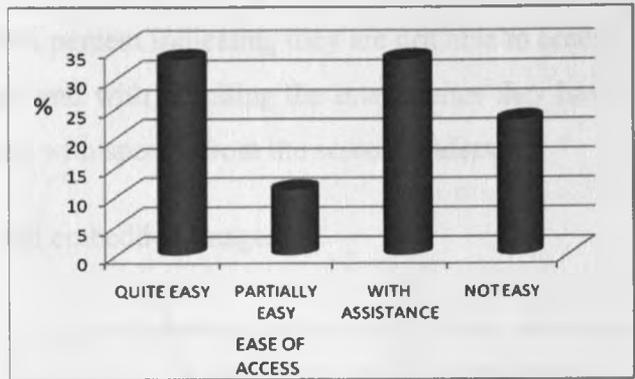


Figure 4.11: Ease of navigating Web forms

From the above three types of analysis, i.e. ease of accessing hyperlinks, ease of navigating the hyperlinks and headings and ease of navigating and filling web forms, it can be highlighted that the blind are generally able to access the Internet, noting that 66% are able to access hyperlinks without assistance, 77% are able to navigate the hyperlinks and headings with ease, while 77% of the respondents are able to navigate and fill Web forms. These statistics indicate with exposure, training and access to assistive technologies, the blind are able to access and derive information from the Internet with ease.

From the review of Internet access and experience, it was also observed that all the respondents uses screen readers to access computers and the Internet, Jaws being the one used by all of them.

4.2.3 Challenges in Web Access and Recommendations

4.2.3.1: Ease of access of multimedia files.

Table 4.12: EASE OF ACCESS OF MULTIMEDIA FILES

| | Frequency | Percent |
|-----------------|-----------|---------|
| NOT ABLE AT ALL | 22 | 56 |
| NOT EASY | 17 | 44 |
| Total | 39 | 100 |

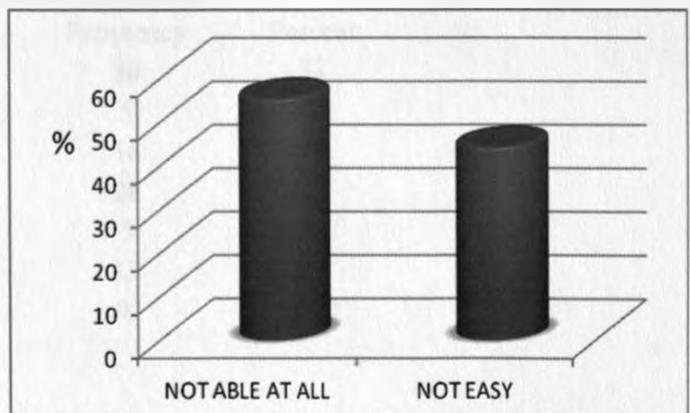


Fig. 4.12: Ease of accessing multimedia files

This analysis indicates that despite being able to access the Internet, none of the respondents is able to access multimedia files with ease, with 56% percent indicating they are not able to access at all, while the rest, 44%, have found it not easy and with all citing the interference they have encountered of the multimedia files being accessed with speech from the screen readers.

4.2.3.2: Access of accessing graphical, pictorial and embedded images.

Table 4.13: ACCESS OF GRAPHICAL, PICTORIAL AND EMBEDDED IMAGES

| | Frequency | Percent |
|----------------|-----------|---------|
| ACCESSIBLE | 0 | 0 |
| NOT ACCESSIBLE | 39 | 100 |
| Total | 39 | 100 |

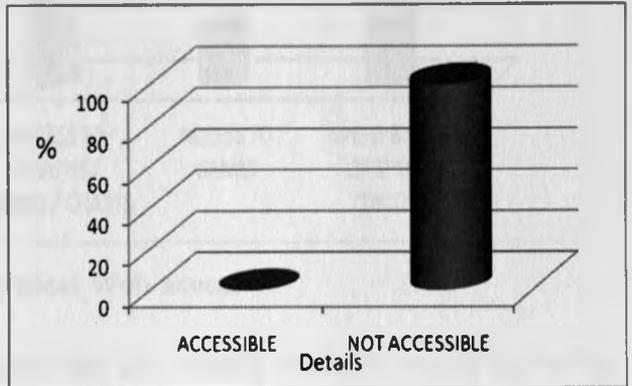


Fig.4.13: Accessing graphs and images

The analysis on access of graphical, pictorial and embedded images by the blind indicates another challenge area where all the respondents, 100%, are not able to access these features either on Web pages or in other types of files.

4.2.4. Design recommendations for ideal Web access

Table 4.14: FEATURES OF IDEAL WEB ACCESS FEATURES

| | Frequency | Percent |
|------------------------------------|-----------|---------|
| ACCESS TO MULTIMEDIA FILES | 30 | 32 |
| EXTENSION TO MOBILE PHONES | 5 | 5 |
| LOCALISATION OF DIALECTS | 16 | 18 |
| ACCESS TO GRAPHS / TABLES / CHARTS | 26 | 27 |
| ACCESS TO GAMES | 5 | 5 |
| SPEED & TONE OF SPEECH CONTROL | 13 | 14 |
| Total | 95 | 100 |

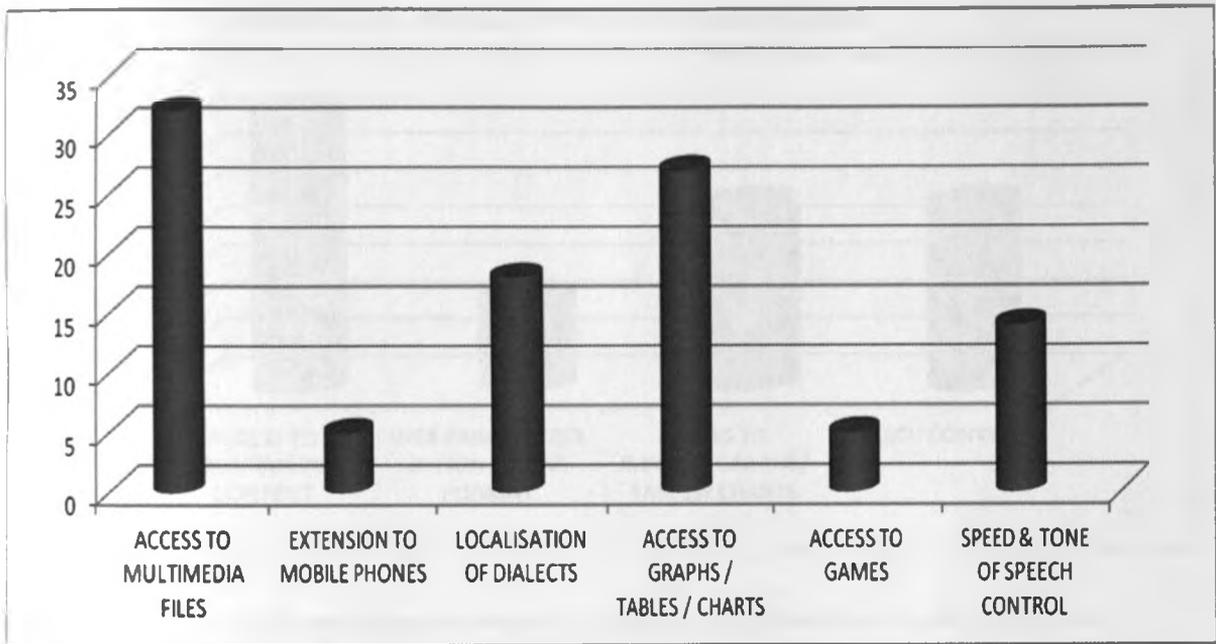


Figure 4.14: Design recommendations for ideal Web access

The analysis above illustrates features/ requirements that the visually impaired would like to be included in the design of assistive technologies and especially the ones they are familiar with. From this, accessing multimedia files and images rank the highest requirements having 32% and 27% respectively of all responses.

4.2.5. Analysis of respondents who assist the visually impaired

An analysis of the respondents who assist the visually impaired was done. These respondents were useful since they could provide an insight into what challenges the blind encounter, how they assist them and their recommendations to improve the assistive technologies.

Table 4.15: Design recommendations by those who assist the visually impaired

| RECOMMENDATIONS FOR IMPROVEMENT | Frequency | Percent |
|--|-----------|---------|
| ACCESS TO MULTIMEDIA CONTENT | 3 | 37.5 |
| WEB PAGE ACCESS IN NON LINEAR FORMAT | 1 | 12.5 |
| ACCESS TO IMAGES/ GRAPHS/ TABLES/ CHARTS | 2 | 25 |
| SPEECH CONTROL | 2 | 25 |
| Total | 8 | 100 |

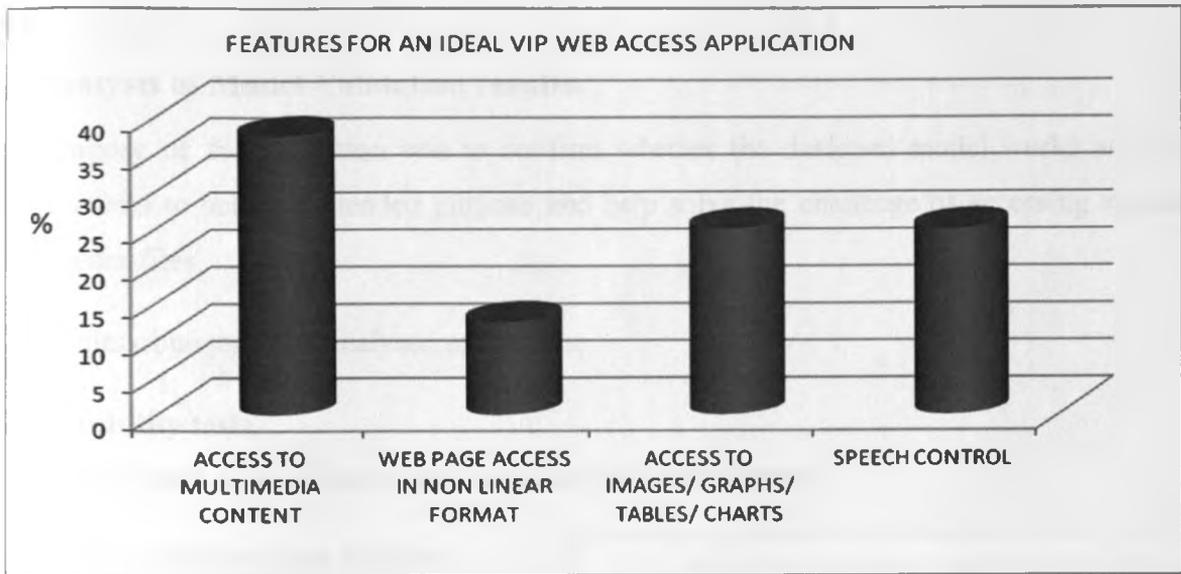


Fig. 4.15: Design recommendations by those who assist the visually impaired

The analysis above illustrates features of an ideal application that those who assist the visually impaired find useful for those whom they assist, requiring 37.5% for multimedia and flash content and 25% for images, graphs and charts.

4.2.6 Summary of survey findings.

From the field survey conducted the following can be deduced from the research findings;

- i. It is evident that the visually impaired persons are able to access some aspects of computers and the Internet, where the level of access is dependent on level of computing skills and knowledge one has acquired and the degree of exposure to computers and Internet one has. It can also be concluded that once trained on use of assistive technologies, majority of them can easily access and navigate hyperlinks and headings on Web pages.
- ii. In addition major challenges encountered by the visually impaired in using computers have been highlighted and include access to information represented graphically and access to streaming multimedia files.
- iii. The blind have also identified major areas that would require improvement to increase their access to computers and information through Internet and include; localization of the screen readers' voices to local dialects, access to graphical information and access to streaming multimedia information.

4.3 Analysis of Model Validation results.

The purpose of the validation was to confirm whether the designed model works as per the requirements to achieve intended purpose and help solve the challenge of accessing streaming multimedia files.

The results obtained were analysed as follows;

4.3.1 Usability tests.

4.3.1.1: Presence of an elaborate way to access required resource

Table 4.16: Elaborate way to access required resource

| | Frequency | Percent |
|----------------|-----------|---------|
| Excellent | 5 | 56 |
| Good | 3 | 33 |
| Fair | 1 | 11 |
| Unsatisfactory | 0 | 0 |
| Total | 9 | 100 |



Fig. 4.16: Elaborate way to access required resource

From this evaluation, all the respondents who participated acknowledged that the interface has an elaborate way of accessing the required information, where 89% found it rather easy with the rest, 11%, having some difficulty but finally being able to access.

4.3.1.2: Consistency of the interface in achieving objective

Table 4.17: Consistency in achieving objectives

| | Frequency | Percent |
|----------------|-----------|---------|
| Excellent | 6 | 67 |
| Good | 3 | 33 |
| Fair | 0 | 0 |
| Unsatisfactory | 0 | 0 |
| Total | 9 | 100 |

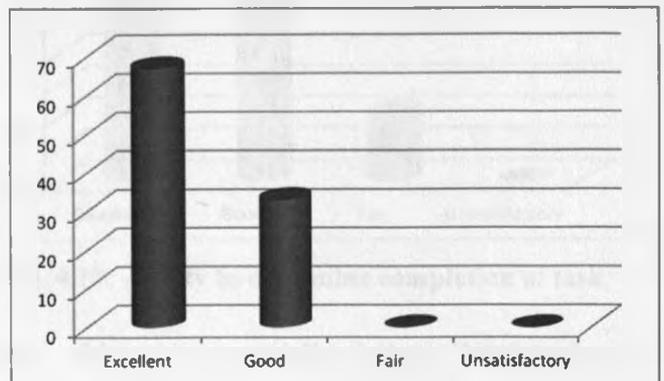


Fig. 4.17: Consistency in achieving objectives

This indicates that all the respondents, 100%, found the interface consistent in achieving the objective of eliminating the interference of the screen reader's voice, i.e. it has a consistent layout and a set of actions which once followed would yield the same results.

4.3.1.3: Ability to get informative feedback from the system

Table 4.18: Ability to get Informative feedback

| | Frequency | Percent |
|----------------|-----------|---------|
| Excellent | 5 | 56 |
| Good | 2 | 22 |
| Fair | 2 | 22 |
| Unsatisfactory | 0 | 0 |
| Total | 9 | 100 |



Fig. 4.18: Ability to get Informative feedback

From this, 78% of the respondents ranked the interface as helpful and user friendly in being interactive with the user by providing useful feedback. This indicates how useful the interface is to the users.

4.3.1.4: Ability to determine successful completion of task

Table 4.19: Ability to determine successful completion of task

| | Frequency | Percent |
|----------------|-----------|---------|
| Excellent | 4 | 44.5 |
| Good | 4 | 44.5 |
| Fair | 1 | 11 |
| Unsatisfactory | 0 | 0 |
| Total | 9 | 100 |

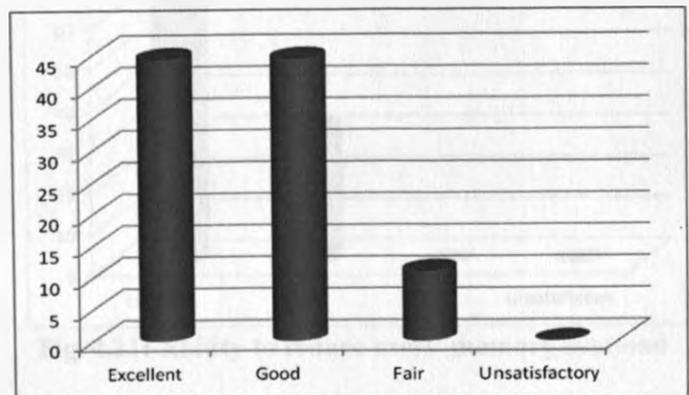


Fig. 4.19: Ability to determine completion of task

This shows that 89% of the respondents were able to successfully follow the interface's procedures and were to determine that a given task that they were undertaking was successful,

that is the designed dialogs can successfully yield closure.

4.3.1.5: Ability of the interface to handle errors

Table 4.20: Presence of mechanisms to handle errors

| | Frequency | Percent |
|----------------|-----------|---------|
| Excellent | 3 | 33.3 |
| Good | 3 | 33.3 |
| Fair | 3 | 33.3 |
| Unsatisfactory | 0 | 0 |
| Total | 9 | 100 |

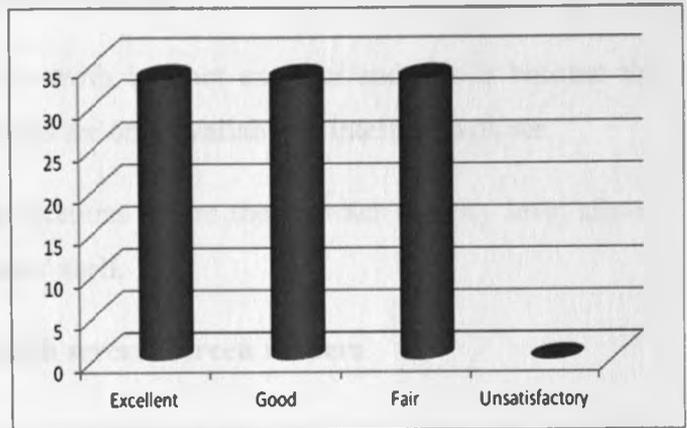


Fig. 4.20: Presence of mechanisms to handle errors

In terms of errors handling, 66.6% of the respondents could comfortably handle errors arising while 33.3% were not able or had major difficulties in handling errors. This was found to be one of the areas that the interface ranked poorly but with proper following of the user guidelines, errors can be prevented from occurring.

4.3.1.6: Ability of the interface to reduce user's memory overload

Table 4.21: Ability to reduce users' memory overload

| | Frequency | Percent |
|----------------|-----------|---------|
| Excellent | 6 | 67 |
| Good | 3 | 33 |
| Fair | 0 | 0 |
| Unsatisfactory | 0 | 0 |
| Total | 9 | 100 |

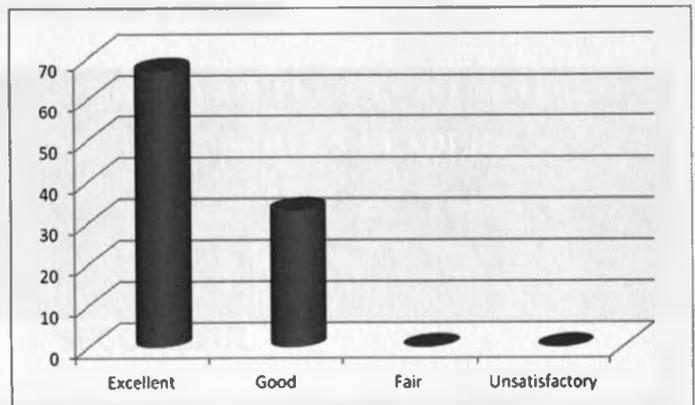


Fig. 4.21: Ability to reduce users' memory overload

All the respondents cited that the interface's instructions once mastered did not overload with trying to remember many and complex procedures, 67% cited it was excellent while the rest 33% cited it as being good.

From the above analysis of the model interface, it was found that it is easy to use, achieved the intended objective and thus generally acceptable by the users.

Though the following points were noted for improvements;

- i. The model interface is only compatible with Internet explorer and this is because the Shell commands to allow ActiveX objects are only available to Internet Explorer.
- ii. This would work only on intranet applications where the browser security level allows the browser to access the client machines' shell.

4.3.2 Comparing usability of the interface with several screen readers.

This test involved confirming whether the model interface is generic, that is, the usability of the plug-in interface with several screen readers that are used by the blind.

Though all the respondents in the studies conducted used Jaws screen reader from Freedom Scientific, testing was done using Jaws, Windows eye, IWebReader and Ace High Text To Speech Reader (ATTSR).

This yielded the following;

Table 4.22: Evaluating the interface with several screen readers.

| SCREEN READER | ABILITY OF PLUG-IN TO ACTIVATE SCREEN READER |
|----------------------|---|
| JAWS | SUCCESSFUL |
| WINDOWS EYE | SUCCESSFUL |
| IWEB-READER | SUCCESSFUL |
| ATTSR | SUCCESSFUL |

The evaluations confirmed that the model interface designed is able to call and execute the screen readers as and when required thus giving the blind to access streaming audio files as and when required.

This is facilitated by the fact that the interface code designed allows calling the reader application from its root shell by use of ActiveX interface, which allows interactive content.

From this evaluation, the interface has been confirmed to be generic and thus acceptable and usable by many users having various screen readers.

4.3.3 Having a control test.

This involved having the blind access multimedia files, where one set of users having the interface while the other having to access the files with the audio interference on.

The control test involved eleven (11) visually impaired persons being divided into two groups; group one having five (5) persons while group two having the rest six (6), where the first group accessed a sample file without the plug-in interface while the second was having the interface.

The file being accessed was from; <http://www.youtube.com/watch?v=SG0RuHUQ8pE>, being a video clip from citizen TV entitled: ICT Development in Kenya.

Analysis of the test results showed the following;

4.3.3.1: Identification of No. of voices in the Discussion

Table 4.23: Group one- Identifying no. of voices

Group One

Identification of No. of voices in the Discussion

| | Frequency | Percent |
|----------------|-----------|---------|
| Correctly tell | 0 | 0 |
| Incorrect | 5 | 100 |
| Total | 5 | 100 |

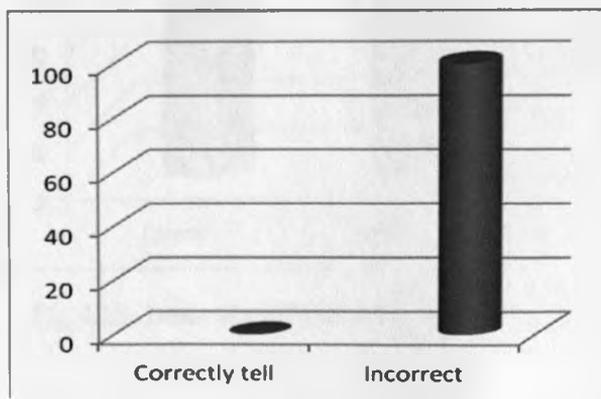


Fig. 4.23: Voices identification in discussion

Table 4.24: Group two- Identifying no. of voices

Group Two

Identification of No. of voices in the Discussion

| | Frequency | Percent |
|----------------|-----------|---------|
| Correctly tell | 5 | 83 |
| Incorrect | 1 | 17 |
| Total | 6 | 100 |

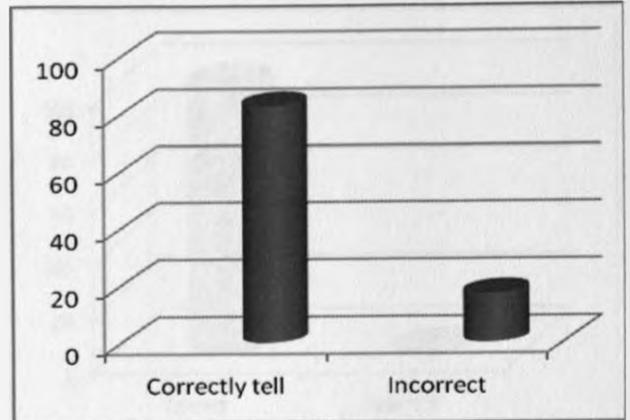


Fig. 4.24: Voices identification in the discussion

The above analysis indicates that none of the participants from group one were able to determine the number of persons in the discussion, while 83% from the second group were able to correctly identify. This can be explained as due to interference and mix-up of the voices of the panelists with voice from the screen reader for group one which was eliminated for participants in group two.

4.3.3.2 : Identification of Issue under discussion

Table 4.25: Group one- Issue identification

Group One

Identify Issue under discussion

| | Frequency | Percent |
|-----------|-----------|---------|
| Correct | 2 | 40 |
| Incorrect | 3 | 60 |
| Total | 5 | 100 |

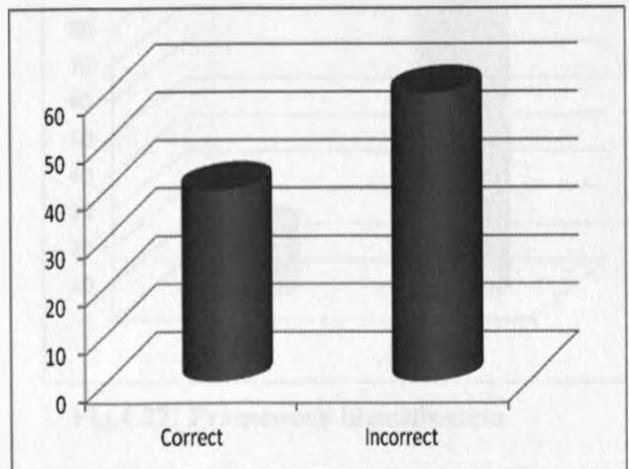


Fig.4.25: Issue identification in the discussion

Table 4.26: Group two- Issue identification

Group Two

Identify Issue under discussion

| | Frequency | Percent |
|-----------|-----------|---------|
| Correct | 6 | 100 |
| Incorrect | 0 | 0 |
| Total | 6 | 100 |

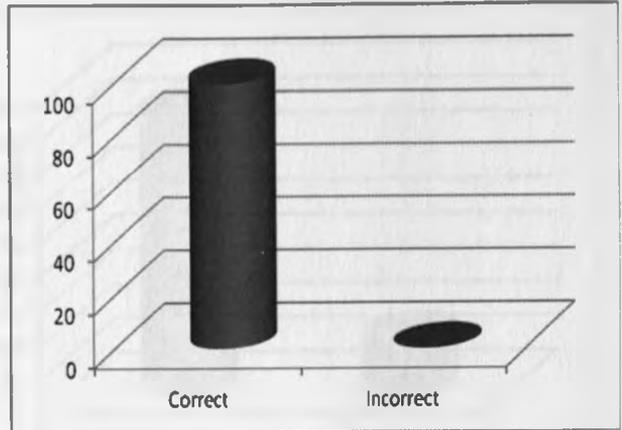


Fig. 4.26: Issue identification in the discussion

From this, 40% of group one participants could correctly tell the topic under discussion whereas 60% were not able to, as compared to all (100%) from group two who correctly identified the discussion topic. This is further due to non-comprehension of the proceedings of the discussion by group one due to the interference by voice from the screen reader.

4.3.3.3: Identification existence of legal framework in ICT

Table 4.27: Group one-Framework identification

Group One

Identify existence of legal framework in ICT

| | Frequency | Percent |
|-----------|-----------|---------|
| Correct | 1 | 20 |
| Incorrect | 4 | 80 |
| Total | 5 | 100 |

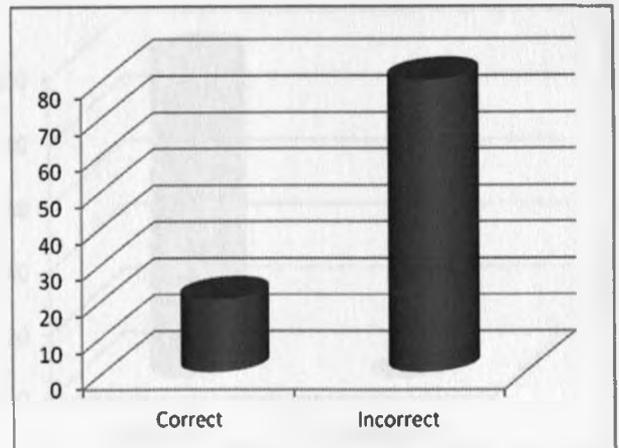


Fig.4.27: Framework identification

Table 4.28: Group two-Framework identification

Group Two

Identify existence of legal framework in ICT

| | Frequency | Percent |
|-----------|-----------|---------|
| Correct | 5 | 83 |
| Incorrect | 1 | 17 |
| Total | 6 | 100 |

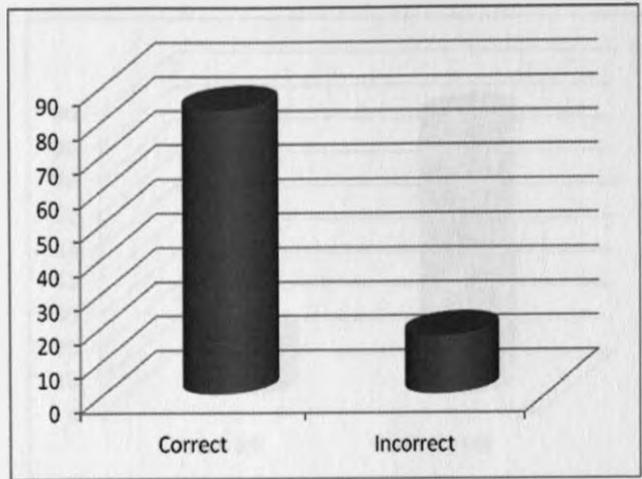


Fig.4.28: Framework identification in the discussion

This indicates that the discussion was not clear for group one participants since only 20% answered correctly compared to 83% from group two.

4.3.3.4: Identify roles of KIE towards ICT access to schools

Table 4.29: Group one- roles identification

Group One

Identify roles of KIE towards ICT access to schools

| | Frequency | Percent |
|----------------|-----------|---------|
| Cannot tell | 5 | 100 |
| Correctly tell | 0 | 0 |
| Total | 5 | 100 |

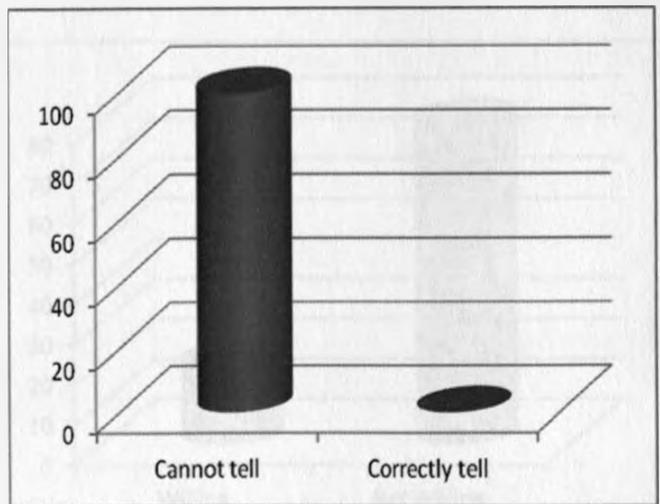


Fig. 4.29: Group one- roles identification

Table 4.30: Group two- roles identification

Group Two

Identify roles of KIE towards ICT access to schools

| | Frequency | Percent |
|----------------|-----------|---------|
| Cannot tell | 1 | 17 |
| Correctly tell | 5 | 83 |
| Total | 6 | 100 |

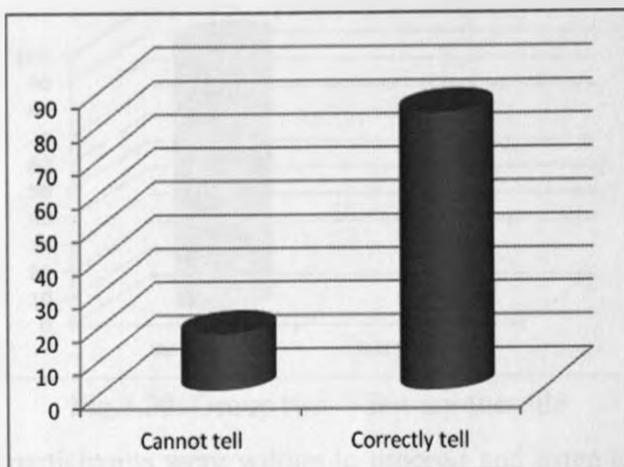


Fig. 4.29: Group two- roles identification

None of the participants from group one were able to correctly answer this question due to the screen reader's voice interfering with the clip's voice, while 83% of group two correctly answered it correctly.

4.3.3.5: Willingness to view another file

Table 4.31: Group one- View another file

Group One

Willingness to view another file

| | Frequency | Percent |
|-------------|-----------|---------|
| Willing | 1 | 20 |
| Not Willing | 4 | 80 |
| Total | 5 | 100 |

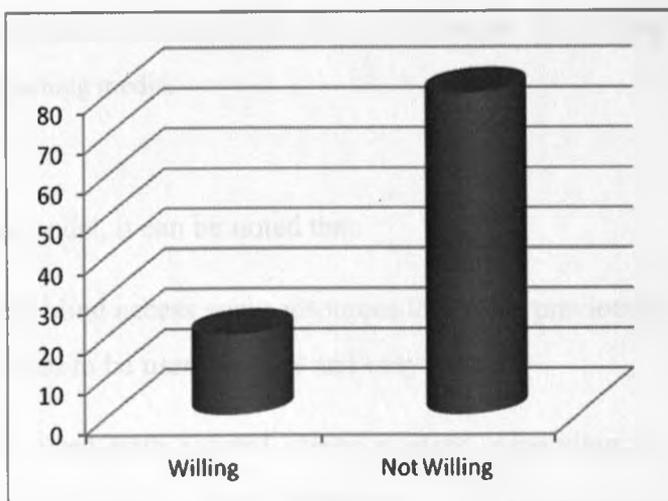


Fig. 4.30: Group one- View another file

Table 4.32: Group two- View another file

Group Two

Willingness to view another file

| | Frequency | Percent |
|-------------|-----------|---------|
| Willing | 6 | 100 |
| Not Willing | 0 | 0 |
| Total | 6 | 100 |

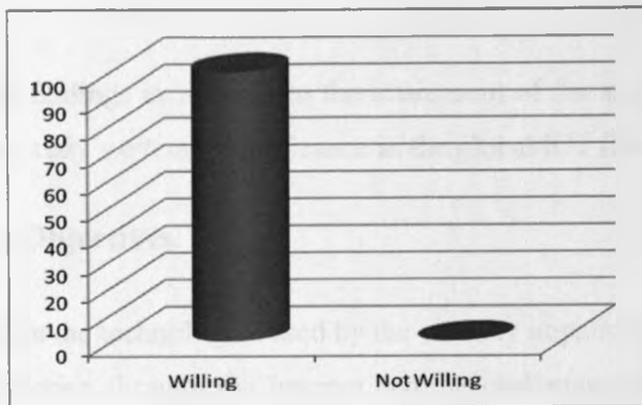


Fig.4.30: Group two- View another file

This analysis indicates that 20% of group one participants were willing to proceed and listen to another clip compared to all (100%) participants in group two. This can be explained due to the noise of the interference, lack of clarity experienced by group one participants, which was not experienced by group two participants hence the willingness to proceed and listen to another file.

From the above analysis, presence of the plug-in interface to control exiting the screen reader when not required, that is during times of accessing the multimedia files, and calling it when required is a useful resource for use by the blind since they are able to access streaming media without the interference from the screen reader and thus are able to advance in getting information through the Internet including streaming media.

4.4 Summary

Based on the analysis evaluating the designed model, it can be noted that;

- i. The interface model is able to assist the blind access some resources that were previously not accessible. Thus the model has proved to be user-friendly and easy to use.
- ii. The model is generic since it can be used with several screen readers, depending on which type one is using.

It is worth noting that the blind, like everybody else improves internet access through exposure, training and acquisition of relevant skills and knowledge. This is however limited to the already existing assistive technologies, thus the need to design and develop a model interface of extending the existing screen readers for the blind to access more resources through the Internet.

CHAPTER FIVE: DISCUSSION

5.1 Introduction

This focuses on discussing the results of the findings in relation to the attainment of the study objectives while taking into consideration the study's overall significance in the global ICT field.

5.2 Review of the achievement of Study Objectives.

5.2.1 Carrying out an investigation to find out the technologies used by the visually impaired in using computers and accessing information through the Internet and the challenges that they encounter.

The study together with the literature review indicated that the visually impaired, especially the blind are able to gain access to information provided through the Internet because of the availability of technologies which convert the information to audio media. This is possible through use of voice output technology referred to as screen readers. These produce synthesized voice output for text displayed on the computer screen, as well as for keystrokes entered on the keyboard.

Observations indicated that screen readers forced users to navigate pages in a serial way, which was not always appropriate for the design of the page. For example, pages with a large number of links are designed for quick scanning, but a screen reader will read out each link one by one which can be very difficult to remember, and users often have to go back and listen to all the links again in order to find (or not find) a suitable one.

Experienced users are able to overcome this by use of keystrokes which assists in the moving from heading to heading, listing of all linked lists, navigate through Web pages and identifying areas of interest, navigating and filling of Web forms, but this is not the case for all visually impaired users. This highlights the functionalities of the screen readers which are available and can be used by the visually impaired upon gaining of adequate training on their use. Despite these uses, the blind are also met with challenges which include access to streaming multimedia

files, which brings about interference with the speech from the screen reader, non-accessible content like images and graphs among others.

From the study's findings, we can deduce that;

- i. The blind are able to access and use computers and the Internet depending on their level of education, level of computing skills that they have, availability of Internet facilities, frequency and duration of use of these facilities. This is the same case as those who have visual capacity, where usage of computers and the Internet is dependent on the above highlighted factors. The significance of this was to identify their strengths while trying to evaluate the opportunities, at the same time trying to avoid re-inventing the wheel.
- ii. For the challenges that the blind encounter in their quest to advance technologically, the main ones were found to be access to information from images, charts and graphs, access to streaming multimedia file, challenge of not having the screen readers in local dialects among others. Some of these are unique to this group of users due to their lack of visual capacity. This was significant in providing a background of requirements by the visually impaired in those areas that little or no advancement has been done.

5.2.2 To design a model that facilitates un-interfered access to streaming audio from the Internet and other sources. This ensures there is minimal or no interference of multimedia files with speech from the screen readers.

To enhance the access of streaming multimedia files, the researcher resulted to the design of a model interface in the form of a plug-in. The design of the plug-in involved understanding that a screen reader by default is designed to be always running on machines used by the blind and thus the challenge of streaming multimedia files because there is only one physical volume control available in the typical user environment and therefore the users cannot control the volume of the multimedia content separately.

From the results of the design, a visually impaired user is able to access contents from the Internet using the screen reader normally and deactivate the screen reader application when he/she wants to access streaming multimedia content, and then activate it back using the plug-in

when required. The significance of this is that the visually impaired are able to increase the range of information that they can access, access unprecedented amounts of information that was previously unavailable and subsequently provide a social connection to the outside world through improved communicative abilities.

5.2.3 To develop and validate the model designed.

The purpose of the model interface is to activate the screen reader after closing during the period of accessing streaming audio files. The development of this model involves the development of a plug-in whose purpose is to launch the screen reader. A plug-in interface is a set of software components that adds specific abilities to a larger software application. After designing the model interface, it was developed and tested to confirm that it assists the blind and from the results obtained, it had conformed to its requirements.

Results from validation of the model were used to evaluate the interface's usability by the visually impaired, comparability of usage of the interface among various screen readers and a control test to confirm the results of two groups one using the interface and the other not using. This evaluation shows that the interface was found to be easy to use, user friendly and generally acceptable by the users. It was also confirmed to be generic and thus acceptable and usable by many users having various types of screen readers.

It was also deduced that the presence of the plug-in interface to control exiting the screen reader when not required, that is during times of accessing the multimedia files, and calling it when required is a useful resource for use by the blind since they are able to access streaming media without the interference from the screen reader and thus are able to advance in getting information through the Internet including streaming media.

5.3 Summary

From the above discussion of the analysis's findings, it can be noted that the field survey and the evaluations done are effective in confirming the essence of the study and especially the design, development and validation of the model interface towards necessitating widespread access and usage of computers by the visually impaired.

CHAPTER SIX: CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

Arising from the study's research, findings, analysis and discussion, there has been extension of the ICT facet and this can be summarized as follows;

- i. A plug-in interface used in a screen reader to control when to use a screen reader and when not to is suitable to facilitate access of streaming multimedia files without interference of speech from screen readers. Thus the blind will hence forth be able to access unprecedented amounts of information that was previously inaccessible while also effectively sharing information with the sighted.
- ii. The visually impaired are able to access Internet and other technological information provided they have adequate skills, knowledge and the right assistive technology. This will be significant to trainers and to all those who wish to assist the visually impaired since they know where to channel the support.
- iii. With the necessary resources, the visually impaired are able to function equally like their sighted counterparts, and thus the significance of the study to designers, manufacturers and service providers of various ICT products and services since they will be able to identify the best practices to ensure accessibility by the "niche" market.

6.2 Limitations of the research

While this study has produced valuable findings, it does, however, have certain limitations. These include;

- i. The absence of another means to access the streaming audio files without interference means that the blind were left with the option of comparing the designed model with the original practice of having interfered access or no access at all. The presence of another way of access would have made easier to compare two working models.
- ii. Lack of necessary assistive technologies to many blind persons because of the costs involved means that many of them have not fully mastered the workings of the screen

readers and thus the study was almost confined to those who had access to the technologies.

6.3 Recommendations for further research.

As highlighted in the discussion part of the study and evidenced by the research findings about the major challenges that the blind encounter in trying to access computers and information through the Internet, the following recommendations if researched would help reduce if not eliminate the challenges;

- i. Research to facilitate the visually impaired access information found in images, graphs and charts. This will not only be beneficial to the visually impaired but will also provide a good research area to the researchers due the extension of ability to access information by the visually impaired.
- ii. Research towards localization of speech from screen readers to local dialects and enabling flexible audio speed control. This will work towards better access to various types of information since all the screen readers evaluated were based on one language.
- iii. Research into ways that the screen readers can automatically stop their speech once streaming audio is sensed. This will be an extension of the current study of solving the interference of streaming multimedia files by voice from the screen readers, hence an easier way to access the files. This will provide an exciting area for any researcher to extend the research.

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Appendix I: The JavaScript code

```
<html>

<head>

<script>

function LaunchApp() {

if (!document.all) {

    alert ("This ActiveXObject is only available for Internet Explorer");

    return;

}

var ws = new ActiveXObject("WScript.Shell");

ws.Exec("C://Program Files//Text readers//jfw.exe");

}

</script>

</head>

<body>

<FORM name="Form1">

<INPUT TYPE="button"    onclick="LaunchApp()" value="CLICK TO OPEN SCREEN
READER" style="height: 600px; width: 1000px" />

</FORM>

</body>

</html>
```

Appendix II: SURVEY QUESTIONNAIRE FOR THE VISUALLY IMPAIRED

NOTES:

A

- Fill in your answers to all questions in the space provided.
- Do not indicate your name anywhere on the questionnaire
- There are no correct or incorrect responses.
- The questionnaire is divided into four (4) sections, each having an objective, please respond as requested.

Part One

Demographic information

Please provide some background information about yourself (Tick the appropriate answer with 'X').

- Age (yrs): Below 15 16-20 21-30 Over 30
- Nature of Visual Impairment - Congenital (From birth) Adventitious (Resultant)
- Level of Visual Impairment - Fully Impaired Partial impairment
- Level of education - High school College/University

Part Two

Review of Internet Experience

- Indicate your level of computer skills
Excellent Good Fair Poor None
- How frequently do you have access to a computer?
Always Frequently Occasionally Rarely Never
- How frequently you access the Internet
Daily Weekly Monthly Occasionally Never

(If Never in 3 above go to 4, else go to 5)

4. What is the reason for the non use of the Internet?

Lack of necessary skills/knowledge

Lack of necessary technology

Do not see the need to

5. How long have you been using the Internet?

More than 4yrs 2-3 yr 1 yr Less than 1yr Never

6. For what purpose have you been using the Internet?

Email Academic Entertainment All the above Never used

7. What assistive technology do you use to access the internet?

Screen reader Braille reader Special browser Other None

Specify _____

8. If you use a screen reader, which one are you familiar with?

9. Do you access the Internet sequentially line by line through a page or do you move to the section of interest?

Read sequentially

Move to the section of interest

10. To move to the section of interest immediately, what technology assists you?

11. What do you do if you feel you have lost your sense of direction while browsing the Internet?

Try to trace by reading the page features Ask for assistance

Go to previous page and retrace Close and restart the computer

Close the page and start again

12. Do you access the Internet using a special assistive browser?

Yes

No

13. If yes in above, please specify its name and description of how it assists.

14. Have you ever been distracted by features on a website, preventing you from accessing the page that you want to view?

Never Rarely Occasionally Frequently Always

15. How have you been able to overcome such distractions?

16. How easy is it locating where the hypertext links are on a web page?

Quite easy Partially easy Not easy With some assistance Not able

17. How easy it navigating from hyperlink to hyperlink or heading to heading?

Quite easy Partially easy Not easy With some assistance Not able

18. How easy is it locating the 'Search' function on a web page?

Quite easy Partially easy Not easy With some assistance Not able

19. How easy is it getting an item when performing a search on a web page?

Quite easy Partially easy Not easy With some assistance Not able

20. How easy is it navigating and filling web forms?

Quite easy Partially easy Not easy With some assistance Not able

21. How confident are you with online commercial transactions (e-commerce)

Quite Partially Not With some Not able
Confident Confident Confident Assistance

22. How easy is it accessing multimedia files, example YouTube media files?

Quite easy Partially easy Not easy With some assistance Not able

Part Three

Challenges/Barriers in Web Access

1. Are you comfortable using a keyboard and mouse when browsing the web?

Comfortable with both Comfortable with keyboard Comfortable with mouse With Assistance Not Able

2. How do you rate the screen reader (assistive technology) you use in being able to help you access the contents of a web site?

Excellent Good Fair Poor Very poor

3. What are the reasons for your answer above?

- i. _____
- ii. _____
- iii. _____
- iv. _____
- v. _____

4. What is your experience in accessing from the web, graphical, pictorial and embedded images?

Accessible Accessible but with difficulty Not Accessible

5. What is your experience in accessing from the web, multimedia files (streaming audio and video)?

Accessible Accessible but with difficulty Not Accessible

6. What is your experience in accessing from the web, Adobe PDF files?

Accessible Accessible but with difficulty Not Accessible

Part Four

Further Screen reader requirements

1. What features/ requirements would you like to be included in a screen reader to fully enable web access?

i. _____

ii. _____

iii. _____

iv. _____

v. _____

3. How long have you interacted/ assisted the visually impaired?

Over 10yrs 6-9 yrs 3-5 yrs 1-3 yrs Less than 1 yr

4. In what ways do you assist them?

i. _____

ii. _____

iii. _____

iv. _____

v. _____

5. From your experience with the visually impaired, how frequently do they access the Internet?

Daily Weekly Monthly Occasionally Never

6. For those that have never accessed the Internet, what is the major reason?

Lack of necessary skills/knowledge

Lack of necessary technology

Lack of motivation

7. For those that use the Internet, what purpose do they use it?

Email Academics Entertainment All the above

8. What assistive technology do they use to access the internet?

Screen reader Braille reader Special browser Other None

Specify _____

9. When assisting the visually impaired, are there cases when they are distracted by features on a website, preventing them from accessing the page that they want to view?

Never Rarely Occasionally Frequently Always

10. How are they able to overcome such distractions?

11. How easy is it for the visually impaired locating where the hypertext links are on a web page?
 Quite easy Partially easy Not easy With some assistance Not able
12. How easy is it for the visually impaired navigating from hyperlink to hyperlink or heading to heading?
 Quite easy Partially easy Not easy With some assistance Not able
13. How easy is it for the visually impaired locating the 'Search' function on a web page?
 Quite easy Partially easy Not easy With some assistance Not able
14. How easy is it for the visually impaired getting an item when performing a search on a web page?
 Quite easy Partially easy Not easy With some assistance Not able
15. How easy is it for the visually impaired navigating and filling web forms?
 Quite easy Partially easy Not easy With some assistance Not able
16. How confident are the visually impaired in handling online commercial transactions (e-commerce)?
 Quite Partially Not With some Not able
 Confident Confident Confident Assistance

Part Three

Challenges/Barriers in Web Access

1. In your interactions with the visually impaired, are they comfortable using a keyboard and mouse when browsing the web?
 Comfortable Comfortable Comfortable With Not Able
 with both with keyboard with mouse Assistance
2. How do you rate the screen reader (assistive technology) they use in accessing the contents of a web site?
 Excellent Good Fair Poor Very poor

3. What are the reasons for your answer above?

- i. _____
- ii. _____
- iii. _____
- iv. _____
- v. _____

4. What is your experience with the visually impaired, when they are trying to access from the web, graphical, pictorial and embedded images using a screen reader (assistive technology)?

Accessible Accessible but with difficulty Not Accessible

5. What is your experience with the visually impaired, when they are trying to access from the web, multimedia files (streaming audio and video)?

Accessible Accessible but with difficulty Not Accessible

6. What is your experience with the visually impaired, when they are trying to access from the web, Adobe PDF files?

Accessible Accessible but with difficulty Not Accessible

Part Four

Further Screen reader requirements

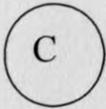
1. What features/ requirements would you like to be included in a screen reader to enable the visually impaired access the web adequately?

- i. _____
- ii. _____
- iii. _____
- iv. _____

Appendix IV: Observation guide

1. Observe how the users starts up the computers
2. Check how they are able to access computer information once they have started the computer.
3. Check the method of access items saved on the desktop and in documents.
4. Observe how they interact with the screen reader, whether it is always running or they have to start it up.
5. Check how they identify what to access and how they open files of interest.
6. Check on procedures to access the Internet, how to get the Web pages of interest and moving through Web pages.
7. Observe whether the users get any distractions or get lost when accessing Web pages.
8. Check how they are able to locate headings, links and how they perform search.
9. Check whether they are able to access graphical information and streaming multimedia files.

Appendix V: SURVEY QUESTIONNAIRE FOR USABILITY TESTS



NOTES:

- a. Fill in your answers to all questions in the space provided.
- b. Do not indicate your name anywhere on the questionnaire
- c. There are no correct or incorrect responses.

Performing usability Tests on the Model interface designed.

1. How well does the interface present of an elaborate way of accessing the required resource?

Excellent Good Fair Unsatisfactory

2. How consistent is the interface in achieving the objectives?

Excellent Good Fair Unsatisfactory

3. How well does the interface provide ability to get informative feedback from the system?

Excellent Good Fair Unsatisfactory

4. How useful is the designed interface in assisting the user to determine the successful completion of task?

Excellent Good Fair Unsatisfactory

5. Does the interface has the mechanism to detect, prevent and correct errors which would otherwise prevent objective achievement?

Excellent Good Fair Unsatisfactory

6. How well is the interface's design in reducing the users' memory overload?

Excellent Good Fair Unsatisfactory

Appendix VI: SURVEY QUESTIONNAIRE FORM FOR CONTROL TESTING

NOTES:

D

- a. Fill in your answers to all questions in the space provided.
- b. Do not indicate your name anywhere on the questionnaire
- c. There are no correct or incorrect responses.
- d. If you cannot derive the answer from the sampled media, indicate cannot tell.

Review of the model use by the visually impaired in accessing sample multimedia files.

(Kindly answer the following questions in reference the sampled multimedia file.)

1. How many voices could you identify in the discussion?

Two Three Four Cannot Tell

2. Can you identify the issue (s) under discussion?

.....
.....
.....

Cannot tell

3. Has there been a legal framework in the health sector in Kenya?

Yes No Cannot Tell

4. Has there been a legal framework for accessing computers and the Internet?

Yes No Cannot Tell

5. What are the roles of KIE in terms of computers access to schools?

.....
.....
.....

Cannot tell

6. How can the Internet be used to make money?

.....
.....
.....

Cannot tell

7. Is there willingness to access other multimedia files thereafter?

Yes

No

8. Reasons for answers above

.....
.....
.....