

# **Cognitive User-centred Design Approach to Improve Accessibility for Blind People during Online Interaction**

**Khulud AlJarallah**

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Faculty of Art Design & Humanities  
School of Design  
De Montfort University

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## **DECLARATION OF AUTHENTICITY**

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Khulud

15 July 2013

## ABSTRACT

The use of internet and other communication technology has become predominantly common in the life of normal sighted users. In order to have a fair level of equality in the society, blind people must also be able to use these facilities with equal ease and effectiveness. Many governments decided to implement e-Government applications to enhance the delivery of information and services to its citizens, residents and businesses. These e-Government applications were carefully designed with the help of international standards to serve the whole group of population and especially people with disabilities. However, recent studies showed that the acceptance rate of these e-Government applications among the community, especially between people with disability, is not up to the expectations. The aim of this research is to investigate the accessibility issues faced by blind people while interacting with online services like e-Government portals.

Owing to the nature of content and the importance of information which is to be delivered to the whole country, the accessibility standards of such portals are of paramount importance. It is this idea of evaluation of such websites for special category of blind people that has been the main focus of this thesis.

The main aim of this doctoral research is to discover any accessibility problems that could be faced by people with blind users during online interaction and not covered in accessibility standards. A real example of online interaction is the e-Government portals. This research followed a rigorous tri-staged evaluation process for a selected e-Government portal (Saudi Arabian portal) to analyse the accessibility issues faced by blind people. The aim of this evaluation process is to understand the cognition and perception of a blind user while interacting with a web-based environment. The first step of the evaluation process was to verify the level of adherence of the selected portal to the Web Content Accessibility Guidelines (WCAG). The second stage includes a detailed experimental exercise with a number of blind people following the task-

oriented approach. The third step of the evaluation process was a detailed interview with web designers to analyse the problems faced by blind participants in the experimental exercise. Thereafter, cognitive-based solutions were proposed to improve the accessibility of online interaction for blind users and fill the gap in the accessibility standards. The introduction of navigational landmarks and the insertion of virtual map description improve the navigation and hence the performance of blind users. The proposed solution has been tested with a separate group of blind users to validate the research findings and to ensure the desired level of accessibility of the e-Government portals is achieved.

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## List of Acronyms

<b>WCAG</b>	Web Content Analysis Guidelines
<b>HTML</b>	Hypertext Markup Modeling Language
<b>W3C</b>	World Wide Web Consortium
<b>GUI</b>	Graphical User Interface
<b>CSS</b>	Cascade Style Sheets

## List of Publications

- AlJarallah, K., Chen, R. C., & AlShathry, O. (2013). Cognitive-Based Approach for Assessing Accessibility of e-Government Websites. In Universal Access in Human-Computer Interaction. User and Context Diversity (pp. 547-554). Springer Berlin Heidelberg.
- AlJarallah, K.&Chen, R. C.,(2013). The effect of space representation on online interaction. International Journal of Technology and Human Interaction (IJTHI) (refereed)

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## CHAPTER 1

### INTRODUCTION

#### OBJECTIVES

- Introduce blindness and visual impairment concepts.
- Introduce accessibility and usability issues with web interaction for blind people
- Introduce the research problem and objectives.

#### 1.1 Introduction

It is believed that utilizing information and communication technology (ICT) tools will help improving the delivery of government services. The Governments worldwide have adopted the ICT means to deliver information and services to their citizens via e-Government portals. Thus it is of extreme importance that these e-Government portals are tailored to suit the needs and requirements of citizens from all groups to assure its success and effectiveness. A common and important group of any community is those who suffer from blindness. According to a report published by World Health Organization (WHO) in 2009, there exist more than 314 million blind or visually impaired people around the world; 39 million of them are totally blind (Visual impairment and blindness, 2012). Considering the increased population of blind people, a high degree of web accessibility is undoubtedly an important criterion to successfully implement an e-Government system. The efficiency and effectiveness of web based interaction for blind is still a critical issue while developing an e-Government system.



The prime reason for increased level of difficulties specifically for blind users is that a web page is an inherently complex resource since it simultaneously conveys multiple informational content and relationships among them, with links to other pages, advertisements, etc.

## **1.2 Problem Statement**

The process of web based interaction for blind users is far more complex and difficult as compared with their sighted counterparts. The literature review has revealed that blind users face increased level of difficulties because of inadequate access and poor usability of the available resources. Whilst the use of assistive technology devices and character based interfaces have offered an extraordinary possibility to blind people for utilizing their skills in using computers and other IT based resources, many visual features and the use of the computer mouse have caused their use of the valuable resources offered by the internet to become a difficult and cumbersome task. A high degree of accessibility and usability would have a tremendous impact on boosting their motivation towards using internet facilities. Blind users' access the internet and web based services in a way that is far different from their sighted counterparts. Sighted users rely on a mouse to navigate through a webpage; however blind users have keyboard shortcuts to browse through the same contents. Sighted users are accustomed to use the tab key to navigate from one link to another and to search within a page for keywords.

The assistive technology devices like screen readers have several options to navigate through a webpage, and it has been found that every individual has his or her own favourite techniques. Blas's research showed that there are always some variations between the blind users the thing that makes it difficult to understand how a web site should be in non-visual web interaction, and how this web site behaves in reality (Blas, 2004).

The inaccessibility and poor usability of e-Government websites is not only undesirable to everyone involved but it also creates additional complexities for blind users (Blas, 2004). As compared to their sighted counterparts, blind users on an average are half as likely to complete web based tasks or activities. This could severely hinder the very basic idea of having an effective e-Government system so that information exchange could be eased between the Government and its citizens. A common thought from several research papers emphasizes that graphical user interface (GUI) based applications are the core reason for poor accessibility and usability amongst blind users. The primary reason being that most of the assistive technologies are based on textual conversion (to audio or Braille) and thus fail to transmit the information embedded in graphical elements.

Conventionally the web designers assume that blind people are also typical users, except the fact that they perceive information non-visually. They forget to consider the different ways in which information would be conveyed to blind users and thus the user's cognition of the task to be performed remain isolated. The existing guidelines and laws force them to improve the human interface design which improves its accessibility but the usability of the service for blind users remain unaddressed. Thus it can be said that the most important factors to be considered while addressing the problems of accessibility with blind users are technical accessibility and the cognitive usability of web based interaction. Therefore an in depth understanding of web experiences of blind users is required in order to develop effective solutions to combat the accessibility and usability problems.

The typical constraints observed in many web experiences of blind users in non-visual web interaction have been identified as the following:

- a) The sequential nature of non-visual Web interaction forces the blind user to scan the whole page unlike their sighted counterparts who can do it more quickly and efficiently. This inability to quickly scan a web page also raises difficulty in locating exact required and relevant information (Blas, 2004). It also poses limitations on certain online activities that require significant online searches (like market research, etc.).
- b) It has been observed that the screen reader's feedback becomes ambiguous if the content layout on a web page is very complex. The accuracy of screen readers also has a significant influence as they have been found to mispronounce some words. These factors might increase confusion and hinder the information being conveyed.
- c) For the same amount of information to be read or understood, the process of hearing is far more tedious than visual perception. Thus the broad range functionality of a screen reader increases complexity in the process of understanding and ease of use. This distinct feature of a screen reader also interferes with the use the appropriate functions and commands during the Web based interaction.
- d) The cognitive process during a Web based interaction consists of understanding the website, the web browser and the screen-reader simultaneously which is expected to create excessive cognitive overloading leading to increased level of stress or mental fatigue.

### **1.3 Aims and objectives**

The main aim of this research is to propose a cognitive-based solution for the problems faced by blind people during online interaction, whereby their needs are firstly understood, fulfilled and satisfied. The Saudi eGovernment portal is adopted in this research as a case study of online interaction environment.

This aim leads to the followings objectives:

- 1- To review the current accessibility problems faced by blind people while interacting with the Saudi eGovernment portal.
- 2- To present contextually-situated, observational and experiential-based explanation to the way blind interact with the Saudi eGovernment portal. .
- 3- To propose a cognitive and mental model-based navigational land marks to improve the Saudi eGovernment portal's accessibility for blind users.
- 4- To evaluate and test the proposed model on a set of blind users and to identify the level of improvement.

### **1.4 Research problems and research questions**

The main goal of an e-Government system is to allow universal access to its information and services on the web to its users. Users are the whole group of population including people with disabilities, no matter how severe it is, e.g. blindness, impaired vision, deafness, physical disabilities or any other cognitive disabilities. It is also required that the information is fully accessible by assistive technology to allow people with disability to get a complete understanding of the information or services offered and hence allowing a satisfactory level of interaction with the website wherever necessary.

The literature review has revealed that in spite of the abundance of accessibility standards and in spite of complete adherence to such standards by web designers, there still exists a lack of acceptance and inaccessibility among users. Some governments have invested in e-Government initiatives; however, the relative acceptance and success rate is yet to meet their expectations especially among people with disabilities. The literature published till date, does not fully take into account the detailed reasons and effective solutions to the problem of accessibility faced by blind users which led to such non-acceptance.

The W3C Web Content Accessibility Guidelines (WCAG) guidelines do specify various technical standards for web content designers and developers but they just focus towards developing sound “technical readability”. However from the literature review, it has been found that the “usable accessibility” of a website or any other web based resource is often neglected, which is of paramount importance to ensure an effective user experience

The e-Government endeavour of serving its citizens, partners, and government employees is critically dependent on the accessibility and usability of its integral websites to the intended target users. The literature review has suggested that the most important issue for making e-Government systems accessible is to make text equivalents for non-text items such as images and multimedia files, available. The text equivalent gains its importance because blind users can successfully use assistive technology to exploit web based resources.

The process of web based interaction for blind users is far more complex and difficult as compared with their sighted counterparts. In medical terms, the process of web based interaction can be subdivided into the basic sequential activities namely perception,

cognition, and action. The biggest problem caused by this lack of accessibility and usability is that it forces the user to spend much more time with additional physical and mental effort than their sighted counterparts. Thus in order to get an accurate assessment of e-Government websites' accessibility and usability it is imperative to have a clear and in depth understanding of the cognitive processes (perception, cognition, and action) involved under such challenging situations (Norman, 1987).

Addressing the role of perception, cognition, and action in non-visual Web based interaction could be extremely helpful in countering the challenges and bridging the gap between blind users and their sighted counterparts. It is of paramount importance that the accessibility and usability of e-Government websites is examined and evaluated accurately by using appropriate evaluation methods, accessibility guidelines and analysis tools. Moreover, many websites tend to use excessive visual effects that are often not related to the main content. Such contents when not required can be easily ignored by sighted users, but it tends to create increased levels of complexities and obstacles for blind users.

This unique characteristics and behaviour of blind users also puts the overall results and findings of the existing research work into question. Thus a close examination is required of this unique characteristic along with their detailed perceptions, actions, and cognitions during the web based interaction process to accurately examine the problem and find out an optimum solution.

Thus the research questions that remain unanswered are the following:

Q.1) Are e-Government websites in full compliance with the WCAG Guidelines (Web Content Accessibility Guidelines)?

Q.2) Does a WCAG compliant e-Government website satisfies the requirements of blind people? Does it result in an effective and efficient web based experience for blind users?

Q.3) What is the nature of accessibility problems faced by blind users while using the e-Government website?

Q.4) Are the blind users satisfied and motivated enough with the services and facilities of e-Government website?

Q.5) Are the web designers and web developers able to understand the problems and difficulties faced by blind users?

## 1.5 Thesis Structure

The thesis is structured as follows:

**Chapter 2** presents critical review to the literature of accessibility problems in e-Government context and an overview of accessibility standards and guidelines. It also highlights the bounded reality theory the concept of mental models followed in this research.

**Chapter 3** outlines the research methodology followed to undertake this research and the reasons for adopting such methodology in this research.

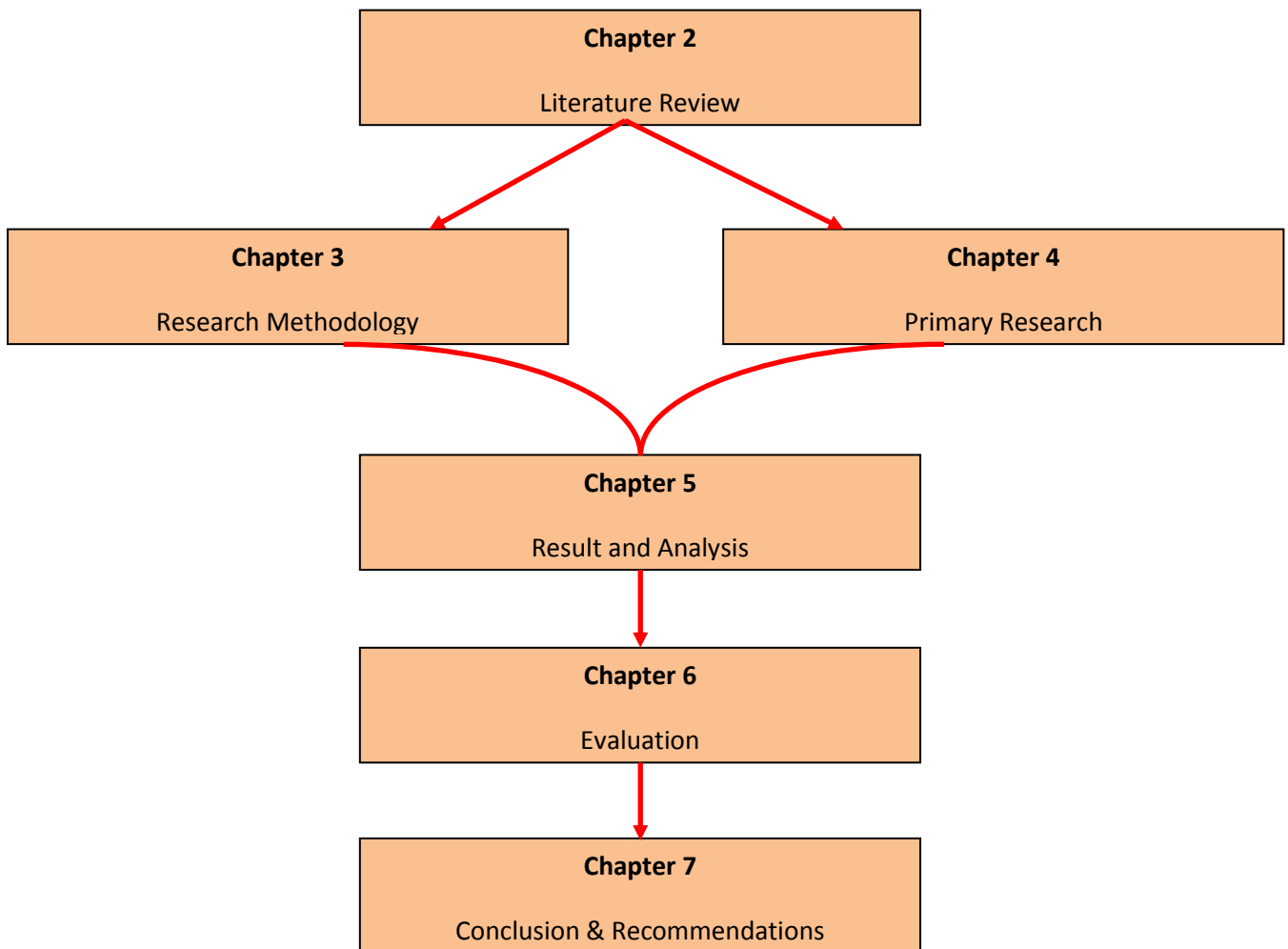
**Chapter 4** describes the specification of the experimental exercise and the sampling technique followed.

**Chapter 5** presents the result and the analysis of the primary study activities demonstrated in chapter 4, and proposes solutions based on the data analysis.

**Chapter 6** In this chapter, a portal was designed to evaluate the proposed mental model of online accessibility. A new experiment was conducted to serve this purpose.

**Chapter 7** Concludes and summarize the proposed work in this research. It also highlights the research limitations and gives suggestions for future research.

An overview of the dependencies between the chapters is depicted in Figure 2.



**Figure 1: Chapters dependency structure**



## CHAPTER 2

### LITERATURE REVIEW

#### OBJECTIVES

- Review existing literature on visual blindness and accessibility issues in online interaction.
- Outlines the goals of e-Government systems as a type of online interaction.
- Review existing standards and guidelines applicable on e-Government websites.
- Discuss the cognitive theory and problem solving process for online users.

#### 2.1 Visual Blindness

The term blindness is the condition of lacking visual perception due to physiological or neurological factors. In medical terms vision is a result of light beams hitting the eye retina and gets transmitted to the human's brain. Thus blindness happens either when an insufficient amount of light hits or fails to hit the retina, or when the details from retina failed to reach the brain correctly. According to World Health Organization (WHO), blindness in the normal eye with the normal symptoms; can be defined as a visual keenness of less than 3/60 (20/200, 0.05), whereas vision impairment is measured from less than 6/18 (20/50, 0.3).

The degree of blindness is the extent of this lack of visual perception. Whilst blindness includes different levels of vision ability, it can be broadly subdivided into four

categories of impairment namely partially sighted, low vision, legally blind, and totally blind.

Based on a report published by World Health Organization (WHO) in 2009, there exist more than 314 M. blind and visually impaired persons around the world (Visual impairment and blindness, 2012). A survey has revealed that globally there are approximately 38 million persons who suffer from blindness and 110 million people have impaired vision and are at great risk of becoming completely blind. The most common types of blindness found in this country are refractive errors, cataracts and glaucoma. Amongst these, cataract is the most significant type of blindness affecting both males and females. According to WHO estimates, cataract is also the most common reason of blindness around the world. About 47.9% of world's blind and visually impaired population suffer from this kind of impairment.

#### **2.1.1 Blindness in Saudi Arabia**

Saudi Arabia has a population of nearly 27.4 million (World Development Indicators, 2012). According to a report by Saudi-Medicare association, the country has about 160,000 people who are totally blind and 500,000 people who are visually impaired. However more than one million citizens in the country suffers from at least one form of optical defect. Currently, the prevalence of blindness in the country is observed to be between 0.6% and 0.7%, which is expected to double by 2020 (International Agency for the Prevention of Blindness, 2010). A survey shows that there are approximately one in five who suffer from visual problem are totally blind. The group of visually impaired people still have abilities to sense light and shape. However the level of this visual impairment may vary from one person to another depending on lighting conditions and from time to time. These symptoms may be stable or it could develop to a complete loss of vision abilities. Cataract, glaucoma and trachoma are the most common causes of blindness and visual impairment affecting both males and females. Amongst elderly population, it has also been revealed that 20% of the whole

population who are 60 years aged or older suffered from blindness. The data certainly proves that blindness and visual impairment are two of the main health concerns in Saudi Arabia.

## **2.2 Blindness and Online Interaction**

The process of web based interaction for blind people is entirely different from that of sighted users (AlJarallah, Chen, & AlShathry, 2013). The interaction with online resources for blind people is a listening activity. They need a specific strategy and assistive devices to access online information. Blind people predominantly depends on special computer software tools, known as assistive technologies, like online screen-readers, text to speech tools, or text based web pages to read web contents and to interact with computers properly. Assistive technologies use add-on assistive software to transparently provide an existing system with specialized input and output capabilities. Blind people use assistive technology and haptic devices that incorporate some specialist software and/ or hardware which help these users overcome their disability. Screen readers are specially designed software applications that identify, interpret and announce the text content of a web page in the form of sound or a Braille output device. Screen readers are often a combination of a hardware device and a software package which help blind users in navigating the web content (as shown in Figure 2).



**Figure 2: Screen reader (Educational technology and people with special needs)**  
**Source: (Di Blas, 2004).**

Although screen readers being extremely sophisticated applications feature innumerable key commands for various operations, but only a handful of these are normally known to most of the users (Theofanos, 2003). These methods of non-visual interaction have a major disadvantage of giving serial access to information unlike the instant access from normal visual interaction. Thus blind people would take longer to interpret the contents on a web page. It is this nature of non-visual interaction, employing a distinct information access mechanism which makes the accessibility and usability a distinct feature for blind people in web interaction.

A very common perception of adapting a design to suit the requirements of disabled users is the concept of enabling such a group of computer users to utilise assistive

technology to compensate their inability of accessing website content. But very unfortunately that is not completely true for blind users. Blind users face increased level of difficulties because of inadequate access and poor accessibility of the available resources (Abanumy A. , 2005) (Yu, 2004). The root cause of this increased level of difficulties for blind users is the fact that recent advancements have made web pages an inherently complex resource conveying multiple informational content and inter-relationships among them. The efficiency and effectiveness of web based interaction for blind is indeed a critical issue while developing an e-Government system. The prime reason for the increased level of difficulties specifically for blind users is that a web page is an inherently complex resource since it simultaneously conveys multiple informational details and relations among these details, with links to other pages, advertisements etc (Jokela, 2000). Moreover modern web based applications tend to use excessive visual content for instance pictures, graphics or tables in order to make it more attractive. For normal sighted users it is very easy to locate the core information on complex web page but blind users have to verify all the information on a webpage in order to identify the required and/or relevant information. Thus it is of extreme importance that the e-Government's websites are tailored to suit the needs and requirements of people from all groups. The blind people must also be able to use the information and services with an equal degree of ease and comfort as compared to the normal sighted users (Abdelbaset Rabaiah, 2009). The existing literature does identify the lack of accessibility levels required in a non-visual online interaction (Henry, 2006) (Loiacono & McCoy, 2004). However it does not point out the diversity and types of problems faced by blind people. The main focus of this research is towards those users who are completely blind and who rely on screen reader to read web contents.

### 2.3 e-Government services

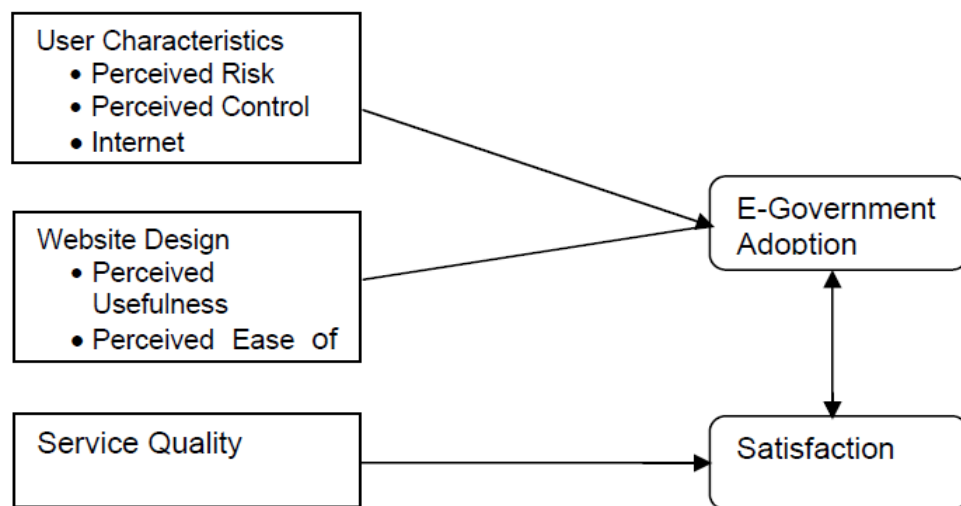
In recent years, the use of the internet has become increasingly popular for information exchange services. Internet is also the easiest and cost-effective channel for providing government products and services to its citizens (Abanumy A. N.-B., 2003) (Kumar, Mukerji, Butt, & Persaud, 2007). Governments worldwide have also adopted electronic means to deliver information and services to their citizens in order to offer an easily accessible expanded view of national services to their citizens in a proven, streamlined and cost effective way (Collinge, 2003). It is believed that utilizing information and communication technology (ICT) tools will help improving the delivery of government services. The term that is used to describe such a process is called e-Government. The term 'e-Government' has been defined by many experts in several ways (Al-Khourri, 2011). According to Carter "e-Government is the use of information technology is to enable and improve the efficiency with which government services are provided to citizens, employees, businesses and agencies" (Carter, 2008).

Heeks defines e-Government as the reliance on information technology (IT) by organizations in the public sector (Heeks., 2006). According to Jeong 'e-Government (also known as electronic government, e- government, online government, digital government, or connected government) is digital interaction between a government and its citizens (G2C), government and employees (G2E), government and businesses/ commerce (G2B), and also between government and governments /agencies (G2G)' (Hai, 2007).

A report published by The Department of Economic and Social Affairs in United Nations titled "United Nations E-Government Survey 2010" defined e-Government as "the employment of the Internet and the world-wide-web for delivering government information and services to the citizens" (Abanumy A. N.-B., 2004).

Based on the foregoing definitions of e-Governments, a general definition can be drawn which is the delivery of governmental services to citizens and business partners through the use of information technology tools and infrastructure (Alhomod & Shafi, 2012).

The concept of e-Government is not only to implement a suitable IT infrastructure, but it also includes a major re-engineering process to the current public systems to make them conform to the e-Government initiatives (Zahir Irani, 2006). Figure 3 shows a common model of the e-Government system and the aspects related to it.



**Figure 3: Conceptual model of e-Government adoption (Kumar, Mukerji, Butt, & Persaud, 2007)**

There also exists a concept of non-internet based e-Government systems using technologies such as telephone, fax, MMS, SMS, wireless networks and services such as Bluetooth, intelligent navigation systems, human biometric devices, road traffic systems, smart cards and other communication applications (Millard, 2002).

### 2.3.1 Importance of e-Government services

The most important feature of e-Government is that its implementation is believed to help improve the efficiency of delivering government services, optimize time, effort and government resources and enhance the productivity and interaction between citizens, employees, businesses along with the various other government sectors (Christensen, 2000).

It also allows the establishment of a systematic and transparent government to its citizens by informing them about both the current practices and the future policies that the government is working on, which otherwise is very difficult and impractical. Furthermore it reduces the red tape by implementing simple tasks such as changing address, marital status, etc. to be performed through electronic government system which saves both people's time and government employee's workload. It also increases voter awareness among the public and provides easy access to the most recent information to businesses, without the need to spend extra time, effort and money (Heeks, 2006).

Another distinct advantage of e-Government is that it leads to a greater degree of citizen's participation in political and public issues by using various internet channels like blogging, interactive surveys, forums and chat rooms to make their voices heard. In some cases citizens could also have the facility of having a real time chat with the elected officials or other public servants on certain issues. Theoretically this could be a perfect move towards creating a true democratic government (Al-Badi, 2003).

The implementation of e-Government makes the administrative tasks flexible to citizens, businesses as well as the public servants themselves. Needless to say that e-Government is far fast, efficient and convenient than the conventional system. A special advantage is for people with disabilities who no longer have to be mobile and can access all the information from home. It also allows individual citizens, foreign visitors



and investors to have a quick look through various government departments and agencies. In short the concept of e-Government provides huge support and growth prospective to both the government as well as its citizens and has been widely used by all developed economies (Boldyreff, 2002). Launching e-Government services helps in making the services available within the government organization to become available online (ECEG 2007 - 7th European conference on e-Government, 2007). In other words the website would be designed to ensure online availability of these services so that users can access and use them (Z. Al-adawi, 2005). Along the general benefits of e-Government discussed earlier, there are also some additional benefits of relying on websites and other forms of web based communication, as a mean of delivering e-Government services (Yu, 2004).

These benefits are as follows:

- 1) Increased efficiency

One of the major reasons that drive governments to shift to e-Government systems is the increased efficiency. The efficiency will not just improve the services delivered to the people and society but also within the governmental departments. On-line transactions will help reduce the overload and optimise the effort given to the paperwork (Ndou, 2004).

- 2) Service improvement

The services delivered to the e-Government users will be improved in terms of the time reduction and the day to day inquiries that can be answered and dealt with. The workforce that was recruited to deal with the usual paper works can be utilized in more critical areas within the organization as the e-Government will handle services electronically (Kumar, Mukerji, Butt, & Persaud, 2007).

### 3) Transparency

An e-Government website will help increase the transparency level within the organization. The user can track and review its application easily. The organization policies can be made available to the users (J.C. Bertot, 2008).

### 4) Promoting the information technology society

The users of e-Government websites need to get the required skills in IT and computer in order to interact with it. This would help reduce the computer illiteracy from the society and increase the awareness of new technologies (D. Gilbert, 2004).

## 2.3.2 e-Government success issues

Despite the fact that e-Government as a term is widely accepted and used, there are some obstacles in its implementations. Factors that contribute to these difficulties can be political, economical, etc., which impact the required result of e-Government systems. Depending on this fact, the United Nations (UN) produced a list that describes the e-Governments readiness level based on an empirical assessment of 192 countries (Morris, 2009).

One of the main obstacles in the implementation of e-Government applications is the inaccessibility of technology to the public (Blakemor, 2006) (Abanumy A, 2005). In many countries there exists a huge degree of inequality among its citizens towards the knowledge and access to internet based applications. The issue of inaccessibility is mainly related to the users who are either remotely located or have low literacy levels or exist on poverty line incomes. There are also concerns about vulnerability to cyber-attacks and hyper-surveillance of the citizens. There are also some psychological and cultural factors involved due to which citizens just do not want to use internet facilities for contacting the government (Ebrahim, 2003).

There have been also many critics against the lack of user involvement in designing and establishing e-Government services (Summermatter, 2007). Many researchers have suggested that most of the e-Government initiatives implemented are based on what technology can do, rather than what the user needs (WE Ebbers, 2008). The e-Government system is like any information systems which should follow a suitable development life cycle for its development. The main step of any development cycle is the creation of specification document which holds all the functionalities of the intended system to be built as stated by its users and stakeholders (Jaeger, 2009). In the context of G2C e-Government website the main users are mainly the citizens who will interact with that website to accomplish their services. Therefore, the recent trend of e-Government evaluation and implementation models regards customers or the users as the corner stone for its successfulness and acceptance (Toasaki, 2003).

### **2.3.3 e-Government perspectives in Saudi Arabia**

As this research takes the e-Government portal in Saudi Arabia as a case study for investigating the accessibility issues in online interaction, I give a short overview about this country and the current status of e-Government implementation there. The Kingdom of Saudi Arabia is located at the southwest of Asia. It represents the largest Arab country in the Middle East region. According to the national Census in 2011, Saudi Arabia population was 27,000,000 (Abanumy A. , 2005).

Over the last decade, there has been a growing awareness of IT tools and practices among Saudi citizens. The number of Internet users jumped to around 40% of the total population. With regard to the e-Government services, the Kingdom of Saudi Arabia has invested a substantial amount of its budget to improve the ICT infrastructure. The infrastructure is not restricted to the telecommunication and Internet services only, but

also encompasses all the activities that ensure the awareness of using IT services among citizens. The e-Government system in Saudi Arabia was launched as the country took an initiative of moving forward to the information century. The kingdom had set up a national information technology plan focused on information and communication technology (ICT) as a tool to reform existing government organizations and achieve organizational success. The government's plan focuses on improving IT infrastructures towards e-Learning, e-Government and e-Health, aimed at improving productivity at a low cost, setting up guidelines and standards for a national network and preserving society's characteristics in a digital age (Alhomod & Shafi, 2012).

The government of Saudi Arabia has been working on bringing a major transition to their e-Government system. The government has launched an enormous project for implementing e-Government services throughout the Kingdom. It established a web presence for most of its public sectors ministries and departments to start delivering the governmental services electronically. This helped to enhance the services of government agencies and improve the internal progress of the government organizations (Atallah, 2001). The National Information Technology Plan (NITP) launched in 2001 had a number of initiatives aimed at improving ICT and telecommunication infrastructure in the Kingdom of Saudi Arabia. It was focused to reform public organizations and to make the delivery of government services to its citizens easy and fast. Several measures were taken in order to meet the objectives like upgrading existing information technology (IT) infrastructure, improving e-learning systems, e-health facilities, increasing productivity, building up standards and best practices for IT network services, implementing international security framework and maintain the society's data in the new digital age.

Acting towards improving existing IT infrastructure, the government has begun to privatise the telecommunication sector. This step hastened Internet and mobile penetration in the country. The results from a study published by Internet Service Unit showed that the number of internet users increased from 820,000 in 2003 to 6,467,000

users in 2011 (Abanumy A. N., 2003). The statistics show that successful implementation of an e-Government system would certainly meet its defined objectives. Realizing the importance of ICT to improve communication and services delivery to its citizens and businesses, the government of Saudi Arabia launched a new national information technology plan in 2004. The plan was a part of country's national information technology plan, concentrated on using ICT as a driver for public organizations reform (Abdullah AL-Shehry, 2006) (Alhomod & Shafi, 2012).

#### **2.3.4 Constraints for full adoption**

Although the majority of the Saudi government divisions have their official websites; most of these websites are ineffectively designed which made them inaccessible to common people. A report suggests that the e-Government system needs some major reforms in terms of increasing awareness amongst citizens and employees and increasing the availability of internet access across the full spectrum of society (Abanumy A, 2005). Another study advocate boosting internet usage at public facilities, ratifying a legal framework for securing e-transactions and coordinating with financial institutions and private firms to establish electronic fund transfers (BURAGGA, 2010). It also suggested providing suitable IT training to government employees and finally, fostering a two way communication between the government agencies and the public (BURAGGA, 2010). The government has always been active in developing welfare reforms for disabled people, giving them equal opportunities and facilities. The government follows 'AAAQ' concept which stands for 'availability, accessibility, acceptability and quality' to achieve the highest attainable standard of health. The concern for disabled people especially blind ones has been equally important while developing the national information technology plan (Abanumy A. N.-B., 2003).

### 2.3.5 Implementing e-Government through web Development

The government of Saudi Arabia decided to implement the e-Government applications to improve the information and services delivery to its citizens and businesses. The role of information and communication technology (ICT) to successfully initiate an e-Government system is very critical. It aims to establish an effective and efficient way to deliver the information and services to its citizens and business. The implementation of e-Government system could be broadly divided into five sub-categories:

#### 1) Web Presence

At the first stage, government demonstrates and disseminates information about their products, services and policies which have to be made accessible on the website.

#### 2) Enhanced Presence

Enhanced presence includes an improved version of the web presence stage where more information and services are given. Downloaded documents are made available to the e-Government website users. More website features are also provided where users can search, ask for help and explore the website through its site map.

#### 3) Interactive Presence

The content of the e-Government website at this stage is provided with some dynamic interaction so as to attract the website users. Downloadable forms and initial online application for e-Government services are also available.

#### 4) Transactional Presence

In the stage of transactional presence, users of the e-government website can make transactional and authentication processes (Deloitte Consulting, 2000). Usually these

kinds of e-Governmental websites implement high security standards which ensure the confidentiality of the documents and information given and sent to the user (K. Layne, 2001).

#### 5) Fully Integrated Web Presence

In the fully integrated stage, the e-Government website should be equipped with all the services that serve the needs and requirements of its citizens and businesses. A more dynamic interaction is also provided where users can fill in forms, vote on decisions, etc (Moon, 2002).

### **2.3.6 m-Government: An extension of e-Government system**

m-Government, sometimes referred to as mobile government, is the extension of the existing e-Government system to wireless mobile platforms. It's a strategic use of government services and applications using cellular telephones, mobiles, laptop, computers, personal digital assistants (PDAs) and wireless internet infrastructure. The implementation of an m-Government system is expected to further amplify the effects of e-Government system in terms of flexibility and availability (Abanumy & Mayhew, 2005). However; the use of m-Government facilities has some serious issues to be dealt with. Firstly with regards to data protection and consumer identification, wireless networks and mobile devices are more vulnerable and easy to be hacked because they use public airwaves to send signals. Secondly the government needs to offer the information and services in alternative forms in order to increase its usability. m-Government applications also require a higher level of computer literacy and a well-established wireless and related IT infrastructure (Ghyasi, 2004).

Particularly in Saudi Arabia, it is of extreme importance that the development of an electronic framework government initiative duly takes mobile technology into account, primarily because of the high mobile phone penetration rates in the society. Whilst the country has seen a steady growth in the number of landline phones and internet subscribers, the number of mobile phone users and its penetration rates are skyrocketing. Mobile technologies not only create new channels of communication, but also help significantly in improving the accessibility and usability of government's resources and information (Kushchu, 2003).

## **2.4 Accessibility and Usability**

Accessibility and usability sound similar and coherent, but are clearly two distinct concepts. Accessibility is to measure whether the information or resource can be accessed by the whole targeted population, and usability is the degree of ease to which an information or resource could be used. In the context of e-Government system, web accessibility and usability are the two most crucial requirements for its successful implementation.

Accessibility refers to access by all individuals, regardless of technological or physical discrimination. The Web Accessibility Initiative (WAI) has described the term "Web Accessibility" as "people with disabilities can use, in terms of being able to perceive, understand, navigate and interact, with the Web" (Henry, 2006). Accessibility for web based interaction with blind users refers to making the content perceivable, operable, understandable, robust and easy to navigate and interact with. It is treated as a technical



construct that allows the use of assistive technologies such as screen readers etc., in order to give necessary access to interface elements of a system.

A good degree of perceivability in web based interaction can be achieved by making alternatives such as providing text captions for images and audio, adaptability of webpage layout, and suitable colour contrast (Katz-Haas, 1998). The web based interaction can be made more efficient by taking into account issues like keyboard use, colour contrast, timing required for input and more importantly navigability feature through the website.

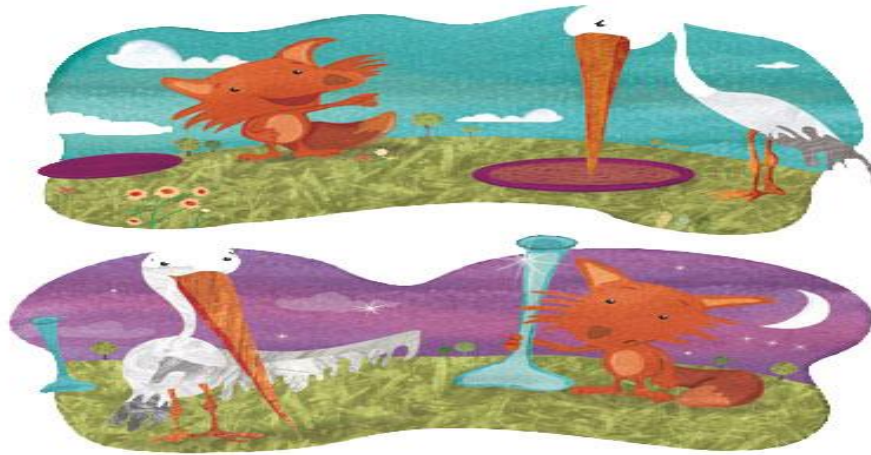
This is particularly important for blind users in order to make their experience more productive and satisfactory. The content on a modern website is often arranged with a high degree of complexity and use of visual effects. Thus it is of paramount importance that the content on a website is clear and easily understandable. This can be achieved by addressing issues such as readability, predictability, and input assistance for the required information (Tractinsky, 2004).

The role of usability starts at a point where the role of accessibility ends. Once the designed system or program is easily accessible, usability ensures that the users can use it both efficiently and effectively. The international standard of software quality, ISO/IEC 9126-1 describes usability as “The capability of the software product to be understood, learned, used and attractive to the user, when used under specified conditions” (ISO 9126-1 Software engineering-Product quality- Part 1: Quality Model, 2000).

A good degree of usability is specifically important while designing websites. These days there are multiple websites that offer the same service. Thus, in order to maintain competitiveness, it is important to ensure a high degree of user satisfaction. In simple terms, usability is the ease with which a system or program can be used. It refers to how fully a program or a system conforms to the users' perception of performing an activity (Goodhue D. L., 1986).

The interaction between a person and the system is affected by several key considerations such as the ease of learning, ease of memorization, error tapping and efficiency of use. Usability for web based interaction with blind users is not just limited to getting the information on the webpage, but also the blind users should be able to use all other features and functions such as links, buttons and form controls.

A system that is not accessible to users is certainly not usable too; however a well-designed accessible system also does not guarantee usability. The problem of inaccessibility would prevent access to features and functionality of a web based application. However usability would hinder the use of these features and functionality. In order to give better understanding of concepts of accessibility and usability, the fable is described in the next paragraph. A clear distinction between the two concepts can be best described by the most famous Aesop's Fables, 'The Fox and the Stork', also known as 'The Fox and the Crane' credited to a slave and story-teller named "Aesop" believed to have lived in ancient Greece between 620 and 560 BCE. The picture story is depicted in Figure 4 .



**Figure 4: The Fox and the Crane Anecdote to differentiate between accessibility and usability problems**

Once upon a time a fox and a crane were very close friends. On good terms, fox invited her to his house for dinner. The next day crane went to his house happily expecting to have a good meal. Fox welcomed her to the house and said that he had prepared a delicious soup for the dinner. Being cunning in nature, fox served the soup in broad flat bowl with which the crane could only wet the end of her long beak. The crane returned to her home hungry and unsatisfied and the shrewd fox felt extremely amused. After a couple of days the crane also invited fox to her home for dinner. They fixed a day and time and the crane welcomed the fox whole-heartedly to her house. Fox sat around the table waiting for dinner and the crane brought fresh prepared soup in a long-necked jar with a very narrow mouth, in which the Fox could not insert his large snout. The crane enjoyed eating the soup with great taste but all fox could manage to do was to lick the spilled soup of the jar and returned home hungry. The fox faced a typical accessibility problem as he cannot reach the soup served in the narrow-necked vessel. The crane faces a usability problem as she cannot drink the soup in spite of having access to it as it is served in a bowl. The situations of the fox and the crane can be directly compared. The key principle of web accessibility and usability for web based

interaction is that the system is effective and flexible to meet needs, preferences, and situations of varied user groups.

The accessibility of web based interaction primarily refers to the degree to which the information could be conveyed to all its users and automatic tools (Boldyreff, 2002). The development of an effective user-system interaction for internet users requires both technical accessibility and cognitive usability (Norman, 2002). The good degree of accessibility and usability entails ensuring that the websites are user-friendly in nature. This includes readability, browser independence, content layout, choice of colour, as well as considering the requirements of those who use assistive or adaptive technology or haptic devices.

#### **2.4.1 The concept of universal design**

Universal design is an underlying principle, first thought by an architect 'Ronald L. Mace' who himself was a wheelchair user and referred it as a design concept guides the production process of buildings, physical products and environments that are implicitly accessible to both people without disabilities and those with disabilities (College of Design, 2012). The main interest is to have a product which is aesthetically appealing and usable to the largest number of people, regardless of their age levels, ability factors, profession or life status.

Although the aim is for mutual benefit of everyone, however the main focus is towards disabled people who are often left isolated in the society because of several restrictions and limitations. In the last few years, with the advancements in medical sciences and rise in life expectancy, the survival rate of people with illnesses, birth defects and

significant injuries has also surged. This has resulted in a growing interest in the philosophy and applications of universal design.

The Centre for Universal Design (CUD) of NC State University has developed seven principles of universal design adapted to pedestrian mobility on April 1, 1997, as shown in Figure 5.




PRINCIPLE	APPLICATION	GRAPHIC
<u>Equitable use.</u> The design should be useful and convenient for all people of different disabilities	To overcome a considerable inequality, the fully able pedestrian will use steps, and the pedestrian with reduced mobility will use a ramp.	
<u>Flexible use.</u> The design should be adapted to a wide variety of individual preferences and capabilities	The length of the ramps should be such that the user does not get fatigued, for which intermediate rest areas are implemented.	
<u>Simple and intuitive use.</u> The design should be easy to understand, regardless of the experience, knowledge, linguistic abilities, or concentration level of the user.	Entrance to a TransMilenio station from a public space should be the most direct and shortest route possible.	
<u>Use with sensitive information.</u> The design should communicate the necessary information in an effective manner.	The use of blue seats for senior citizens or pregnant women on buses connected to TM.	
<u>Use with tolerance for error.</u> The design should reduce to a minimum the risks and adverse consequences of accidental actions.	Crosswalks with curb ramps at street corners are being used more and more by pedestrians, guaranteeing more safety than at other crossing points.	
<u>Use with reduced physical effort.</u> Elements designed in the urban context should be utilized by the users with a minimum of fatigue.	Transversal inclines in public spaces should be made in such a way as to not affect the balance of the pedestrian.	
<u>Use with ergonomic spaces</u> Elements designed in the urban context should contemplate efficient and comfortable use with a minimum of fatigue.	The special area for wheelchair users on buses connected to TransMilenio should allow them to travel efficiently and provide safety belts that are easy to adjust.	

Figure 5: Principles of universality adapted to pedestrian mobility

In Europe the concept was highlighted as Design for All (DFA) by European Commission in seeking a more user-friendly and uniform society (DPEPA, 2002). This also included the involvement of ICT so that everyone can participate in the Information Society (Blakemor, 2006).

The terms used were e-Inclusion and e-Accessibility which proposed that products must be accessible by almost all possible users without modifications or changes. Products in this case should be able to adapt to suit different needs using agreed on interfaces which can be accessed using assistive technology devices. These concepts can also be used to improve web accessibility and usability. The concept of universal design capitalizes on the inherent flexibility of internet based technology to meet the needs of diverse users.

#### **2.4.2 Standards and guidelines on web accessibility and usability**

Just like other internet based applications, e-Government services being available round the clock, 7 days a week would provide its citizens, businesses and partner's greater degree of flexibility to process their applications or transactions outside normal office hours. However, in order to successfully accomplish the set goals a high degree of web accessibility and usability is of paramount importance (The Office of Government Commerce, 2003).

Numerous guidelines have been formulated by the growing community of website accessibility experts and a brief subset of these is currently in common use (Al-Badi, 2003 ). The extensive literature review clearly outlines that the present system of web based interaction for e-Government websites does not conform to the accessibility and usability requirements of blind users (Loiacono & McCoy, 2004) (Hailpern, 2009).

A report published in 2004 points out that 80% of the web sites do not meet the basic accessibility and usability requirements (Loiacono & McCoy, 2004).

Jakob Nielsen who is a leading web usability consultant in Denmark, stated that the web usability is defined by five quality components that are learnability, efficiency, memorability, errors and satisfaction (Nielsen, 2000). Learnability in web based interaction refers to how easily the users can carry out basic tasks for the first time. Efficiency relates to how quickly and effectively can the tasks be performed (Theofanos, 2003).

A good degree of memorability is about maintaining the same level of experience when the users return after a prolonged period of break. To ensure a high degree of usability, it is important that the website is designed in a way to minimize the probability of errors and yield in a high level of satisfaction. The inference of errors in web based interaction is about how many users make errors while using the website, and how easily can they recuperate from such errors. Practically the effect of all these measured can be judged by evaluating that how much the users prefer to use the website (Abanumy A. N., 2003).

### **2.4.3 Web Content Accessibility Guidelines**

The Web Content Accessibility Guidelines (WCAG) documents present standards in order to make the web content accessible and usable for the blind people. The guidelines are primarily laid out for web content developers, web authoring tool developers, page authors, site designers and others who need a technical standard for web accessibility. The design principles and standards were established in 1999 by the World Wide Web Consortium (W3C) through the development of Web Accessibility



Initiative (WAI) (Gerber, 2001). The W3C is a well-known international organisation that develops and enforces defined standards to ensure the compatibility and continuous growth of the Web. W3C is a huge consortium of web users and stakeholders in the industry and public organisations in many web related fields. One important role of W3C is to publish "recommendations" which are adopted as a standard in the industry. W3C was founded by Tim Berners-Lee at MIT and currently headed by him (Blas, 2004). The consortium consists of member organizations which recruit dedicated full-time staff for the goal of developing and improving web standards.

The W3C is administered by the Massachusetts Institute of Technology and the Computer Science and Artificial Intelligence Laboratory in the USA, the European Research Consortium for Informatics and Mathematics (ERCIM) in France, and lastly Keio University in Japan. The W3C has presences in sixteen regions around the world to promote the W3C web standard for local communities. They also welcome voluntarily contribution in W3C development activities. Most of newly improved or created standardization work is carried out by external experts in W3C's international community group.

From a blind user's perspective, one of the design principle followed by W3C is "Web for All". The design principle illustrates one of W3C's primary goals to make the benefits of web services accessible by all people regardless of many factors like: available infrastructure capabilities, language, cultural and geographical location, physical or cognitive ability levels.

An updated version WCAG 2.0 came in December 2008, as a result of recommendations of WCAG 1.0, which acted as the main guidance for web developers and designers on Web accessibility and usability (New W3C Web Standard Defines Accessibility for Next Generation Web, 2013). The WCAG recommendations have also

been incorporated by several other governments into obligatory requirements on web evaluation and accessibility (Leuthold S., 2008).

The latest version of Web Content Accessibility Guidelines (WCAG) 2.0 published on 11 December 2008 by W3C Recommendation, succeeds Web Content Accessibility Guidelines (WCAG) 1.0, which was published on May 1999 (Web Content Accessibility Guidelines (WCAG) 2.0 - W3C Recommendation 11 December 2008). The WCAG 2.0 includes 18 assessment criteria belongs to 4 main categories of general guidelines as shown in the following section.

#### **2.4.4 WCAG success criteria**

The success criteria represent testable statements clearly explaining what needs to be done to meet the requirements of each guideline. The success criteria has been ranked depending on the extent to which the web designing and development process needs to be modified, from 'Level AAA' being most accessible and usable down to 'Level AA' and 'Level A'. From the point of view of a web content designer or developer it is imperative to satisfy the requirements of 'Level A' guidelines. 'Level A' guidelines represent the most basic requirements for some group of users to be able to use web based resources. The web content designer or developer should follow 'Level AA' guidelines, which is expected to uplift significant barriers to access the information. The 'Level AAA' guidelines may be followed which would further improve the access, making it most accessible by all the users.

At this point, it is clear that the guidelines and standards are being set, taking due considerations of requirements by disabled users and also considering the business

interest in making the web content accessible to all the users. It goes without saying that the feature of increased accessibility and usability comes at a price which not everyone would like to pay for. That is why the minimum requirements being set as ‘Level A’ guidelines, makes the website least accessible by all the users. And the ‘Level AAA’ guidelines which if followed would make the website most accessible by all the users. This division leaves the choice of web accessibility and usability standards on the web content designers and developers whilst specifying a minimum level of standard which is deemed to be followed.

**Table 1: Important WCAG Principles and Guidelines. Taken from W3C (Web Content Accessibility Guidelines (WCAG) 2.0, 2012)**

<b>Principles</b>	<b>Guidelines</b>
Perceivable	<ol style="list-style-type: none"> <li>1. All non-text content that can be expressed in words should have a text equivalent of the function or information that the non-text content was intended to convey.</li> <li>2. Synchronized media equivalents must be provided for time-dependent presentations.</li> <li>3. Any information/ substance and structure must be separable from presentation.</li> <li>4. All characters and words in the content should be unambiguously decodable.</li> <li>5. Structure must be made perceivable to more people through presentation, positioning, and labels.</li> <li>6. Foreground content must be easily differentiable from background for both auditory and visual default presentations.</li> </ol>
Operable	<ol style="list-style-type: none"> <li>1. All functionality must be operable at a minimum through a keyboard or a keyboard interface.</li> <li>2. Users should be able to control any time limits on their reading, interaction, or responses unless control is not possible due to nature of real time events or competition.</li> <li>3. User should be able to avoid experiencing screen flicker.</li> </ol>

	<p>4. Structure and/ or alternate navigation mechanisms must be added to facilitate orientation and movement in content.</p> <p>5. Methods must be provided to minimize error and provide graceful recovery.</p>
Understandable	<p>1. Language of content must be programmatically determined.</p> <p>2. Definition of abbreviations and acronyms must be unambiguously determined.</p> <p>3. Content must be written to be no more complex than is necessary and/or supplemented with simpler forms of the content.</p> <p>4. Layout and behaviour of content must be consistent or predictable, but not identical.</p>
<b>Principles</b>	<b>Guidelines</b>
Robust	<p>1. Technologies must be used according to specification.</p> <p>2. Technologies that are relied upon by the content must be declared and widely available.</p> <p>3. Technologies used for presentation and user interface must support accessibility, or provide alternate versions of content that support accessibility.</p>

The focus of making the content perceivable aims to ensure that the web content cannot be understood or perceived in any other way that is not serving its purpose. The guidelines are aimed to help those who are designing and developing websites to make contents perceivable to the largest number of users possible.

The first point raised in the guidelines is to provide text captions for all non-textual content that to be used by different assistive technology devices. The next point emphasizes on about providing synchronized alternatives for all the non-textual and multimedia information that is present on the web. This can be achieved by designing tools that synchronising audio and video captions with their online content.

The guidelines on improving understandability of the web based content demands that all the information whether it is textual or non-textual and controls of navigation buttons must be understandable by all kind of users. This can be most effectively achieved by making the placement and functionality of the web based contents predictable. Most blind users use screen reader as their assistive technology device to browse web based information. It has been observed that majority of the screen reader users do not listen to an entire webpage instead they browse through headings and key words within the pages to locate the required information. They are likely to listen to an entire page only either if the content is very important or if they are new to the site. Thus it is very important for the web designers and web developers to get a real insight of how blind users read and browse through the contents in order to be able to address their particular needs effectively and efficiently.

The guidelines to improve robustness of the system emphasizes on the fact that the contents must be designed in such a manner, so that it would perform in a satisfactory manner when viewed in future user agents. Experts suggest that this can be best achieved by ensuring compatibility with current and future user agents including the assistive technologies (Costa, Kazemi, & Brandao, 2010). It is also suggested that the contents are provided with an accessible alternative that can possibly be provided in future. The main focus of these guidelines has been to establish equivalent alternatives for all kinds of data whether textual or non-textual, to be available online. The requirements also insist on making all the information conveyed with colours to be available without colour as well. Moreover if the web pages are using scripting languages to display some content, then the information conveyed by the script is required to be available as functional text as well, that can be easily read by assistive technology. The electronic forms must also have provisions which allow blind users to

use assistive technology to access the required field elements and information including all directions and cues. Moreover, accessibility becomes even more difficult when the web based information is in complex tabular form, charts or in some other graphical representation. Thus the guidelines insist to put headers or titles right in the first row and first column along with a brief description so that blind users can get a better understanding while using their assistive technology instruments.

There is also an issue of having rapid visual changes or the use of blinking objects for web accessibility. The WCAG guidelines suggest avoiding flicker; however it does not recommend using blink or marquee elements mainly because their effects are very difficult to be controlled in the browsers. blind users who use magnifying glass or screen magnification are the ones being most affected as a result of this. It is also believed to cause confusion for people with cognitive disabilities.

An article published by M. F. Theofanos (Theofanos, 2003) analysed a survey of interviewing 16 blind users for accessing websites. The results proved that the existing website accessibility standards did not fully satisfy the user's requirements. The literature review revealed that many other experts have argued over the effectiveness of WCAG recommendations in meeting the accessibility and usability needs of blind people. In order for the web based material to be perceivable, the WCAG recommendations suggest to modify the graphical interface to suit the requirements of screen reader. However, this method severely restricts its applicability over web content. It is impractical to be applied to all the websites. The WCAG recommendations neglect the semantics and design principles that are critical to improve understanding of the content (Di Blas, 2004). Also it does not consider the difficulty in accessing non textual data and complexity of navigating through web pages. The complicated content layout also remains isolated. Along with these limitations, the conceptualization of the

four WCAG guidelines needs to be fulfilled in order to make the blind user's Web interaction more perceivable, operable, understandable and robust.

There is another school of thoughts on design of websites by Jenny Grannas (Grannas, 2007). According to this school, the design of website can be divided into four important stages namely, graphical design, information design, interaction design and online trust. The purpose of graphical design is to improve the aesthetics of the website making it attractive to the users.

The information design is about presenting the main content or information in a very easy and user friendly manner. It is important that the website is simple to navigate and the user can get an overview in the first sight. An important decision to be made here is the amount of textual information required on a website. If the textual content is too long, it is difficult for users to read. And too little information might not satisfy the customer. Thus it is important to decide on the optimum amount of information that would serve the purpose.

The interactive design of a website refers to the facilities which help the user to give feedback or read comments in order to make the session more interactive. Security of a website is also an important issue. Especially with an e-Government website where users could be giving their personal information and details, it is imperative that the information remains safe and secure.

## 2.5 Aesthetics in web design

The consideration of aesthetics in website design is a must to ensure good user experience. It is believed that the word aesthetics emerged from the Greek word ‘aisthetikos’, which means beautiful appearance or sensation (Tractinsky, 2004). The term aesthetics has several definitions and interpretations. Some researchers defined aesthetics as ‘critical reflection on art, culture and nature’ and another definition defines it as “pertaining to, involving, or concerned with pure emotion and sensation as opposed to pure intellectuality” (Mahlke, Hassenzahl, Lindgaard, Platz, & Tractinsky, 2008).

However, for blind users the term is better understood as an experience or as a behaviour (E. Michailidou, 2008). An aesthetically good product for blind users would be the one that makes the process of interaction more effective, efficient and a satisfactory experience (Wang, Hernandez, & Minor, 2010).

It has been found that the basic components that involve the success of websites design are written content, effective navigation, compliant coding and functional feedback. For sighted users the focus is towards pleasing and attractiveness to the browser eyes (Costa, Kazemi, & Brandao, 2010). However for blind users, good aesthetic design means making the transfer of information easier and user friendly.

A satisfactory description of contextual layout and proper link to other relevant resources is equally important as quality and substantial content of the information. There are many approaches of implementing such appealing principles. These approaches of websites appealing differ from one website to another depending on its contents, domain of use, its target audience, etc.



blind users expect that the website provides the required resource or information in an easy manner and within reasonable amount of time spent. Another important desirable feature is effective navigation, which is also a critical component of aesthetic website. There are several things that should be considered in effective navigation in website such as its accessibility, meaningfulness, understands ability and prevalence.

It has been found that the most common design principles to design an aesthetic website are consistency, interaction, instruction, choices and control (Phillips, 2003). Regarding to the concept of consistency of a website it means the website and its internal web pages and subsections should be consistent to prevent confusion and mix-up. The webpages should have similar layout, graphic representations, colours and all other aesthetics aspects.

When the user clicks on a link, there must be some change on the screen so the user is aware the system has registered the action. Interaction means open channel of communication between the consumers and the company so that it make trust and credibility between them. Also, choices that mean there are more than one way for users to find what they are looking for. Finally, control that mean if the user visited the site or use it regularly such as transaction-oriented sites, it provides personalization features for the user to customize the website option to suit its needs (Costa, Kazemi, & Brandao, 2010).

It has also been observed that in the recent years there has been growing recognition of the relationship between usability and aesthetics and the way that each of them affects one another. This recognition emerged from the fact that there is a harmony between usability and aesthetics (S. Djamasbi, 2010). Some researchers also suggested that what is beautiful is perceived to be usable (N. Tractinsky, 2000). Some empirical studies

showed that the aesthetics of a user interface have a significant impact in people attitude toward computer systems (J. Hartmann, 2008).

Studies were conducted to analyse the relationship between automatic teller machine and the appearance or beauty of its interface. This study showed that aesthetics plays an important role not only with the actual usability of the ATM but also with the initial perception of its usability (Phillips, 2003).

## **2.6 Current tools and techniques to evaluate accessibility of national e-Government portals**

The websites that follow the WCAG recommendations and satisfy the accessibility requirements should provide satisfactory experience to its users (Costa, Kazemi, & Brandao, 2010). However, it is cumbersome process to check the adherence to the wide requirements of WCAG manually. Therefore, for facilitating this process many numerous tools available to check whether a website conforms to multiple web accessibility guidelines and if not, these tools could also provide important feedback to web designers and developers to assist them in the repair and improvement of a website. Some of the famous tools are Becker, 2002; Brown, 2002; Graves, 2001; Hower, 2002; NIST, 2004; Thatcher, 2002; W3C, 2003; and WEBAIM, 2004 (Abanumy A, 2005).

These tools use a wide variety of methods for evaluating the accessibility and usability of a website. The methods can be broadly divided into quantitative methods and qualitative methods, depending on their functionality. The quantitative methods focus on measuring the performance of a website whereas the qualitative methods make use of user's opinion about a website (Abanumy A. N.-B., An Exploratory Study of

EGovernment in two GCC Countries, 2003). There are many usability maturity models currently in use which compare the different usability levels attained, however they do not provide an insight of users' perspective regarding the usability of the website (Jokela, 2000) (Lalli, 2003).

The tools mentioned above are functionally designed with a large set of properties that can be used depending on attributes and not on the context of websites. Those tools which give feedback and support repair actions have the potential to dramatically reduce the time and effort required to perform such maintenance tasks (Brajnik, 2000).

Web designers or web authoring tool developers have several options to choose from for accessibility guidelines unless specified by their client. The accessibility guidelines have been published by government bodies such as EUROPA (Web Accessibility Policy), Universities such as "The MIT's Web Accessibility Principles" and "The Oregon State University Web Accessibility Guidelines", Institutions such as UK RNIB and UK Mencap, and some companies such as 'IBM Guidelines for Writing Accessible Applications' and 'Microsoft's Guidelines for Accessible Web Pages'. Thus the web designers have quite diverse options to choose from. Alternatively, one may decide to take the best features from all of them in order to get superior web accessibility and usability standards.

The web accessibility guidelines of UK RNIB (The Royal National Institute of Blind People) have been studied in depth for a better understanding the accessibility issues. The Web Access Centre of UK RNIB provides guidelines on designing websites, testing (automatic and manual testing) and evaluation techniques, web accessibility training courses, a blog, articles, FAQ section with useful links and download options.

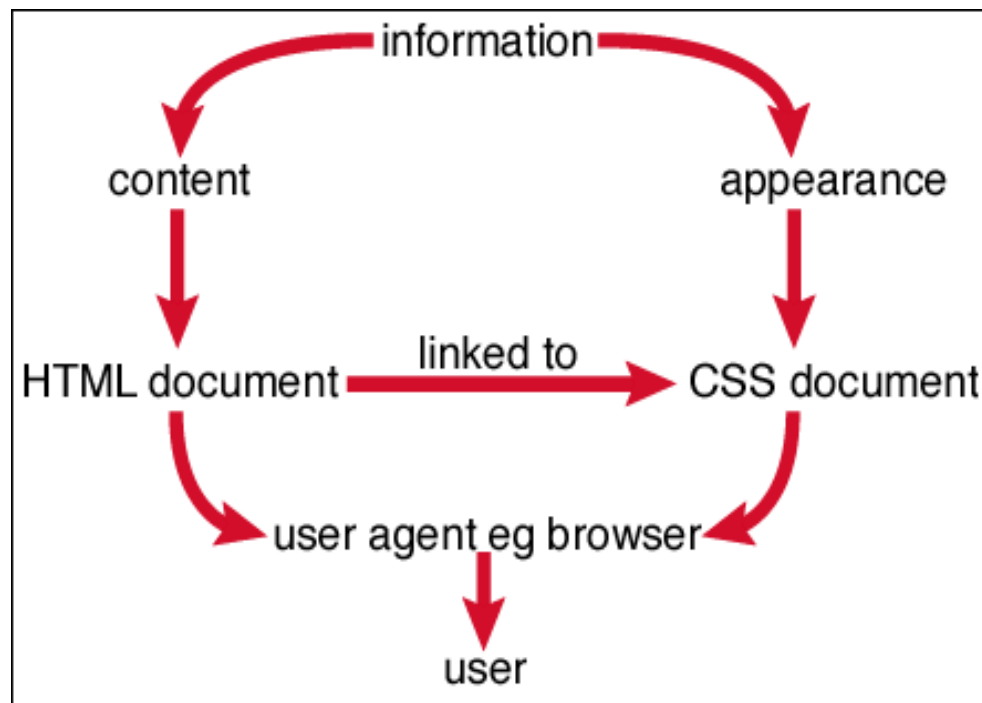
It also provides comprehensive information about various tools for testing accessibility of website along with access software for blind users. For further flexibility it also entails the processes to be used with different web browsers such as Internet Explorer or Firefox.

### **2.6.1 Cascading style sheets (CSS)**

An important component of web designing for blind people is the use of cascading style sheets (CSS). CSS is commonly used by web designers or developers to isolate display of web pages from their content. CSS is a style sheet language is used to explain the representation of a web content written in HTML (Meyer & Koman, 2004).

A style sheet language is a web programming language that manipulates the presentation of web content. The functionality of style sheet languages vary from syntax, selectors, properties, values and units, value propagation mechanism and formatting model. Figure 6 shows the use of style sheets to disconnect content of a webpage from its appearance (Meyer & Koman, 2004)

.



**Figure 6: Use of style sheets to separate content of a webpage from appearance (Allsopp)**

Every style sheet (which can be contained in an external .CSS file, or embedded in the HTML code of the webpage) is a set of instructions. Every instruction plays two roles:

- Identifying the elements in an HTML document it style
- Informing the web browser how to design and display these elements

Elements could refer to plain text, hyperlinks, items etc. In HTML, an element is anything that can be marked up within HTML tags. An HTML document consists of a series of HTML elements and sub elements each of which has its own attributes.

In the HTML syntax, every element is coded with a start tag (< >) and an end tag (< />), with the content required to be marked up between them. The HTML tag includes the name of the element, surrounded by angle brackets (<>). Figure 7 shows an example of an HTML element of type (<p>) paragraph.

```
<p>In the HTML syntax, most elements are written ...</p>
```

**Figure 7: Example of a HTML tag with a start and an end tag (w3schools)**

Some HTML elements do not follow the above structure of start tag and end tag. An example of this element is the <br> element, which represents a normal line break. Figure 8 shows an example of this element.

```
<p>P. Sherman<br>42 Wallaby Way<br>Sydney</p>
```

**Figure 8: Example of HTML code with a void element (W3C, 2012)**

The main other advantage of CSS includes its ability to arrange large complex websites such as, in our case, the e-Government websites. With the use of cascading style sheets, web designers can ensure consistency in designing large number of webpages especially when some editing or updating is required for the whole website (Schmitt, Trammell, Marcotte, Orchard, & Dominey, 2005).

Another main usage of CSS is that it enables the web designers to implement W3C guidelines of accessibility. As the CSS's prime job is to separate content from its structure, it also has other features to control the spacing of the text and its alignment and positioning so as to make it readable by screen readers (Meyer & Koman, 2004)

Moreover, as the style elements and its HTML code are separated from the webpage, this results in a notable reduction of the webpage size and hence avoids confusion to screen readers (Schmitt, Trammell, Marcotte, Orchard, & Dominey, 2005) (Meyer & Koman, 2004).

## **2.7 The inter-relationship between tasks, goals and problems**

The process of performing an online task follows a simple lifecycle of setting a goal and performing set of steps or tasks to achieve this goal. In this section and the following sections, we will analyse and highlight this concept so as to determine where the shortcomings are in the way blind user perform an online task.

According to the Oxford Dictionary, a task is a piece of work to be done or undertaken that involves some level of difficulty. A task is typically described as an identifiable outcome which could be a goal or an output. It can also be defined as a series of physical or mental actions to solve a problem (Sweller & Cooper, 1985).

Goal can be defined as the objective or desired result of a person's ambition or effort which he/ she envisions plans and commits to achieve. It is a planned outcome that needs specific actions to satisfy one's needs. A book published by Alan Cooper has described it as an abstract created by the human brain via a continuous process of questions, thoughts and personal reflection (Sweller & Cooper, 1985).

The term goal and task are very closely inter-related. A task is a sequence of activities carried out with effort and difficulty in order to reach an intended outcome (goal). A group or sequence of tasks form the basic components of goals, thus it becomes the actual 'doing' that gets the job done. In this research, I have used these definitions to

understand how blind users determine their goals and how these goals are linked with a problem.

The inter-relation between tasks and goal is the same as those between problems and solutions. A problem can be described as an unknown obstacle, impediment, difficulty, challenge, or a situation due to which a person want to accomplish a goal (solution) (Borgman, 1999). A problem tends to prevent an outcome from taking place by implying a desired outcome coupled with an apparent deficiency, doubt or inconsistency (Borgman, 1999) (Norman, 1987).

A solution represents a sequential arrangement of tasks heading towards the goal that a person wants to accomplish. In some cases a problem may have a single or multiple solutions. The inception of a problem in human brain stimulates a need to find an acceptable solution so as to reduce variations. Therefore, it can be said that problem solving involves processes that are very similar as to performing a task (Arthur, 1994). Such kind of an environment surrounded by the task, goal, or problem stimulates an individual to look for and find a solution. This environment governs the approach and behaviour of an individual during his/her problem solving process. Contextually the focus in this research is to understand the web based experience of blind users from a problem solving perspective.



## 2.8 Problem solving mechanism

Every theoretical problem that a human brain might encounter asks for an answer or solution, and the art or science of trying to find a solution to a problem is known as problem solving. In professional and psychological contexts, problem solving is regarded as the most important cognitive activity that a human brain gets involved in. The process of performing an online task on the e-Government website can be interpreted to be same as the process of problem solving (Newell & Simon, 1972). Problem solving is about selecting issues that require great amount of attention, defining goals, designing suitable courses of action and assessing the course of action in order to get the best result (Gog, Liesbeth, & Fred, 2010).

The process of problem solving can be conceived as a mental process of discovering and analysing the issue to tackle difficulties and find a suitable solution to resolve the issue. A problem, on other hand, is defined as the desire for the reaching of a single goal from current conditions that are complex, distributed or not linked together to formulate course of actions to the goal (Norman, 1987). A problem occurs as a result of the initial perception of a situation, and that its solution is towards reorganizing the situation in a way that its whole structure and its relative attributes become clear.

The questions about problem solving behaviour of an individual can be answered at various levels and in varying degrees of details. The way in which blind people see a problem is purely through perception, action and cognition. In cognitive psychology, the term problem-solving is defined as normal mental process that people have when they are exposed to relatively difficult tasks. In simple words “A problem is any given situation that differs from a desired goal” (Newell & Simon, 1958) (Newell & Simon, 1972).

According to the model of problem-solving cycle (Sweller & Cooper, The use of worked examples as a substitute for problem solving in learning algebra, 1985), a systematic and logical approach could be to firstly identify the problem, then define the problem with its boundary conditions and limits, then develop a solution strategy, then organize information and knowledge about the problem, provision and utilise the mental and physical resources required to resolve the problem, then monitor the progress toward the solution and finally evaluate the results for accuracy. This model gives a comprehensive set of information on how to proceed with a problem, however since problem could vary significantly in their nature and complexity; some steps may be skipped or combined.

In practical situations, sometimes the method of problem solving might not be the most optimum one because of the involvement of bounded rationality (Young, 1983), however, it is enough once a solution is found which goes well with the created mental model to the problem context. Also the use of such an approach usually goes through many steps, and every stage is linked with a single mental model and its relative course of actions.

The mental model is updated by using details about possible repercussions of a single action on the current situations. If this information happen to be inconsistent with expectation, then additional cognitive efforts are required for its processing. But this tends to hamper the effectiveness of the created mental model.

Moreover, the discrepancy occurs in the observed and expected output increase the inconsistency which tends to affect future mental state. The problem solver is required to reframe the task environment.

There is another school of thought proposed by Hermann (Herrmann, 1995) states that a human brain goes through four different stages namely, preparation, illumination, incubation, and verification while trying to solve a problem. The first stage of preparation refers to an initial search in many directions using logic and reasoning whilst recalling any previous experiences. The remaining stages could be by-passed if a solution could be found at this stage.

However if the problem is ill-defined or complex in nature, it is unlikely that the preparation stage would be able to generate a satisfactory solution. Once an impasse is reached, the conscious mind of user restrains itself from solving the problem, which leads to the beginning of incubation phase. The incubation phase is not time bound in nature and empirically it is expected to increase the probability of eventually finding the correct solution.

The next stage illumination is the “spontaneous” manifestation of the problem and its solution in conscious thought of the problem solver. The fourth and last stage verification is for ascertaining the correctness of an insight solution (Herrmann, 1995). The process of verification involves the use of deliberative thinking processes with logic and reasoning, just like the process of preparation. If the solution is invalidated at this stage, the problem solver usually goes back to the first or second stage and the cycle is repeated.

There are three main underlying concepts, namely, state, operator, and problem space that are required to accurately model this problem. The first key concept, state can be

defined as the data structure that illustrates the potential course of actions to move from a problem towards a solution. The data structure in such a human computer interaction includes users' actions and system responses (Borgman, 1999). The second key concept, operator, is essentially a procedure that could be used for moving from one state to another by performing some action (Newell & Simon, 1972). These two key concepts illustrate the different stages that a blind user may pass through, and the corresponding processes employed to progress towards goal attainment.

The third concept, problem space, is the fundamental organizational unit of all goal oriented activities that might be carried out by human beings (Newell & Simon, 1958). The problem space consists of various states and operators available for achieving a goal, along with the knowledge of initial state and goal state. It outlines the given initial situation along with various possibilities for transforming this situation (Newell & Simon, 1972). This concept has been used to understand the notions of blind users about different stages that they must go through, and the corresponding procedures that must be followed to complete a learning activity.

Thus within a problem space, the problem solver starts at some initial state (problem state), and then transforms that state through the application of operators till the time the state of desired goal is reached. Such an activity of selecting and applying various operators constitutes the process of problem solving (Newell & Simon, 1972).

### **2.8.1 Problem solving process for blind users**

For blind users, problem solving is considered as conscious and controlled cognitive process that encompasses various mental activities such as attention, perception, memory and reasoning to discover, analyse and solve a problem. Thus it is important to

have a practical and efficient problem-solving mechanism that includes the whole interaction between the user and the e-Government website, including his/ her perception, action and cognition. In order to better understand the interaction of blind users with web based resources as a problem solving mechanism, the actual working environment and their cognitive behaviour needs to be conceptualized while dealing with the problem. In medical terms, the process of web based interaction with blind users can be subdivided into the basic sequential activities namely perception, cognition and action. It is important to understand the way in which a blind user perceives accessibility problem during online interaction.

The problem of poor accessibility of web based resources faced by blind people is a type of an ill-defined or a complex problem, where there are many interpretations to the current situation and the final solution is not apparent. The typical problem faced by blind users in web based interaction is that the solution or an approach towards solution could be readily available on the web page, but they will either have to imagine it or scan through the whole web page until they get the correct path which leads to the solution. The first form of imagination cannot be relied upon, from a web designer or web developer's perspective but their thinking could be broadened and moulded by appropriate training and exercises. The second option of navigating through a whole webpage to find the solution of one problem is theoretically true but the time and effort spent by the blind user and the mental fatigue would defeat the purpose of having an effective and efficient e-Government system. Here it is important to understand the way in which a blind user would tend to tackle a problem faced while working on the e-Government website.

Appropriate training or previous experience could be extremely helpful to blind users in tackling problems related to web based interaction. The reason for this is that whenever human brain comes across a problem, it readily reproduces the response from its past

experiences which is called reproductive thinking. And reproductive thinking could be a strong tool against problems encountered during web based interaction.

## **2.9 Decision making and environment boundaries**

It was believed that one prominent way of researching decision making process could be by finding the most optimal solution among many alternatives (James, 1990). However, the idea of optimal choice was already rejected by Simon in his theory of “bounded rationality” (Simon, 1955). The main point of argument was that, it is very difficult for human beings to evaluate all the available expected decision outputs and select the best and optimal output of them due to time constraints and cognitive limitations. The theory suggested that human beings normally tend to behave normally within physical boundaries that shape their physical environment (Simon, 1955).

As a result of these cognitive limitations and time constraints, problem solvers restrict from exploring and assessing all the available alternatives before selecting the one that fits the problem context. This philosophy of physical boundaries has been deployed in this research to investigate the behaviour of blind during their online interaction experience which is in our case the e-Government portal (Simon, 1956).

It is known that individuals when encounter a complicated or difficult situation, they search for patterns and then utilise them to build mental models to help them accomplish their work (Arthur, 1994). In this way they facilitate the problem to a much greater extent. They act on personal and subjective deductions based on their created mental models (Simon, 1955) (Simon, 1990).

By getting feedback from the external environment, human brain tries to continuously assess the efficiency of their already created mental models. Then, they take out the ones that are not functioning well, and use other ones instead (Arthur, 1994). Thus whenever there is a lack of complete description of the problem or whenever it cannot be fully reasoned, the human brain usually constructs more abstract models to enhance the reasoning process. Such behaviour of human brain is termed as 'inductive' in nature (Zhang, 2008). Therefore they use of pattern identification search mechanism to facilitate the problem when there is a lack of distinct solution and comprehension of problems. This leads to the fact that blind users are able to find solutions to problems faced during their online interaction if they managed to build a reasonable pattern of the current problem from their past understandings.

Another type of behaviour relevant to the way human brain functions is called 'satisficing'. 'Satisficing' means constructing an acceptance criteria and thresholds which will be evaluated to use the final best-fit option from them (Newell & Simon, 1972). It also performs as a 'stop rule' which helps the decision maker in concluding the decision process, once an acceptable option is found (Simon, 1955). However, 'satisficing' does not restrain the decision maker from making further choices. According to a theory proposed by Simon (Simon, 1955), it is believed that people often choose decisions which serve the need, even though they are not the most optimum ones, primarily because of limited information processing capacity. Simon has also proposed that in certain circumstances where the nature of problem or the course of actions towards it has multiple aspects, then it requires evaluation of the associated advantages and disadvantages of all relative solutions, and then one of these solutions can be preferred with one aspect and the other alternatives with others. The search would be completed when a solution is discovered that is suitable for all the aspects (Simon, 1955).

By employing the above concept in our research, it can be said that the strategy adopted by blind users while using the e-Government website would include the following three steps:

- 1) Setting up of a suitable criterion.
- 2) Selecting the first suitable option.
- 3) Calling off their way of exploring the methods during problem solving.

A very similar research has been done by several other researchers on studying human behaviour during online interactions. Borgman (Borgman, 1999) has revealed in his report that normal users of online search engines mostly tend to check only few search outputs before making new searches, instead of looking at all search results. Another study focused on analysing cognitive abilities and personal behaviour of users during their interaction with Google search engine. It was also noted that the users used their keyboard for browsing the search result (Brajnik, 2000).

The case mentioned above is a very good example of satisficing behaviour which allows users to work with huge amounts of details in reasonable amount of time. The satisficing behaviour of users allowed them to shortlist the search result instead of trying them all out. Another study performed on school students, has also found similar results (Goodhue D. , 1986). The application of satisficing strategy significantly reduces the amount of details required for choosing the right search result.

Thus it can be said that while using the e-Government website, if a user faced a complex e-Government environment, they would tend to mitigate the effect of this complexity by utilising concepts like satisficing and pattern search to perform their goals. For instance, if the blind user is in search of the problem context, he or she is likely to perform in two scenarios. Firstly the user would match it with similar past



problems that could guide him or her towards current problem solving task. Alternatively the subject is likely to follow a satisficing principle which will examine the possible solutions based on their relative simplicity. Of these, the user would like to choose the one that is the easiest and more optimum.

It is now time to focus the discussion on schema theory which is a very specific aspect and key to problem solving. The in-depth study of schema theory deals with internal representation which is known as mental model (Simon, 1956). This concept is detailed in the following section.

### **2.10 Mental models and human reasoning process**

The term mental model originated 1934 in the field of psychology. It is the representation of external reality, hypothesized to assist an individual in cognition, reasoning and decision-making process ( Craik, 1943). It provides an explanation of an individual's thought about how something operates in real world and has particular significance in problem solving. It represents the surrounding world and at the same time inter-relates it with a person's perception about the consequences of his/her own acts. The concept of mental models could be helpful in shaping cognitive behaviour of human brain and to set up an approach towards solving problems.

Mental models can be created from intuitive perception, thoughts and representation of surrounding. Kenneth Craik had proposed that human brain tends to translate surrounding actions into self-created mental models and process to reach acceptable comprehension these mental models or symbolic representations can either be translated back into actions or could be used to build a relationship between them and their surroundings (Craik, 1943).

It is a common practice used by normal people to convert a problem or situation into a simple mental model in order to understand the surrounding environment of a task and then use these created models to guide their actions during the process of problem solving. The conceptualization process of the role of mental models has been used in this research to analyse problem solving activity of blind users.

Several contemporary scholars have defined mental models as dynamic cognitive representations which arrange thoughts and perceptions of objects and surrounding that allow people to interpret the world (Norman, 1987). What differentiates mental models from other reasoning theories in psychology is the fact that they rely on small set of fundamental assumptions or axioms (Norman, 2002).

Research shows that every mental model represents a potential course of action which are believed to be true and efficient (Errey, Ginns, & Pitts, 2006). Mental models describe those course of actions that are practically possible, and therefore every mental model is linked to a possibility describes the true aspects of this possibility. Nevertheless, in certain circumstances mental models may describe what is not true which was thought as true. This is called subjunctive conditional and remote conditional thinking (Vessey I. , Cognitive fit: A theory-based analysis of the graphs Versus tables literature, 1991). Apart from its important to problem solving domain, mental models also provide great help to people comprehension of complicated problem context and help them to anticipate what possible repercussions might occur to selected solutions (Marchionini, 1988).

The concept of mental models consists of a block of knowledge that comprises of two parts. The first part is called Knowledge structure which is responsible for stipulating knowledge in human memory through its internal parts the linguistic representations and structural models. The second part cognitive processes allow people to manipulate and modify the knowledge stored in these knowledge structures. These two concepts form the basis of psychological understanding in human brain and provide tools for problem solving in a given domain (Zhang, 2008).

Thus it can be said that mental models comprise of knowledge structures and cognitive processes which are relevant to the problem situation. Such a method of conceptualizing mental models would help in identifying certain critical components of a mental model that are crucial in problem solving.

Depending on the context of usage, an individual may hold multiple mental models of the same system. A report by Gentner (Gentner & Stevens, 1983) suggested that each mental model has a unique structure corresponding to the structure of the situation. Furthermore the contextual nature of mental models has also been explained by Young with the example of an electronic calculator (Young, 1983). Young has argued that human brain formed three different mental models of the calculator which are used depending on their purpose of usage. The purpose of usage could be to perform basic arithmetic operations, to perform complicated tasks or to diagnose errors.

### 2.10.1 Mental models in the problem domain

Human brains are believed to be highly intellectual with strong capability of recognizing patterns (Simon, 1955). It is a normal tendency of people to build their mental models depending on implicit analogies, which is more common, and explicit ones. This behaviour helps in solving unexpected and unprecedented problems. When an individual is required to face a novel task environment, he or she first tends to search for similar and successful mental model to the current task environment. The individual then tends to borrow from this similar model the architecture and its relative procedures to create an effective mental model to work out the current task or problem. This infers that during an online task environment, blind users would also count on previous experiences and create a mental model for the current task which could be a simple mouse click.

Newell has compared mental models as abstract representations of problems. When an individual tries to solve a problem, he or she executes a set of actions to convert a mental model which belongs to the initial state of the problem then progress to the creation of mental models for the middle and final stages of the problem. The main criterion to determine a mental model of final stage is when a solution is found. This life cycle of the mental model process is important in describing the succession of cognitive representations during problem solving process (Newell & Simon, 1958).

The Newell approach of problem representations and its relationship with problem solving is very much similar to what Johnson-Laird's proposed theory of human reasoning process. According to Johnson-Laird's, human reasoning process includes three semantic procedures as follows (Newell & Simon, 1972):

- The construction of mental model of a task environment requires both holistic and relevant knowledge to this task.
- The formulation of an optimum solution should be drawn from mental models relative to the task environment.
- Other mental models should be sought that may refute the proposed solution

If the user does not have an alternate model available, then the proposed solution is considered to be acceptable. However, if more optimal solution is found then the problem solving process should revert back to the second procedure, and tries to recreate a solution aligns with all previously created mental models. This rigorous process of evaluating mental models and searching for possible alternatives gives us a clear picture on the complexity and difficulty that blind users experience in their task or problem environment. The quantity and complexity of mental models for blind users is by far not comparable to sighted users.

In the process of human-computer interaction, a typical user experience starts with an initial mental model of the system depending on his or her knowledge structure. This knowledge structure could be created from reading about this system or from some other external resources. As the user advances in level of interaction, the human brain develops a rough and workable mental model, which continuously evaluates the relevance of incoming information. At the same time, it also continuously associates new information with the previously acquired knowledge. And as the experience and level of interaction grows, the user tries to transform his or her present mental model into a matured and sophisticated mental model (Norman, 2002). Thus it can be concluded that mental models of blind users during their online interaction would certainly enhanced due to their increased experience. This could be specifically

important and appealing in establishing educational and training programs for blind users to improve their level of IT literacy.

Besides its importance to problem solving process, mental models can also help in giving clear explanation to user behaviour like the reasons for selecting a specific method and the nature problems that may be faced by the user (Young, 1983). An experiment was conducted to explore the impact that mental models have on users' behaviour while interacting with Microsoft Excel spread sheets (Mohammed, Ferzandi, & Hamilton, 2010). The experiment consisted of asking two groups comprising users and they were asked to describe and use Microsoft Excel tool. It was observed that one group described the application at its conceptual level, while the other group came up procedural-based description of introduction of the application. Also, both of the two groups showed different behaviours in using the content of the package.

Unlike the subjects of second group, the first group members preferred to create their own formula to deal with the application rather than using the built-in ones. This indicates that this group chose not to put load on their cognitive abilities even though that this decision would entail extra physical effort. This experiment proves that mental models also suggest the methods used by problem-solvers to achieve a goal. In context to the theme of this doctoral research, the above experiment implies that the choice made by blind users while solving a problem would rely on the efficiency of the mental model they create during their online interaction process.

Another important case study following similar thoughts was published by Gog (Gog, Liesbeth, & Fred, 2010), where he has examined and observed novice users of a text processing system in order to identify their mental models of this system. The

parameters used for drawing conclusions about the models were user's behaviour and verbal protocols. Moreover various drawings were also used to show that the information was connected. It was also observed that over time the user's models were improved which reflects the hierarchical nature of the system.

This proves the statement made previously by (Johnson-Laird, 1983) that users adapt their mental models over time based on interaction with the system. The study conducted by Gentner (Gentner & Stevens, 1983) also discovered that many of the problems arose as a result of misinterpretation of the meaning of the terms used in the system. Thus it is proposed that the users would have a better success rate with the interface if they are provided with a more accurate vocabulary model.

Young (Young, 1983) also performed an experiment to understand the performance of mental models with reference to using information and IT systems. The experiment involved observing two groups of undergraduate students who were engaged in browsing a library online catalogue. The first group had received training for system's conceptual model, while the second group was trained on how to search the system. The experiment showed that the first group performed better while managing complex tasks. It was also observed that students with matured mental models in their mind did less error and simultaneously identifies more items while browsing through the online catalogue. This clearly indicates that users equipped with a distinct mental model would conduct more complex online tasks in an efficient way.

Although mental models are applicable in most of the situations, however the diversity of definitions and the lack of a coherent methodology could cause confusion, resulting in contradictory results. It has been observed that most of the researchers develop their

own methodology which is based on verbal protocol analysis. Thus different experimenters yield different mental models while observe the same interaction. With this kind of widespread analysis in experimenter's interpretation there is quite a high risk of having significant bias in results.

Therefore it can be concluded that designers must be encouraged to design interfaces that help the users to create better and accurate mental models. However there is very little research work done to come up with a design which helps the user to create the best mental model.

Although the problem solving process and mental model philosophy were comprehensive discussed in the literature and provide excellent explanation on the human reasoning in the task domain, they were not applicable to the online tasks environment (Zhang, 2008). The discipline of human-computer interaction (HCI) had emerged in 1980s as an independent field of study since the wide spread of computers devices and its applications.

Realizing the importance of usability characteristics and ease of operation, the user-centered systems design concept was able to attract the attention of most of the designers. This sparked the idea of modelling behaviour and thought of users during their computer interaction process. This gave birth to the 'Seven-Stage Action Model' first thought by the usability consultant Donald Norman, and it explains a user's behaviour in the human-computer interaction process.

### **2.11 Seven-stage action model**

The term 'Seven stages of action' was first coined by the usability consultant Donald Norman in chapter two of his book on 'The Design of Everyday Things', in the context



of explaining the psychology of a person behind the task performed by him or her (Norman, 2002). The model includes both cognitive and physical activities and explains the activities carried out by a user while problem-solving with a system (Zhang, 2008).

According to Norman, a user initiates the task by forming a goal followed by mapping it to an action on the computer, execution of the action, perceivance and understanding the feedback from the system in order to examine if anything has gone wrong (Norman, 2002). This model explains both the physical and cognitive activities of human brain.

During a task, a user usually takes into account the goal of the task, the task environment and the evaluation process relative to the task. The action plan is to set up a goal first termed as 'goal formation', then decide and perform what needs to be done termed as 'execution' and finally evaluate if the goal is being met by 'evaluation'. The stage of execution initiates with transforming the goal into an intention to act. In simple words, execution means a process to perform or do something.

For instance, a person sitting on a chair while reading a book during dusk time would need more light when it becomes dimmer and dimmer. In order to do so, he would need to switch on the button of a lamp. This process can be instructed by specifying on how to move one's body, how to extend the arm to reach the light switch and how to push the button.

Herein this example, the goal had to be translated into an intention, which in turn resulted into an action sequence. This intention gets mentally translated into a set of

internal commands which results in a plan of action that satisfies the intention. The stage of execution ends with implementing this action sequence on the system.

Thus, the stages of execution can be formulated as:

- i. Initiated with goal setting and the state that is to be achieved.
- ii. Goal gets formulated into an intention to do some action.
- iii. The intention gets translated into a set of internal commands and action sequences to be performed to meet the objectives.
- iv. The action sequence is executed and performed upon the world.

The stage of evaluation can also be subdivided into three stages. Firstly the user perceives the activities that happened in the system. Secondly the user tries to make sense of this information comparing it with his expectations. And lastly the user compares the result or outcome against his or her set goals.

The model proposed by Norman can be broadly divided into three parts and seven stages as follows:

#### I. Goal formation stage

1. Goal formation.

#### II. Execution stage

1. Converting goals into tasks which lead to the goal achievement.
2. Sequentially arranging the tasks or activities to create a plan of action.

### 3. Perform the implementation plan

## III. Evaluation stage

1. Understanding and comprehending the execution result.
2. Comparing the actual result with the expected ones.
3. Comparing the result against the predefined goals.

In this research, we linked the concept of ‘Seven Stages of Action’ along with the problem solving process so as to build solid understanding of the way blind users interact and behave in during online interaction, which is in our case an e-Government portal.

The diagram below (Figure 9) shows how a typical problem scenario is treated in its respective stages of action according to the seven stage action model.

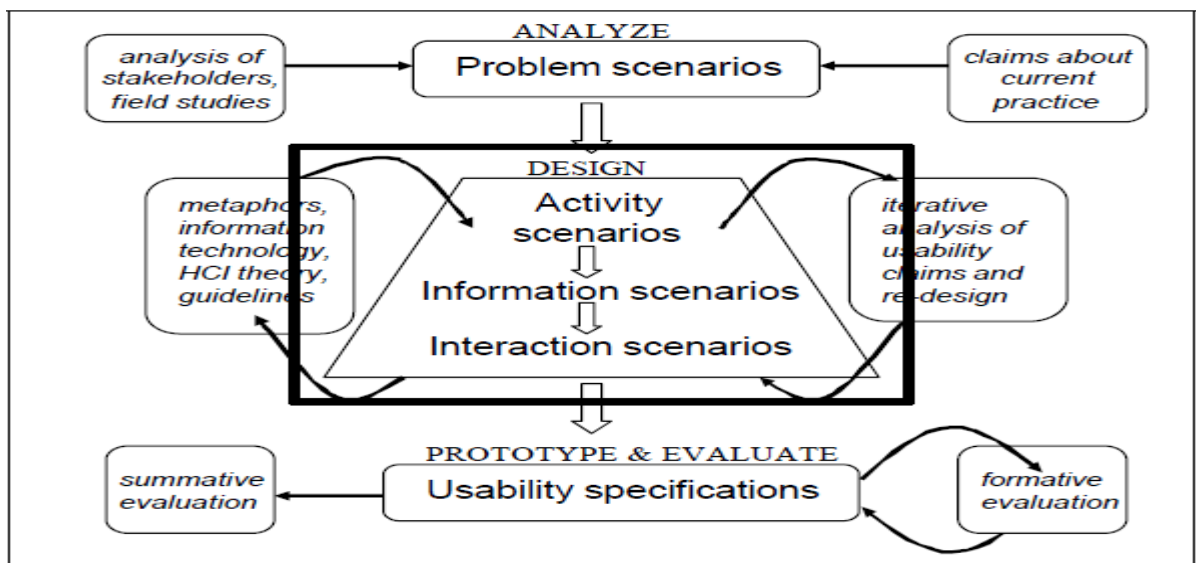


Figure 9: Seven stage action model

The Norman's seven stage action model divides the stages of action in a way to answer the following questions:

- i. What makes a task difficult to accomplish?
- ii. What exactly is the user trying to do?
- iii. In what ways can it be achieved?
- iv. Which is the most optimum and practical way to approach the problem?
- v. How could this way be executed?
- vi. What are the results?
- vii. Do the results meet the original aim or purpose?

Although the model is quite exhaustive in its description, but Norman has pointed out that these seven stages do not still constitute to a full-fledged psychological theory, and serves only as an approximate model. The individual stages are not discrete entities and thus in some cases the mental behaviour might not go through all stages in sequence. There could be circumstances when a particular stage of action might be required to be repeated or omitted depending on individual requirements. There are a lot of activities which are not satisfied by single actions, requiring numerous sequences because of which the activity could last for hours or even days.

The process of goal setting in the first stage can also at times be quite cumbersome. According to a theory, the process of goal setting is effective only when it provide a clear sense of direction and purpose. Goals that are clearly defined, specific,

measurable, achievable, realistic and time-targeted are likely to have a better performance than the ones which are not.

Goal setting is also a powerful way of motivating people and is being organized and used as management objective by several successful multi-national organizations. However in reality the goals set by users might not be so perfect. This is primarily because real tasks are usually more complicated and imprecisely defined. Goals often fail to state actual intentions or lower level statements of what is to be done.

It is believed that the main cause of such a discrepancy is that the process of goal setting might have started at a random point, responding to the events of the world (data-driven behaviour) rather than to think out plans and objectives (Norman, 2002). Another important reason could be that an event in the world has triggered an inappropriate interpretation and a resulting response.

Typically the process of goal setting comprises a continual feedback loop, in which the results of one activity are used to direct further activities, goals lead to sub goals and intentions get transformed into sub intentions. This is important because original goals set by an individual might be ill-formed, vague or imprecisely specified.

There could also be circumstances when some activities are forgotten, discarded or reformulated while the goals were being set. Another important factor to be considered in the process of goal setting is to strike an appropriate balance between a challenging goal and a realistic goal. If a goal is set too high to be achieved, it could possibly result in severe de-motivation as compared to setting up a goal that's too easy.

Moreover even after the stage of goal setting, there is also a risk that actions could be executed before they are fully developed. Considering all the above mentioned factors into account, it can be said that the action model does not impose any structure on people's behavior during the process of problem solving with a system. The understanding of this concept concludes that blind users may not proceed with the process of problem solving in a prescribed sequence of actions.

The most insightful aspect of this model is that it identifies and illustrates the nature of problems in user-system interaction. Norman remarks that the factors responsible for these problems are neither a lack of understanding of goals or tasks, and nor the deep, subtle complexities. The problems arise primarily because of people failing to determine (Norman, 1987):

- (1) The inter-relationship between system mechanisms and intended actions.
- (2) The functionality of a control system.
- (3) The mapping between functions and controls.
- (4) Inadequate feedback for evaluating the results of actions

In simple words, the difficulty is solely because people fail to understand and map intentions to interpretations, and physical actions to system states.

## 2.12 Human cognition and control memory

In a normal learning process, the amount of information an individual is exposed to has a great impact of the working memory of the individual and hence affect the effectiveness of his/her learning process (Simon, 1990) (Akyol & Garrison, 2011). This concept in psychology is called cognitive load. There is a very strong relationship between the magnitude of information that a human's brain can process and the human's ability for understanding and comprehension. This concept is applicable during the online interaction especially with e-Government applications where the user is requested to perform specific tasks or follow set of instructions. The focus and attention of the user should only be to the instruction relative to these tasks in order to reduce the load on the user working memory. In other words, any irrelevant instructions or activities to the task to be performed may deteriorate the user performance (Phillips, 2003). This concept found great attention among the web designers and they started to design their webpages in a simple way to reduce the amount of information the user needs to process. (Sutcliffe, 1995) (Errey, Ginns, & Pitts, 2006).

However, this concept has not been applied on blind users during their online interaction experience. The only possible reason for this is that it may was thought that the cognitive load is affecting sighted and blind users with the same magnitude. However, in this research we argue that the online interaction experience of blind users is by far more complex and generates huge amount of load on their working memory compared with their sighted counterparts. It is believed that the effect of memory load can be mitigated by spending extra effort on browsing orientation, navigation and user interface change. All of these possible amendments are available to the sighted user through their visual interaction which is not the case with blind users. Therefore, a close observation to the blind users in the online environment is necessary to investigate the cognitive process issues. We will utilise the concepts of mental models, problem

solving process and the environmental boundaries discussed to come to clear understanding of the issues that affect blind users' performance.

### **2.13 Exploring blind behaviour within online environment**

A goal driven online task is typically associated with difficulties and hindrances depending on the complexity of the web based resources. A difficulty faced during web based interaction can be defined as an unexpected situation that hinders goal accomplishment. A major contributing factor of such difficulties faced by blind users is the fact that a web page is an inherently complex resource. The complexity of a website is not just because of the physical arrangement of pictures and text, but the arrangement of pages configuring a website. The navigational difficulty in traversing through these web pages has also a significant contribution. The notion of this perceived complexity is specifically important for blind people because it not only impairs the communication effectiveness of a web site but also hinders the attitudes towards using these services. Upon our critical review to the literature in this chapter it was shown that such complexity affects the online experience of both sighted and blind users. However, the accessibility needs of blind users are far more distinct and complex from typical sighted users. It has also been observed that whenever individuals face a complex situation in their online-based activity, they can either follow a task facilitating strategy or complexity resolving strategy. In the task facilitating strategy, the user will bypass the faced complexity and carry on with other tasks. In the complexity strategy scenario, the user tends to look for tool support to reduce this level of complexity.

Both strategies might cause differences in performance expectations among users. If the user chooses to follow complexity resolving strategy, it requires powerful execution orientation which is supported by the selected tools. This powerful execution process



invokes more optimism in attaining the activity, which leads to higher performance expectations.

As a result of this, the normal sighted users might want to switch to some other website or service, but for blind users this factor could contribute towards developing an attitude of completely abolishing the use of such facilities and services. Thus in order to safeguard their interests and following the objectives of Government's plan, significant time and effort has been spent to understand the underlying cognitive principles of complexities faced by blind users. Thus from the point of view of a blind users, the process of goal accomplishment can be considered as a sequence of actions and activities. Such sequence of actions performed for blind user through an internet based application which can be termed as an online task.

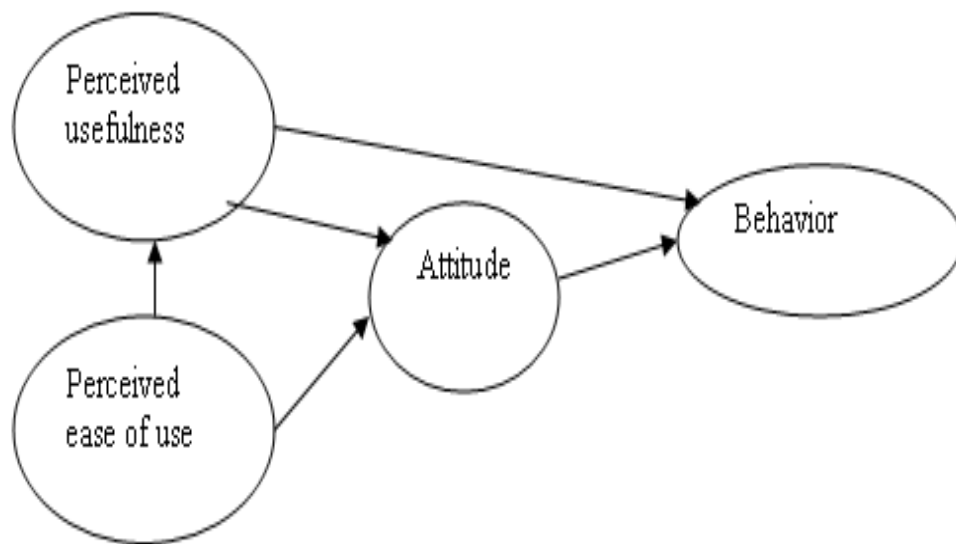
The term 'accessibility' in this case which is adopted in this research, refer to allowing access to all of the features and functionalities an online-based system has. It can be said that problems due to poor accessibility would pose difficulties at different stages of task achievement.

The advantage of seeing 'online task' as a sequence of actions is that by examining the interactive and cognitive-based process through which a blind's user performs these actions, it helps us come to full understanding of the nature of the inaccessibility problems. In this research, the type of this online- tasks selected are those contained in e-Government portals, the Saudi e-Government as a case study. In the following sections, our approach of examining the cognitive process of the user during online interaction is discussed.

### 2.13.1 Cognitive approach

Cognitive approach is a scientific exploration of the human brain and its processes (Sweller J. , 1988). It spans varied levels of dynamic analysis, from abstract learning and problem solving mechanisms to high-level logic and reasoning processes. The major focus of this research is to formally examine the steps that a human brain goes through in decisions making and problem solving processes. By doing so, the human' thoughts and perception will be better understood.

Cognitive science is about examining the various aspects of cognition (the term cognition refers to 'mental processes'), how it works and what it does (Vessey & Galletta, Cognitive fit: An empirical study of information acquisition, 1994). The cognitive processes, being hugely varied and multi-dimensional featured like natural or artificial, conscious or unconscious, needs to be analysed from different perspectives within different contexts. However, primarily it emphasizes on the way in which information is represented, processed and perceived. This relationship is depicted in Figure 10.



**Figure 10: Basic technology acceptance model (Jaeger, 2009)**

One of the most important principles of cognitive science is "Levels of analysis" (Vessey & Galletta, 1994) (Akyol & Garrison, 2011). The central aspect of this principle is that a comprehensive understanding of a human's brain cannot be achieved by single level analysis. The mental states are required to be classified on the basis of their functionality, in such a manner that every system that functions as expected for some mental state is considered as a system in the same mental state (Akyol & Garrison, 2011) (AlJarallah, Chen, & AlShathry, 2013). For that respect, studying a particular phenomenon from different levels gives a better understanding of the reactions that happen in human brain to justify a specific behaviour.

Based on foregoing, in this research the concepts and philosophy of cognitive science are used to understand the state of mind of blind users when they are involved in web based interaction. Whilst analysing human brain, cognitive psychologists make an important assumption that human behaviour is the result of information analysis and data processing. A central idea of cognitive behaviour of people is that they actively try to make sense of the outer environment by imposing logic and meaning on the things that they encounter.

Cognitive behaviour of blind people plays a critical role in obtaining user satisfaction during a web based exercise. Every webpage of a website is unique in its nature and presents a completely new and unknown space to the mind of a blind user. The ability of the blind user to effectively and efficiently exploit the space is directly proportional to his/ her cognitive behaviour (Akyol & Garrison, 2011). A well-structured and guided cognitive behaviour could aid the blind user in progressing towards his/ her goal, while

a poorly guided cognitive behaviour might result in a chaotic situation in his/ her mind, thus interfering with achieving the required goal.

An analogy of blind sticks can be taken to further explain the cognitive behaviour during web based interaction. It is a well-known fact that a blind person will find it extremely difficult to walk without the use of a blind stick. The blind person uses his/ her blind stick to aid the direction of movement and makes him/ her familiar with the surroundings. Without a blind stick, the blind person will be like a person looking for lake or pond in a desert. The blind stick does not help the blind person in walking, however it does reduce the complexity of the process, by providing a cognitive support. The cognitive support helps the blind person to accomplish the task much easily and comfortably.

Similar to the example of blind stick acting as a cognitive support to a blind person, the journey of web experience also needs a tool to aid the cognition of the blind person. As already mentioned in section 1.2 of this thesis, the web space being an unknown region needs to have a high degree of accessibility and usability. The lack of accessibility and usability of an e- Government website could have a severe impact on cognitive behaviour of the blind user and affect web experience.

A tool or guide or distinct functionality of the e-Government portal could act as a cognitive support for the blind user and assist in forming a coherent approach towards achieving the goal or completing the task. Without an appropriate tool, the blind person might get lost on the e-Government portal and distract from its main objective of performing and completing an online task.

The behaviour can also be explained by the methods in which people process and organise information relevant to specific ways of acting. This is particularly relevant to the research theme in understanding the way blind users are handling such a complex amount of web based resource. Cognitive psychologists follow a very common strategy which is based on the example of the behaviourists in preferring controlled, objective and scientific methods for investigating behaviour.

The process of web based interaction for blind users involves three major activities, namely perception, cognition and action. Thus an accurate assessment of the process and problems encountered would require an understanding of their mental reactions, cognitive perception, and action as they interact and perform relatively complex tasks.

#### **2.13.2 User-centred approach**

Based on the literature review in previous sections it was noted that most of the studies on accessibility problems faced by blind were based on the technical aspects of the system under study with very little user involvement. A typical perception among designers is that blind users are ordinary computer users except that they interact and gets the content in a non-visual manner. It presumes that the main problems occur due to the poor design of the user interface which made it inaccessible by the screen readers. Thus, a proper design to the user interface with a well-chosen screen reader would help in resolving this issue of inaccessibility (AlJarallah, Chen, & AlShathry, 2013). This wrong concept resulted in insufficient understanding of the needs and requirements of blind users in the online environment.

In this research, we adopted a user-centred approach as we focuses on the user's cognitive factors like problem-solving and learning process so as to meet the

requirements, preferences and needs of the end users. This approach keeps the central focus on understanding the difficulties faced by blind users in online interaction environment.

User-centred approach can be classified as a multi-stage problem solving process in which the designers are not only required to analyse and foresee how users are likely to use the product or service. It tests the validity of users' assumptions with regards to user behaviour in real time tests and experiments. This kind of testing helps the designers to positively understand the experience of the first-time user of their design and what would the learning curve of each user looks like.

Accessibility issues form the most important elements of this approach. The users must be able to locate the information quickly and easily throughout the web page, regardless of its length (Human-centred design for interactive systems (ISO 9241-210) . Also they must be provided with various ways to find the required information (such as using navigational elements, search functions, table of contents, clearly labelled sections, etc.). It is also advised that the navigational elements to be used must be consistent with the genre of the web page. Some experts also suggest the use of 'Chunking' as this strategy involves subdividing the information into smaller pieces that can be organized into some meaningful order or hierarchy. Another important strategy is to allow skimming of web page as it highlights important information thus saving the time of blind users.

This approach allows getting a clear and precise understanding of the problem. Thus I have adopted this user-centred approach in the doctoral research to understand the nature of accessibility and usability problems that blind users face in web based interaction with e-Government website.

### **2.13.3 Task-oriented approach**

Generally, the e-Services are meant to be designed for a specific group of people to serve a specific purpose which could be academic, commercial, social or even informational in nature. The aim of designing these e-Services is fulfilled when targeted users utilise them to attain their operational goals. This type of interaction is goal-oriented where users target a web page to conduct certain predefined tasks. This is especially true in the case of e-Government websites where users interact with website to accomplish certain key important tasks.

The main standard of success of such e-Services can be shown by analysing how well the targeted group of users performed their intended tasks successfully. The lack of accessibility during the online interaction experience hinders the users from performing their tasks; failing to attain their goals and defeating the actual purpose of the web-based system.

Thus in order to improve the accessibility level of e-Services and online applications for all the users, which could lead to serving its original purpose, a practical approach has been considered to address the accessibility problems and challenges faced by blind users as they try to accomplish certain tasks. This approach provides a holistic and comprehensive understanding of the problem and would be helpful in improving the

functional details of the website for better use by blind users. This concept of task-oriented approach is deployed in our research where a clear and close examination of the blind users during their online interaction experience with e-Government applications.

#### **2.13.4 Verbal Protocol Analysis**

Our cognitive-based approach adopted in this research to examine blind experience during online interaction is mainly built on the interpretation of the problem solving process of a blind user during a real observational experiment. This process includes a close monitoring of a user's reactions when performing a task in a complex environment and their psychological behaviour toward problems. We looked for an examination methodology that adopts this approach and helps us to closely examine the users. We chose the Verbal Protocol Analysis (VPA) approach which collect verbal data and analyse them from a cognitive perspective (Rose & Parfitt, 2010). VPA includes recording a participant's verbal report during his/her engagement in performing an activity. This report is generated under specific instructions and the participant is given very minimal orientation. This report processed and coded to build inference and conclusion from the users' cognitive reactions. This process is called think a loud protocol (Rose & Parfitt, 2010).

The aim of adopting this approach is to get an in depth understanding of web based interaction, and the cognitive capability in solving the problems encountered by blind users. The results and findings from this approach would be used to develop a highly accessible e-Government website. The detailed analysis of seven stage mental model and problem solving theory revealed that the underlying problem of having difficulty in web based interaction among blind people is inherently complex with multiple factors involved and huge variation of individual's knowledge and cognitive thinking. The best approach that could be taken for such a case is to collect some data by studying the problems encountered by an individual's behaviour in solving a problem experienced in



web based environment. Thereafter, analyse it to propose a generic framework for designing e-Government website with significantly higher accessibility and usability standards.

Thus in order to achieve these above mentioned objectives, an exhaustive survey has been conducted to rationalize the problems associated with their web based experience. The survey was conducted personally with their physical presence as any other means won't serve the purpose.

### 2.13 Summary

This chapter reviewed the literature relevant to the accessibility and online interaction issues for sighted and blind users. A comprehensive overview was given on the e-Government applications, as a good example of online interaction, and their benefits to the communities. It showed the current status of the e-Government adoption in the Kingdom of Saudi Arabia and the constraints that hinder its full acceptance by some group of the community like the blind people. This chapter also discussed the term blind and the prevalence of blindness worldwide and in the Kingdom of Saudi Arabia. The main goal of this research is to explore and investigate the reasons behind the low level of acceptance of e-Services among the blind people. It aims to comprehensively examine the way blind users interact with e-Services and their mental and physical reactions during this process. Therefore, this chapter also reviewed extensively the literature on the aspects of cognitive load and online memory restrictions during online interaction. The philosophy of decision making and environment boundaries was discussed and reflected on the case of blind's users during the online interaction. The process of problem solving and mental models approach were also reviewed and linked with the blind online interaction process. Upon our review of these psychological

theories, there was an absence of its application to the blind people while they interact with online services. The thoughts and cognitive load levels of blind during the online interaction were not well considered which may lead to their non-acceptance of any type of online interactions. This research believes in that there are some difficulties faced by blind people in the online interaction environment and the requirements to mitigate these difficulties are not fulfilled by international accessibility standards. The next chapter propose the research methodology this thesis adopt to investigate the problem.

## Chapter 3

### RESEARCH METHODOLOGY

#### OBJECTIVES

- Discuss the qualitative methodology followed in this research.
- Highlights the tri methodological approach used in this research for blind accessibility assessment.
- Formulate an experimental exercise for a group of blind people

#### 3.1 Introduction

The theme of this research is based on an empirical and cognitive-based approach targeted to examine the sensations, perception, mental and physical reaction of blind users during the online interaction environment, Saudi eGovernment portal as a case study.

Chapter 2 of this research has revealed that the issues of web based accessibility for blind users include two main components, namely the blind user and international accessibility standards (WCAG). This chapter outlines the approaches followed to investigate the research problems and the justification for using them over other alternatives.

It outlines the differences between qualitative and quantitative approach, and explains why qualitative method is most appropriate for this research to develop a

comprehensive understanding of the problems faced by blind people. This chapter describes the research methodologies adopted to better understand the cognitive behaviour and typical problems which would be faced by blind users in web based interaction.

### **3.2 Qualitative versus quantitative methodology**

As one leading proponent of qualitative methods has explained, “Quality refers to the what, how, when, and where of a thing – its essence and ambience” (Berg, 2004). Qualitative research thus refers to the meanings, concepts, definitions, characteristics, metaphors, symbols, and descriptions of things. The superiority of qualitative research arises from the core differences in what qualitative and quantitative research are, and what they are able to contribute to bodies of knowledge. At the core, qualitative research focuses on the meanings, traits and defining characteristics of events, people, interactions, settings/cultures and experience. The numerous advantages of qualitative methods provide a depth of understanding of the research problem.

Quantitative research is typically considered to be the more “scientific” approach to doing social science. The focus is on using specific definitions and carefully operationalizing what particular concepts and variables mean. Qualitative research methods provide more emphasis on interpretation and providing consumers with complete views, looking at contexts, environmental immersions and a depth of understanding of concepts (Berg, 2004) (Patton, 2002).

Qualitative methods provide a depth of understanding of issues that is not possible through the use of quantitative, statistically-based investigations. Qualitative methods

are the approach that centralizes and places primary value on complete understandings, and how people (the social aspect of our discipline) understand, experience and operate within milieus that are dynamic, and social in their foundation and structure. The superiority of qualitative research arises from the core differences in what qualitative and quantitative research are, and what they are able to contribute to bodies of knowledge (Patton, 2002).

Interviews are (typically) structured conversations that researchers have with individuals. Just as in everyday life, one of the most productive ways to learn about a person, place, or set of activities is to actually ask questions to people who have knowledge about that topic. Interviews are used to solicit information from people, just as quantitative researchers ask questions with surveys (Schamber, 2000).

However, the difference is that when a qualitative researcher asks questions to a person they are interested in understanding how the person being interviewed understands, experiences or views some topic. The quantitative researcher inquires about if and how a person knows something, and how that knowledge can be translated into a numeric value.

This most frequently requires the use of closed-ended questions on surveys, limiting the possible answers to those identified by the researcher, not in whatever form of understanding the person being interviewed holds and can explain to the researcher doing the interview. In this way, interview data is “richer” than quantitative data in that not only does the researcher learn how the interviewee sees and knows something, but also does the qualitative researcher get an explanation of that observation or knowledge.

In short, interview data provides the answers that quantitative surveys questions produces, but qualitative interview based data also provides the answer in an unlimited range of possibilities and with an accompanying context.

The data that are produced in qualitative endeavours are almost always texts, narratives or visual images. Whereas both quantitative and qualitative methods seek to identify, explain and discuss patterns within and across data, the actual “things” and meaningful labels/expressions for such things about which patterns are the focus supply the actual data for qualitative analyses.

The types of questions that are normally addressed by qualitative research seek to provide in-depth, detailed information which, although not necessarily widely generalizable, explores issues and their context, clarifying what, how, when, where and by and among whom behaviours and processes operate while describing in explicit detail the contours and dynamics of people, places, actions and interactions. At the core, qualitative research seeks to identify and explain patterns and themes in events and persons, and across variously grounded events and persons.

Qualitative research is sometimes referred to as “exploratory” in the sense that it entails venturing into aspects of social structure and interaction that have not been previously adequately explored, and identifying the core elements of structure and interactions. The identification of these concepts and constructs, together with interpretation on the part of the researcher is the process of theoretical development.

The qualitative researcher cannot “prove” that something exists in a particular way or that constructs and concepts relate in particular manners, but the qualitative researcher can and does propose and argue in support of particular manners of relations. These theorized concepts and relationships, then, are the core of theories for explaining the phenomena under study.

Quantitative research requires that one either simply study the counts of events/people/things or that numeric labels be created for meaningful events, experiences and actions. Without numeric labels on “variables” the quantitative scholar is unable to manipulate data and identify patterns. For the quantitative scholar “meaning” is interchangeable with a mathematical value; for the qualitative researcher what the data truly mean is the centrepiece of investigations and analyses (Berg, 2004).

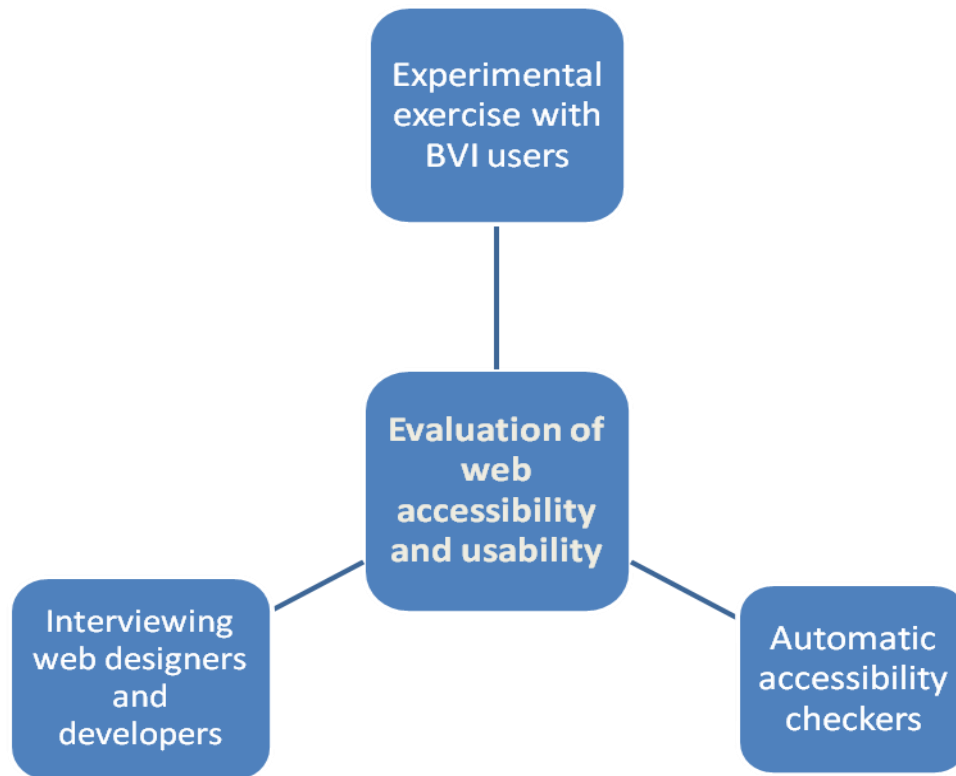
### **3.3 Accessibility evaluation framework**

In this research, the main objectives of evaluating users in online environment such as e-Government portal are as follows:

- To understand the nature of problems encountered by blind people in web based environment.
- Analyse the accessibility and usability problem from user centred perspective.
- Consider a broad range of blind people to understand their cognitive approach to web based problems.
- To check the adherence of website to the international standards.

The aim of evaluating the e-Government portal is to deeply understand and address the accessibility and usability issues faced by blind people.

The three elements of evaluating accessibility and usability of e-Government websites have been identified in Figure 11.



**Figure 11: Three elements of evaluating web accessibility and usability**

### **3.3.1 Objectives**

The main objective of using multi-steps evaluation framework is to understand the way in which blind people understand web based environment and to link their cognitive approach of using web based environment with the designing standards. A careful evaluation of the e-Government website from a user-centred point of view would help to bridge the gap of behavioural understanding between the web designers or developers and the blind users. My contribution in the research is to understand the way in which blind and people model web based environment and then propose a solution which would lead to utmost user satisfaction in using web based resources.



The process of evaluating the website would also take into account the extent and adherence to the WCAG standards and guidelines. The research would tell us how well the e-Government website adheres to the recommended standards and guidelines and also what is the correlation between the level of adherence and user satisfaction of the website.

It was revealed in sections 2.4.2 of the literature review chapter that even a well-designed website which is fully compliant with the WCAG standards and guidelines might not lead to complete user satisfaction, especially in the case of blind users. The reason for this fact is that blind people might face a wide range of difficulties while using web based resources which is not the case with their sighted counterparts. This is due to the fact that their cognitive reactions to the web based environment are often not considered while designing a website.

For instance, a modern and well-designed website which strictly adheres to all the WCAG recommendations might not be accessible and usable to the blind users. The concept of blind users to use web based resources against other means is purely dependent on the assumption that the process of accessing information by web based resources would be more effective and efficient. Thus it is imperative to check the accessibility and usability of a website by physically examining the web based experience of blind users and not just by following the standards and guidelines.

### **3.3.2 Experimental Exercise with blind users**

The main focus is to evaluate the e-Government website both by physical means as well as by using automatic accessibility checkers. The first method of evaluation involves a close observation to a group of blind users while using eGovernment services. The purpose of this observation is to evaluate the accessibility and usability of the website from the blind users' point of view. Thus we conducted an experimental exercise with a set of blind users with a selected e-Government website under due supervision. The result of the exercise on blind people is quite crucial and important. With the results of the experiment, it is hoped that we can understand the cognitive reactions and problem solving process of blind users. Findings of the first experimented will be analysed in the light of cognitive and problem solving theories to define a set of solutions which in turn will be incorporated in redesigned a layout of the eGovernment website under study.

### **3.3.3 Automatic Accessibility checkers**

The next stage of evaluation was to do a self-content analysis of the portal by using automated accessibility checkers. The reason for this stage is to reveal any non-conformity of the website to the WCAG standards that may cause dissatisfaction among blind users. Web accessibility evaluation tools are specialised software programs that evaluate whether or not a web site meets the web accessibility guidelines provided by WCAG or any other accessibility standard. These tools are very helpful when used throughout the process of website design, implementation, and maintenance. Web accessibility tools can be used for many purposes depending on the expertise of the users and the types of criteria they want to evaluate their website against. These tools could be of significant help in assisting the web designers and developers to prevent accessibility barriers, repair the encountered barriers, and to improve the overall quality of the website or e-Government portal. These tools consider a large set of properties

depending on generic attributes regardless of the website context. The tools supporting repair actions may help in dramatically reduce the time and effort required to perform maintenance activities. Primarily there are two ways in which these accessibility tools help users in evaluating their web sites for accessibility which are:

- 1) Evaluating the conformance of a website to WCAG guidelines by using accessibility checks executed automatically.
- 2) Assisting web page designers and reviewers in performing accessibility checks which otherwise would need to be evaluated manually.

Another major advantage of these evaluation tools is that they are usually designed to evaluate multiple pages or a whole website and generate reports with very little user interaction. These reports which show the result of the accessibility check are summarized in reports which can be customised according to the needs of the user. These report-generating tools are very helpful in giving a quick decision on the level of conformance of web sites to accessibility requirements or accessibility checkpoint. Some accessibility requirements though are required to be evaluated manually and are not covered by the automatic accessibility checkers. Sometimes these tools are able to perform some of the accessibility checks automatically and prompt the users to manually evaluate the remaining checks. For example, an accessibility checker may be able to automatically check if an image has a text caption and then display the images with their corresponding descriptions to the users to evaluate how suitable these descriptions are.

There exist numerous tools to evaluate whether or not a website or e-Government portal adheres to the web accessibility guidelines provided by WCAG. These tools provide helpful feedback to web designers about a website and can also assist them in the repair and enhancement process. There are websites that provide a recommended list of these

tools with a full description of the features of each tool. There are also some wizard-based accessibility tools that guide users through sequences of checking steps..

Another important kind of such tools is the ‘In-page feedback evaluation tools’. The in-page feedback evaluation tools insert temporary icons and mark-up into the code of the webpages to display the results of automated accessibility checks and their corresponding location within the pages. Sometimes, other types of icons are also inserted into the Web pages to assist the manual evaluation of checkpoints. For example, some tools may insert icons to indicate the hierarchy of the page headings or lists, or the reading sequence of table cells that are be perceived by some Web site users.

There exists another important kind of automatic web accessibility tools known as ‘transformation tools’. Transformation tools modify the appearance of the Web sites to help identify conceptual design issues with regard to web accessibility. For example, transformation tools may present the content of web sites in text only, without colour, or read the content aloud. These types of evaluation tools are usually especially useful to compensate the limitations of automated accessibility checking and to support the users in evaluating checkpoints that need to be evaluated manually.

#### **3.3.4 Interviewing with web designers and developers**

The last stage of our accessibility evaluation framework of accessibility assessment is conducting interviews with web designers who were involved in designing e-Government portals. The goal of this stage is to frame a valid conclusion about problems faced by blind users on the basis of the web development technology. The

technical point of view is of very important to propose any potential improvement to online accessibility.

### 3.4 Summary

The accessibility and usability needs of blind users are far more distinct and complex from typical sighted users. Therefore, in-depth analysis and observation of the blind user during the online interaction is important to construct a prices overview of these needs. This chapter presented the methodology followed in this research to investigate the research problem. It outlined the concept of cognitive-based analysis and how this would help in understanding the needs of a blind user. The following chapter outlines the primary research carried out to investigate the research problems.

## CHAPTER 4

### PRIMARY RESEARCH

#### OBJECTIVES

- Outlines the result of the conducted primary research.
- Explains the specifications of the evaluation methods followed in this research.
- Explain the sampling method used for the experimental exercise.

#### 4.1 Introduction

As already discussed in chapter 3, this research adopts three steps for the accessibility evaluation process: experimental exercise with blind users, rigours assessment against WCAG standards and lastly interviews with web designers. The following sections explain each stage in details

#### 4.2 Experimental exercise

The main objective of conducting this experimental exercise was to analyse the cognitive thoughts of blind people in web based environment. The exercise was conducted to deeply explore the various aspects of accessibility and usability problems faced by blind people. As already stated in the beginning of this thesis, the e-Government website of Saudi Arabia was selected as a case study for this research; however, the approach followed in this research is applicable to any type of online interaction. Figure 12 shows the home page of e-Government website of Saudi Arabia.



Figure 12: Home page of e-Government website of Saudi Arabia

Figure 13 shows the English version of the home page of e-Government website of Saudi Arabia



Figure 13: English version: home page of e-Government website of Saudi Arabia

The version under study is the Arabic version considering that Arabic is the official language in the country.

#### 4.2.1 Participants allocation

The biggest challenge in conducting the exercise was to select a group of individuals that could represent the view of the whole society of blind people in the Kingdom of Saudi Arabia. Another challenge was to separate those who were born blind, and those who acquire blindness later on in their lives. Thus a comprehensive sampling technique is used for selecting a set of individuals from the population. The selection had to be done in such a way that it covers people from all possible backgrounds with respects to their level of education, IT literacy, professionalism, age group etc. The complete description of the sampling technique used has been given in section 4.2.2. My contribution in this section has been to develop an organized plan to contact a set of applicants and conduct the exercise of evaluating the e-Government portal. I also came up with a unique sampling model to select a set of individuals for this study. The whole process was done under the guidance, supervision and support from ‘Prevention of Blindness Union (PB Union)’ and ‘Arab Gulf Program for Development (AGFUND)’. Prevention of Blindness Union (PB Union) is an NGDO (Non-governmental Development Organization) in Eastern Mediterranean Region (EMR) and AGFUND (Arab Gulf Program for Development) is a regional organization based in Riyadh, Saudi Arabia, established in 1980 upon the initiative of His Royal Highness, Prince Talal Bin Abdul Aziz Al Saud.

The Organizations ‘Prevention of Blindness Union (PB Union)’ and ‘Arab Gulf Program for Development (AGFUND)’ maintain the contact details of all the citizens suffering from any form of blindness. Without their help and support, the exercise of interviewing blind people would have been extremely difficult. Thus both Organizations (PB Union and AGFUND) have been duly acknowledged in the thesis. The group of participants selected were active users registered in a database maintained by ‘Prevention of Blindness Union (PB Union)’ and ‘Arab Gulf Program for Development (AGFUND)’. The selection of interviewees was done under the guidance



and support from ‘Prevention of Blindness Union (PB Union)’ and ‘Arab Gulf Program for Development (AGFUND)’, on the basis of the sampling technique. The group of applicants was selected carefully and then invited to take part in the study. The interviewees were initially contacted on behalf of the Organization to participate in a study carried out to improve the accessibility and usability of the e-Government website. Prior consent of the family or the caretaker or the senior family member was taken for participating in the exercise. The reference from both of them was of tremendous help in contacting the blind people and conducting the exercise. The reference from the two Organizations was used to individually select and contact respective blind people or their families. The family of the selected individual and the applicant himself/ herself was duly explained about the nature of the study and about the confidentiality of the information. Although the personal details of the applicants were used as a part of study, the data was kept confidential under the authority of ‘Prevention of Blindness Union (PB Union)’ and ‘Arab Gulf Program for Development (AGFUND)’. The respective applicants were explained that their contact information and views would be strictly confidential and the results obtained would be solely used for the purpose of research and has no commercial interests.

#### **4.2.2 Sampling method**

The selection of blind people was done on the basis of a scientific sampling method. The aim of using a sampling method is to select a group of people from the whole population of blind people so that their view can represent the issue of accessibility and usability problem of the whole society. The use of an optimum sampling method that models the whole group of blind people and gives minimum sampling variation is very important. It is impractical to survey the entire population as the time and cost of census would be too high. The term ‘population’ refers to the group of people to whom the findings and results of this survey could be applicable and extendable. Stratified

sampling is among the most common statistical methods of sampling from a population (Berg, 2004). It is a well-known fact that the subpopulations within an overall population of blind people vary widely depending on their knowledge and exposure to web based and IT resources.

Thus by using the method of stratified sampling, the total population can be divided into homogeneous subgroups before sampling. The strategy of stratified sampling is often used for political surveys as it reflects the diversity of the population. This also enables the researcher to include participants of various minority groups such as race or religion, based on their proportionality to the total population. As a result of this, a stratified survey could thus claim to be a better representation of the population than a survey of simple random sampling or systematic sampling.

The most prominent advantage of using this method is that it improves the representativeness of the sample by reducing sampling error. Moreover the use of stratified sampling specifically in this case ensures that the original goal of having a higher degree of web accessibility and usability is met for the whole group of blind people.

#### **4.2.3 Stratified sampling**

In this study the total population has been divided into 10 subgroups or 'strata' in such a way that each 'strata' is mutually exclusive. Every element in the population of blind users is assigned to only one stratum and no population element has been excluded. The basis of subdivision of elements into 'strata' is their level of exposure and competency to use web based resources and IT literacy. A total of thirty individuals were selected based on the sampling technique from different educational, social and professional

backgrounds. The subdivision of applicants for the exercise was done under the subheadings shown in Table 2:

**Table 2: Participants Subgroups**

1) Student
2) Professional
3) Professional retired ( > 60 years old)
4) Others, Proficient IT literate users
5) Others, Men aged under 25 ( < 25)
6) Others, Men aged 25 to 50 ( 25 - 50)
7) Others, Men aged over 50 ( > 50)
8) Others, Women aged under 25 ( < 25)
9) Others, Women aged 25 to 50 (25 - 50)
10) Others, Women aged over 50 ( >50)

The division is done in such a way that blind users under category 1 and category 2 have a minimum of three years of internet experience and an adequate level of IT literacy. This kind of division allows us to make a functional differentiation among various categories of blind people. However, it is to be noted that the number of blind people falling under these categories would show a high degree of non-linearity.

The main purpose of doing such a functional division is to minimize sampling errors pertaining to different functionality requirements. Thus the survey would result in getting results from a wide variety of functional groups. My contribution was to select applicants according to the sampling technique in such a manner that represents the majority of the blind population.

#### **4.2.4 Age of blindness**

During the participant allocation process, there was a concern regarding the age of blindness for all participants and how this factor would affect the way they use eGovernment services. There are basically two kinds of people who make up the blind: those who were born blind, and those who acquire blindness later on in their lives due to illness or age factors. In our study, there were 2 in the professional retired group who developed complete blindness due to diabetic retinopathy. However, they never used the eGovernment service prior to their blindness. However, their performance will be carefully noticed to make sure that their distinctive case of blindness will not affect the credibility of the research.

#### **4.2.5 Process of experimental exercise**

The process of user testing was conducted individually for all the users. The participants were briefed with an explanation about the study before commencement of the evaluation, and the procedures to be used. They were also introduced to the WCAG 2.0 guidelines and given some examples of accessibility problems. Participants were assured that the evaluation was of the website and not of their ability to use the web.

The interview and the practical exercise were conducted in the centres of 'Prevention of Blindness Union (PB Union)' and 'Arab Gulf Program for Development (AGFUND)'. The experimental exercise was duly explained to each and every individual. The exercise included undertaking various tasks on the e-Government portal and was carefully observed to better understand the accessibility and usability problems. The tasks for the exercise were selected keeping in mind the most repetitive and commonly used by web users.

Prevention of Blindness Union has several branches in Saudi Arabia, where the exercise was conducted. A total of 30 interviewees were requested to participate in the experimental exercise. 12 out of 30 (40%) interviewees were based in Riyadh, 15 interviewees which accounted for 50% were based in Dubai and the remaining 3 (10%) were based in Jeddah. The exercise was conducted at the date and time convenient to the interviewee and in presence of a representative from Prevention of Blindness Union.

At the end of the exercise, the interviewee was asked for a retrospective verbal feedback and was asked to comment on response to the feedback questions (listed in the Appendix). The response, time taken, accuracy, number of trials and other parameters were noted down during the exercise. This was used in conjunction with the feedback form to evaluate the accessibility and usability problems.

Throughout the exercise, the researcher recorded the time and efforts that participants spent to complete each task. The researcher also rated the degree of difficulty as he/ she observed the blind participants working to complete the tasks. The researcher's rating was not disclosed to the participants at the time of entry. The details of the rating and completion time were noted on the Researcher's Observation Protocol (Appendix D).

At the end of exercise, the users were interviewed personally and asked to fill a feedback form. The feedback exercise was aimed to accurately examine their experiences as well as the time taken in every task. The results were compiled and analysed to point out the major challenges faced by blind users during web interaction. Chapter 5 explains results and analysis of the experimental exercise. The experimental exercise would help to evaluate the effect of improved accessibility and usability on blind users. My contribution in the task was to examine the cognitive activity of the

blind people and fill up the feedback form on behalf of the interviewee in such a way that it describes their involvement and difficulties accurately.

#### **4.2.6 Procedure of experimental exercise**

The exercise was conducted at various locations to suit the interviewee's availability requirements. A standard office based PC with high speed internet connection was provided to the users. Due considerations were also given to ensure that the environment and facilities were adequate and comfortable for the interviewees.

There were no time constraints on the interviewees for completing the tasks. However, the time taken by each individual interviewee was noted by the researcher. This factor has been accounted for in one of the post exercise question asking whether the user felt the time spent was worth for the information and facility obtained from the website and would he/ she like to use the service again. It was not reasonable to time bound the experimental exercise because all the blind users would take different amount of time in completing the assigned tasks, primarily dependent on their level of IT literacy and web based experience. Blind users who fall into the category of professional men or women between 25-50 years old would take far less time in completing the tasks of experimental exercise as compared to an individual with very little or no experience of using web based system or faces the problem of limited level of IT literacy.

Two groups of people may have been separated on the basis of IT literacy or web based experience, however such an approach defies the basic purpose of evaluating the website for the whole blind population of a country, in this case Saudi Arabia. Thus if the e-Government website is designed as per the accessibility and usability

requirements of blind users, the evaluation of website by using an experimental exercise must result in a basic minimum level of operational satisfaction for blind users.

Before the experimental exercise, interviewee was briefed about the purpose of research, the type of exercise and how the results would be used to improve user experience for blind people. As the interviewees came from different background and IT literacy level, a separate briefing document was prepared for each participant. A maximum of two interviewees were called in a day so that there is enough time with the researcher to examine the results and take feedback for the next experimental exercise. This also helped in making the interviewee more familiar about the research, the host organization (PB Union and AGFUND) and examine possibilities of how could such efforts bring a change in their lives. The experiment was conducted using a screen reader developed by 'Nattiq Technologies' called 'Supernova Arabic screen reader installed in a WINDOWS 7 machine with Internet Explorer 10 as a web browser. The logo of the Nattiq screen reader is depicted in Figure 14



**Figure 14: Nattiq screen reader**

#### 4.2.7 Experiment Tasks Lists

The exercise given to the people consisted of a pre-user testing session questionnaire followed by 13 online tasks and lastly a feedback interview (as shown in APPENDIX A). The pre-user testing session questionnaire was designed to ascertain the academic background and level of IT literacy of interviewee. This questionnaire had an important role to play in analysing results obtained from the experimental exercise.

The online tasks given to applicants to be conducted on the e-Government portal are shown in .

**Table 3: Tasks Lists**

- 1) Find a health facility by distance. Ministry of Health (Ministry of health)
- 2) Find a private medical facility. Ministry of Health (Ministry of health)
- 3) Inquiry about social security status. Ministry of Social Affairs (Ministry of Social Affairs, 2011)
- 4) Search the form for filling up “Subscription and Registration in Social Insurance” [“Government services” - “Government forms”] or “Car Registration Form”
- 5) “Inquiry and updating of family member medical records, appointments, details and mobile numbers” – “Health and Environment”
- 6) “Renewal of medical certificate” – “Health and Environment”
- 7) Check the current Government policy
- 8) "Projects and Initiatives" - "National Plans and Initiatives" - find info about "The Eighth Development Plan 1425/26 – 1429/30 AH 2005 – 2009 AD"



- 9) The Internet Awareness Project “SALEEM”
- 10) Check latest IT events
- 11) Register on the website. Log in and comment on a BLOG of your interest.
- 12) Search for Government jobs
- 13) Participate in polls
- 14) Give feedback of the website

The interviewees weren't constrained by time and neither were they provided any kind of assistance during the experimental exercise. However, the interviewees were briefed that they should try to do as many activities as possible. They were also briefed that they could go back to the home page if they are lost or they could choose to leave a particular task if it was taking much longer than expected.

#### **4.2.8 In-Test observation form**

During the experimental exercise, the researcher's role to observe the user and the progress made through the exercise very carefully. The researcher noted and observed the response, time taken, accuracy, number of trials for every task to draw a conclusion on the level of accessibility problems faced by the participants. This was supported by an experimental exercise evaluation form (APPENDIX C), which was to be filled out by the researcher herself.

The experimental exercise evaluation form consisted of five questions on each task, to record the user experience and evaluate the overall performance. The questions were related to the task which involved giving feedback on the e-Government website.

The questions in experimental exercise evaluation form for each task are shown in .

**Table 4: participants' observation form**

I.	How much time did this task consume? __ minutes __ seconds
II.	Did the interviewee found it difficult to locate the correct page? [ ] Yes [ ] Little [ ] No
III.	Did the interviewee perform the task without any problem? [ ] Yes [ ] Little [ ] No
IV.	Did the interviewee found it easy to use write his or her feedback on the website? [ ] Yes [ ] Little [ ] No
V.	Was the feedback entered by the interviewee free of any error? [ ] Yes [ ] Little [ ] No Comments: _____

The questions on time taken, ease of locating the correct webpage, problems faced by the interviewee associated with the task, general comments and rating of overall performance were common to all the tasks. Each point allows for maximum value of 2 for answer [Yes] down to value of 0 for [No]. This value is given based on the researcher close observation to the interviewees' physical and psychological reactions in the test.

As already stated in the previous section, the time taken to perform a task was not considered as a major factor of the task difficulty. This is due to the fact that participants would take different amount of time to perform the tasks depending on their relative subgroup. The time value in the in-test observation form is linked and accounted for in the post evaluation in appendix D which states that

(Do you think that the information and services from web portal were enough to justify your time and efforts spent on the task?)

The user response will indicate the level of satisfaction which justifies the time spent on the task. However, the researcher assumed, based on self-assessment, an average time of 5 minutes for every task is very enough for a blind user. Accordingly, a value of 2 is given when the interviewee performed the task in less than the average time and a value of 1 is given when he/she performs the task in more than the average time. A maximum time limit for every task is determined at 10 minutes before the task is considered incomplete and a value of 0 is given accordingly.

#### **4.2.9 Post-test evaluation form**

After the experimental exercise, the interviewees were asked to give feedback on the exercise and their experience, by using a candidate feedback questionnaire and an additional questionnaire about future recommendations. This procedure helps to draw a comprehensive conclusion on the testing experience (APPENDIX D).

#### **4.3 Self-content analysis by using automatic accessibility checkers**

Three different automatic checkers were selected in this research to perform the accessibility conformance checks to WCAG standards. The reasons for using three different accessibility tools due to the fact that these tool are subjected to producing false or misleading results such as not identifying or signal incorrect code. Therefore results from one evaluation tool cannot be counted on to determine conformance levels of a website to the accessibility standards. Generally, web accessibility evaluation tools cannot give critical decision on the accessibility of websites; they can only help in doing so when they are operated by an experienced person who knows the limitations of each tool.

In this research three different automatic accessibility checkers namely “HiSoftware Cynthia”, “WAVE” and “AChecker” were used to check the accessibility of the e-Government website under study. The three checkers were selected from the W3C list of recommended accessibility checkers. The selection criteria of the automatic checker are based on their accuracy level and to compensate for any limitations of a single tool’s functionality. The “HiSoftware Cynthia” specifically checks for adherence to “Section 508” guidelines. The automatic evaluation tool scans the webpage and generates a report of the content that failed to pass the WCAG accessibility requirements. The report of non-compliance to the WCAG accessibility requirements consist of 16 subsections divided alphabetically.

#### **4.4 Interviews with web designers and developers**

The aim of interviewing web designers and developers was to be able to answer the following question:

- What are the typical constraints faced by the web designers and developers in making the website universally accessible?

Interviewing web designers and developers forms the last part of our evaluation framework. Web designers and developers play a key role in solving accessibility and

usability problems for blind users. They lie in the central part of the issue, who gets information about designing websites or portals for government agencies. Their understanding and tackling of the issue of accessibility and usability problems for blind users would determine the fate of level of involvement of disabled or blind users into the modern world of internet and telecommunications.

A questionnaire was prepared for three major web designing companies in the Kingdom of Saudi Arabia. The aim of the questionnaire was to get a feedback on accessibility and usability issue from designer's point of view and to examine their understanding of the problem. Full questionnaire has been attached in APPENDIX C.

Three web designing companies were interviewed to gather a common interpretation of the problem. The names of the three web designing companies and interview transcripts have not been included for confidentiality reasons. All the three chosen companies had experience of designing e-Services for the government sector. All the interviewees had a minimum of three years of experience in the industry. The interviews were conducted in the premise of the web designing companies.

The core important issues aimed from the questionnaire were to get the designers' opinions of on the matter of accessibility problems faced by blind users, their technical point of view and the feasibility of possible improvements to tackle such problems. The web designers and developers were also asked to comment on the toughest challenges that could be faced by blind users related to accessibility and usability of web based resources and how the user experience could be improved.

It was revealed in the literature review that a very common perception of adapting a design to suit the requirements of disabled users is the idea that all that is needed for such group of people is to acquire special assistive technology that will replace missing accessibility information on websites. However, in real practice the web designers and developers need to be more careful and vigilant about the wide variety of disabled people who would be using the resource or the service and understand the accessibility and usability problem from their perspective to design a better website or a portal that could serve the original purpose.

## CHAPTER 5

### RESULT AND ANALYSIS

#### OBJECTIVES

- Analyse findings and results of the primary research
- Investigate and deploy measures taken to develop a more accessible and usable e-Government website
- Outline the specification of the evaluation approach for the proposed solutions.

#### 5.1 Results of pre-user testing session questionnaire

This section provides a detailed analysis of the results from applying the tri-staged accessibility evaluation approach followed in this research. The first evaluation technique was to conduct an experimental exercise with 30 blind users selected by using a probabilistic sampling method. The procedure of experimental exercise has been described in section 4.2.1.

The questionnaire and feedback form have been attached in Appendix A. The second evaluation technique was to check the website by using automatic accessibility checkers to evaluate the website against WCAG guidelines and recommendations. The third evaluation technique was to discuss the problem of accessibility with experienced web designers and to get their technical point of view on some possible improvements.

The results from the experimental exercise were individually analysed for all the 30 interviewees. The details of pre-user testing session questionnaire (Appendix A) have not been included in this section for confidentiality reasons. However, the summary of responses from the 30 interviewees on the given questionnaire is shown below. The percentages in brackets indicate the number of interviewees out of 30, which gave the selected response.

1) Do you have a personal computer at home?

[20%] Yes; [80%] No

2) Do you have access to internet connection at home?

[13.33%] Yes; [86.67%] No

3) If you don't have internet connection, do you have access to internet by any other means?

[6.67%] Yes; [93.33%] No

4) How many internet users are there in your family?

[50%] None; [6.67%] 1 family member; [10%] 2 family members; [16.67%] 3 family members; [6.67%] 4 family member; [6.67%] More than 4 family members; [3.33%] All family members

5) How would you rate your level of confidence with the use of blind reader?

[46.67%] Novice; [26.67%] Beginner; [10%] Intermediate; [10%] Advanced; [6.67%] Expert



6) Do you have any previous experience with online or web based interaction? If yes, have you visited the e-Government website of Saudi Arabia before?

[33.33%] Yes; [66.67%] No

[46.67%] Yes; [53.33%] No

7) How would you rate your level of computer literacy?

[60%] Never used; [20%] Beginner; [10%] Intermediate; [6.67%] Advanced; [3.33%] Expert

8) If you are an internet user, what kind of websites do you normally visit? And how much is the average time that you spend on internet?

[10%] News portals; [10%] Search engines; [10%] Social networking; [60%] Various; [10%] Professional level

As mentioned in section 4.2.6 the pre-user testing session questionnaire was aimed at profiling the level of IT literacy and web experience of interviewees. Figure 15 and Figure 16 shows the percentage of interviewees with access to computer, internet connection, and the level of IT literacy.

## Access to computer and internet connection

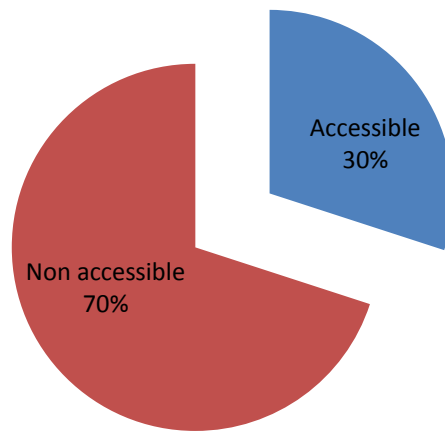


Figure 15: Percentage of interviewees with access to computer and internet connection

## Level of IT Literacy

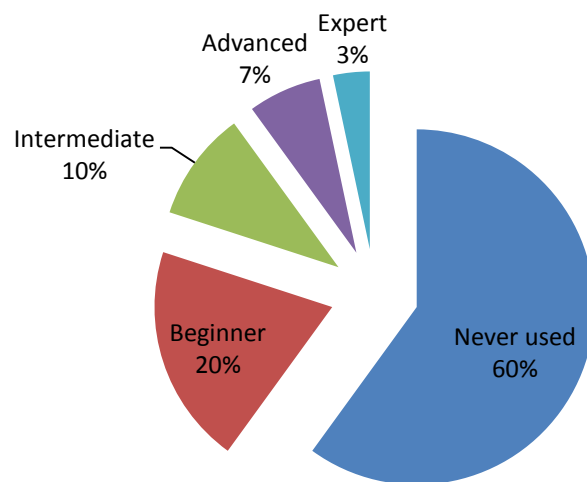


Figure 16: Subdivision of level of IT literacy of 30 interviewees

The result from pre-user testing session questionnaire shows that most of the blind people do not have access of computer and internet connection. The analysis of questionnaire also shows that the average level of computer literacy and IT skills is very poor.

The lack of computer and IT skills re-emphasizes the importance of having a high degree of accessibility and usability of e-Government websites. A blind user would find it very difficult to navigate through a website if due considerations were not given to his/ her requirements and challenges faced during web based interaction.

## **5.2 Results of experimental exercise**

The experimental exercise conducted with 30 blind people shows a clearer picture of challenges faced by blind while navigating through e-Government websites. During the experimental exercise, the activity of interviewee was duly observed and noted by the researcher in the form of an experimental exercise evaluation form (as shown in Appendix C). The aim of filling the experimental exercise evaluation form was to record every minute detail of the tasks performed by the interviewees including the time taken, the number of repetitions if any and the degree of difficulty experienced by them.

The summary of observations made by the researcher is shown below. The percentages in brackets indicate the number of interviewees out of 30 who gave the selected response.

### 5.2.1 Pie chart representation of the result

This section gives a summary of the observational forms filled out by the researchers for two tasks and for all participants. The detailed result of all tasks is shown in Appendix C. The value given for each task is given based on the in-test participants' observation form shown in Table 4.

#### 1) Find a health facility by distance. [Ministry of Health]

- I. How much time did this task consume?

**Average time taken for all participants: 4 minutes 28 seconds**

- II. Did the interviewee found it easy to locate the correct page?

**[ 20% ] Yes [ 80% ] No**

- III. Did the interviewee face any problems with the task?

**[ 13.33% ] Yes [ 86.67% ] No**

- IV. Did the interviewee found it easy to write his/her feedback on the website ?

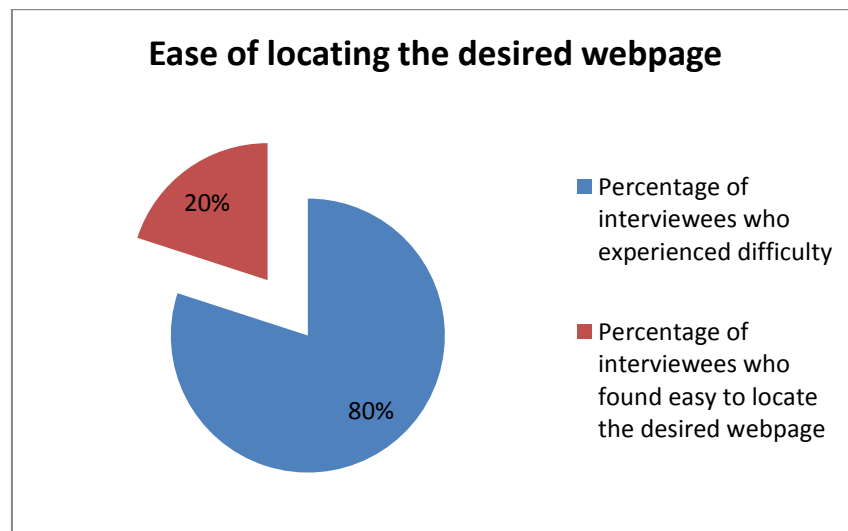
**[ 54.9% ] Yes [45.1% ] No**

- V. Was the feedback entered by the interviewee free of any error? [ 33.5% ] Yes

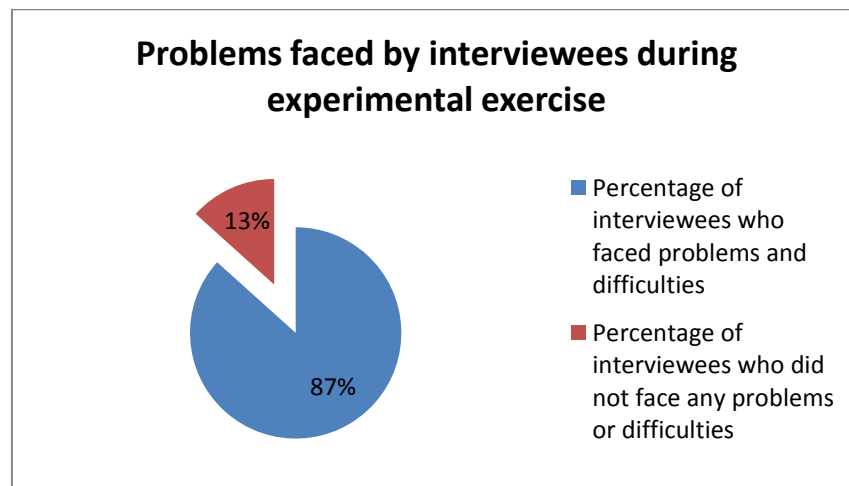
**[66.5% ] No**

- VI. Comments: **Very difficult to navigate from the home page. Poor accessibility.**

- VII. Rate the overall task performed by the interviewees?



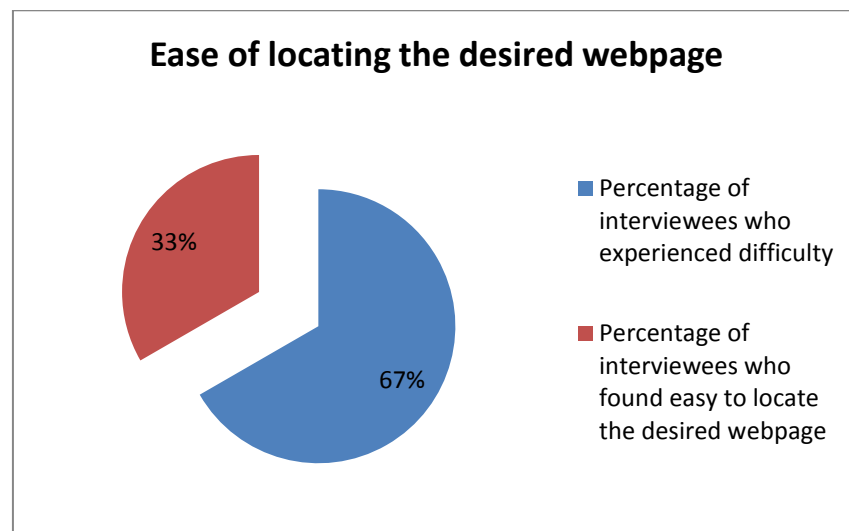
**Figure 17: Comparison of interviewees on the basis of ease of locating the desired webpage**



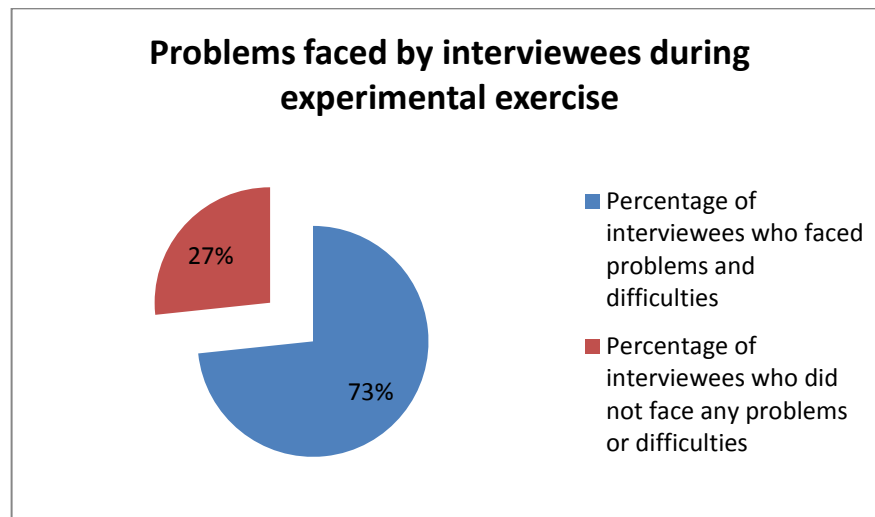
**Figure 18: Comparison of interviewees on the basis of problems faced during experimental exercise**

2) Find a private medical facility. [Ministry of Health]

- I. How much time did this task consume?  
**Average time taken for all participants: 4 minutes 05 seconds**
- II. Did the interviewee find it easy to locate the correct page?  
[ 33.33% ] Yes [ 66.67% ] No
- III. Did the interviewee face any problems with the task?  
[ 26.67% ] Yes [ 73.33% ] No
- IV. Did the interviewee find it easy to write his/her feedback on the website ?  
[ 13.9% ] Yes [ 86.1% ] No
- V. Was the feedback entered by the interviewee free of any error? [ 23.5% ] Yes  
[ 76.5% ] No
- VI. Comments: **Time spent on restarting the screen reader.**
- VII. Rate the overall task performed by the interviewees?



**Figure 19: Comparison of interviewees on the basis of ease of locating the desired webpage**



**Figure 20: Comparison of interviewees on the basis of problems faced during experimental exercise**

The conclusion is that most of the interviewees found it difficult to complete the tasks and took quite a long time. Also most of the interviewees were not able to locate the desired web page and web links because of navigational issues. It was noticed that most of users prefer to go back to the top of the page whenever they were asked to perform a new task. This was a major contributing factor to increased time taken and inability to complete the task. Each task was individually rated by the researcher for overall performance of the interviewee.

### 5.2.2 Numerical representation of the result

In this section, the numerical representation is illustrated on the basis of our performance indicator listed in . For each performance indicator, the performance result of every user performing the 14 tasks is coded following our (2, 1, 0) scale, and then the average performance result for every task is calculated. This average value for every single task will be used as a metric to assess any future improvement for this task.



Table 5: Participants results against the 1<sup>st</sup> performance indicator

P1	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14
U1	2	0	2	1	0	2	0	1	2	0	1	1	1	2
U2	0	2	1	0	0	0	1	1	0	2	2	0	0	0
U3	0	1	0	1	1	0	1	2	0	1	0	0	2	0
U4	1	0	1	0	1	0	0	1	2	0	1	0	1	1
U5	1	1	0	1	1	1	1	1	0	1	0	1	1	2
U6	1	1	2	0	1	2	0	2	2	0	1	1	0	1
U7	0	1	0	2	0	1	0	0	0	0	0	0	0	1
U8	0	1	0	0	0	1	0	1	1	1	0	0	0	0
U9	0	1	1	1	0	2	0	0	0	1	1	1	1	0
U10	2	0	2	0	0	0	2	1	2	0	0	0	1	1
U11	2	0	1	0	2	0	1	1	1	1	1	1	0	0
U12	0	0	1	1	0	1	0	0	0	0	0	1	1	1
U13	0	1	0	1	1	0	1	0	0	2	1	0	0	0
U14	1	0	2	0	0	0	1	1	0	0	1	2	1	2
U15	0	1	0	0	0	1	0	1	2	1	0	0	1	1
U16	2	0	1	1	1	1	0	1	1	0	1	0	0	1
U17	1	2	0	0	0	1	1	0	0	1	2	2	1	0
U18	1	0	1	1	0	2	1	2	1	0	1	0	0	1
U19	1	2	1	0	1	0	1	1	1	0	1	2	0	2
U20	1	0	0	1	0	1	1	0	2	1	0	0	2	1
U21	0	0	1	1	1	1	0	1	0	0	0	2	0	2
U22	0	2	0	0	0	1	1	0	1	0	2	0	1	1
U23	0	0	0	1	0	0	1	2	0	2	1	0	0	0
U24	1	1	2	0	1	2	0	0	2	0	1	2	0	1
U25	0	0	0	1	1	0	1	1	0	0	0	1	2	1
U26	0	1	0	1	0	0	1	0	0	1	1	1	0	0
U27	0	1	0	1	0	2	0	2	1	1	0	1	1	2
U28	2	2	2	1	0	2	2	2	0	0	2	2	0	2
U29	1	0	1	0	1	0	0	0	0	0	1	1	0	0
U30	0	1	0	2	0	1	1	0	1	0	1	0	1	1
Average	.66	.73	.73	.63	.46	.83	.63	.83	.73	.53	.76	.7	.6	.9

Table 6 : Participants results against the 2<sup>nd</sup> performance indicator

P2	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14
U1	1	1	1	0	0	1	1	1	1	1	0	1	1	1
U2	1	1	1	0	0	2	0	1	0	0	0	0	0	0
U3	0	1	0	2	0	0	1	2	0	1	0	0	1	1
U4	1	1	1	0	2	1	0	1	2	1	1	2	0	1
U5	0	1	0	1	1	0	2	1	1	2	1	0	1	0
U6	1	0	1	1	1	1	0	0	1	0	0	2	0	2
U7	0	0	0	1	0	0	1	0	0	1	0	0	1	1
U8	1	0	0	1	0	1	0	1	0	0	1	0	0	0
U9	0	1	1	1	0	2	0	0	1	1	2	1	1	1
U10	2	0	1	1	1	0	2	1	2	0	0	1	1	0
U11	0	1	2	0	1	0	0	1	1	1	2	0	1	2
U12	1	0	1	1	0	2	0	1	0	0	1	2	0	0
U13	2	1	0	1	0	0	1	0	0	1	0	0	2	1
U14	1	1	2	0	1	2	1	0	1	0	1	1	1	2
U15	1	1	0	1	0	0	0	2	0	0	0	0	0	1
U16	1	0	1	1	1	1	1	2	1	0	1	2	1	0
U17	0	1	0	1	0	0	1	1	0	1	1	0	0	1
U18	0	0	0	1	0	1	1	0	1	0	0	1	0	0
U19	2	0	1	0	1	0	1	0	1	1	1	1	1	1
U20	1	1	0	1	1	2	1	2	1	1	0	1	0	2
U21	1	0	1	0	1	1	0	1	1	0	1	1	1	1
U22	0	1	0	0	1	0	1	0	0	0	1	1	0	1
U23	0	0	0	1	0	1	2	0	1	2	1	0	1	0
U24	1	1	1	1	0	0	0	2	1	0	0	2	0	1
U25	0	0	1	1	1	1	1	1	0	1	0	0	1	0
U26	0	2	0	0	1	0	0	0	0	1	2	1	1	1
U27	1	1	0	0	0	1	1	2	1	0	0	1	1	2
U28	2	1	2	2	1	1	2	1	2	2	2	2	0	1
U29	1	0	2	1	0	0	0	1	0	0	0	1	0	0
U30	0	1	0	1	0	1	2	0	0	2	1	0	2	1
Average	.73	.63	.66	.73	.5	.73	.76	.76	.66	.66	.66	.8	.63	.83

Table 7: Participants results against the 3<sup>rd</sup> performance indicator

P3	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14
U1	0	1	1	0	1	1	1	12	1	0	0	1	0	1
U2	1	1	1	0	0	0	1	1	0	1	2	1	1	0
U3	0	1	1	2	1	0	1	0	2	1	1	0	1	0
U4	1	0	2	0	1	0	0	2	1	1	1	1	0	1
U5	0	2	0	0	0	0	2	0	0	1	0	0	1	1
U6	1	1	1	1	1	2	0	2	1	0	1	2	0	1
U7	0	1	1	1	0	1	1	0	0	1	0	0	1	0
U8	1	1	0	1	0	0	1	0	2	0	1	1	0	1
U9	0	1	1	1	0	2	1	1	0	1	0	0	1	0
U10	1	0	2	0	1	0	1	2	0	0	1	2	0	1
U11	2	1	0	0	2	0	0	1	2	1	1	0	1	2
U12	0	0	2	1	1	2	1	1	0	0	0	2	0	0
U13	1	2	1	1	0	0	1	0	0	2	1	0	2	1
U14	0	1	0	0	1	2	1	0	2	1	1	1	0	1
U15	0	0	0	0	1	0	1	0	0	1	0	1	1	1
U16	2	1	1	1	2	1	0	2	1	0	1	1	1	1
U17	1	2	0	0	0	1	0	0	0	1	1	0	0	0
U18	0	0	1	0	1	2	1	1	0	0	0	1	1	0
U19	1	1	1	1	2	2	0	0	2	1	1	1	0	1
U20	0	0	0	1	1	1	2	1	1	0	1	0	1	0
U21	2	0	2	0	1	1	1	1	1	1	0	2	0	1
U22	0	1	1	1	0	0	1	1	0	0	2	0	1	0
U23	0	0	1	1	1	0	1	0	1	2	1	1	0	1
U24	1	2	1	1	2	2	1	2	1	0	0	0	1	1
U25	1	1	0	1	0	0	0	0	0	1	1	1	1	0
U26	0	1	0	0	1	1	1	1	0	0	0	0	1	1
U27	2	0	2	1	0	0	0	1	1	2	0	2	1	1
U28	2	2	1	2	1	2	1	2	2	0	2	0	1	0
U29	0	1	1	0	1	0	0	0	0	1	0	0	0	1
U30	1	1	2	1	0	1	2	0	0	2	2	1	1	0
Average	.7	.86	.9	.63	.76	.8	.8	.8	.7	.73	.73	.73	.63	.63

Table 8: Participants results against the 4<sup>th</sup> performance indicator

P4	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14
U1	1	0	2	0	1	2	0	2	2	0	0	1	1	2
U2	0	2	1	1	0	0	0	0	1	2	0	1	0	1
U3	1	0	0	2	0	1	1	0	1	1	0	1	1	0
U4	2	0	1	0	1	1	1	2	1	0	2	2	1	2
U5	0	1	0	0	1	0	1	1	0	1	0	0	0	1
U6	1	1	1	1	1	0	0	2	1	1	2	1	1	0
U7	0	0	0	1	1	0	1	0	1	0	0	0	0	1
U8	0	1	0	1	1	0	1	0	1	0	1	0	0	0
U9	1	1	1	1	0	1	0	1	0	1	1	1	2	1
U10	0	1	1	1	0	1	1	1	0	0	2	1	0	0
U11	1	0	0	0	1	0	0	1	2	0	1	0	1	2
U12	0	1	1	0	0	1	1	1	0	1	0	2	0	0
U13	1	1	1	1	0	0	0	0	1	0	0	0	2	1
U14	2	0	2	0	2	2	2	1	2	1	2	2	0	2
U15	0	1	0	0	1	1	0	0	0	0	1	0	1	1
U16	2	0	1	0	1	0	1	0	1	1	0	2	1	2
U17	1	1	0	1	1	1	1	0	1	0	2	0	0	0
U18	0	0	1	1	0	1	2	2	1	1	0	1	1	0
U19	0	0	2	1	1	0	1	1	2	0	1	1	0	1
U20	1	0	1	1	1	2	1	1	0	2	1	1	1	1
U21	1	2	1	0	2	0	0	1	1	0	0	1	0	1
U22	0	1	0	0	0	1	1	0	0	0	1	0	1	0
U23	1	0	1	1	1	0	1	2	1	0	0	1	0	1
U24	1	0	2	1	2	1	0	0	1	0	1	0	1	1
U25	2	1	0	1	1	0	2	0	0	2	1	1	1	0
U26	0	2	1	0	0	0	1	1	1	1	0	0	1	2
U27	1	0	0	1	1	2	0	1	0	0	1	2	0	0
U28	2	2	1	1	1	1	1	2	1	2	1	2	1	2
U29	1	0	1	1	1	0	0	0	2	0	0	0	0	0
U30	0	2	0	1	0	1	1	0	0	2	1	0	2	1
Average	.76	.7	.76	.66	.76	.66	.73	.76	.83	.63	.73	.8	.66	.86

Table 9: Participants results against the 5<sup>th</sup> performance indicator

P5	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14
U1	1	0	1	1	0	2	0	1	1	0	0	1	1	2
U2	0	1	0	0	1	0	0	1	0	2	0	2	0	1
U3	0	1	0	1	1	0	1	0	1	1	0	0	1	0
U4	2	0	1	0	1	1	0	1	2	0	1	2	0	1
U5	0	1	1	0	1	0	0	1	0	2	1	0	1	0
U6	1	0	1	1	1	1	1	0	1	0	0	0	0	1
U7	0	0	0	1	1	0	1	1	1	0	1	0	1	1
U8	0	0	0	0	0	2	1	2	1	0	0	0	0	0
U9	2	1	0	1	0	0	1	0	0	1	1	1	2	1
U10	1	0	1	1	1	0	1	1	0	1	1	2	0	0
U11	0	0	0	2	0	0	0	1	2	0	1	1	1	2
U12	1	2	2	0	0	0	1	1	1	0	0	1	0	1
U13	0	1	0	1	1	1	1	1	1	1	2	1	1	1
U14	2	2	2	0	0	2	2	0	1	0	1	0	0	1
U15	0	1	1	0	1	0	0	0	0	1	2	0	1	0
U16	0	0	1	1	1	1	0	2	1	0	1	2	1	2
U17	1	1	2	0	1	0	1	0	0	1	1	0	0	1
U18	0	1	1	0	0	0	1	1	1	0	0	1	0	0
U19	2	0	1	1	1	2	1	0	0	1	1	1	1	1
U20	1	0	0	1	1	1	1	0	0	2	0	0	1	0
U21	0	2	1	0	2	0	1	1	2	0	1	2	0	2
U22	0	1	1	0	0	0	0	0	0	1	1	0	1	1
U23	1	1	0	1	1	1	2	0	0	0	1	2	0	1
U24	0	0	2	0	1	2	1	2	2	0	0	0	0	1
U25	0	0	1	2	1	0	2	0	0	2	1	0	2	0
U26	1	1	0	0	0	0	0	1	0	1	1	1	0	0
U27	2	0	1	0	0	1	1	1	1	0	0	1	1	2
U28	0	2	1	2	2	2	0	2	2	2	1	1	1	1
U29	1	1	1	1	1	1	1	0	0	1	0	0	0	0
U30	0	1	0	2	1	0	1	0	0	0	2	0	1	1
Average	.63	.63	.76	.66	.73	.66	.76	.7	.7	.66	.73	.73	.6	.83

As already stated, the performance of each task was mapped to a scale from 2 to 0 based on the researcher in-test observational form that was filled during the exam ( ).

The maximum value each task can accumulate for all participants is 60 points, and the optimal average value, by dividing the 60 on the number of participants, is 2.

As it can be seen from the illustrated results, most of the tasks got low average value compared to the optimal average value of 2. Some of the tasks got considerably lower average values than other tasks in all of the 5 performance indicators like task 1, task 5 and task 13. It was also noted that in these tasks the participants was required to navigate to the bottom of the web page to perform the task. Moreover, in these tasks, along with other tasks which have similar low average values, participants tended to reset their screen readers repeatedly. Some other tasks like task 7, task 8, task 9 and task 14, achieved better average values in all of the 5 performance indicators. Three of these tasks were close to the top right corner of the webpage where the screen reader usually starts narrating the website content. This is referred to the issue that the mental map and cognitive load of participants at this stage is still effective. Some tasks, on the other hand, which required the user to navigate to the bottom of the webpage, had better performance than tasks on the middle of the website. This could be attributed to the fact that such tasks performed after a precedent task located relatively on top of it. The close sequence of two tasks justifies the difference of results between the two and eliminates any ambiguity. The average value for the task of searching for a job, for example, was satisfactorily completed by more number of interviewees as compared to other tasks. This task is located just below the main headings of the home page.

However, all values shown in these tables does not lead to any conclusion as to whether the eGovernment portal is inaccessible or not, It needs to be used as an indicator and as a baseline to evaluate any suggested improvement.

Based on foregoing, it can be concluded that the problem of accessibility faced by blind users is less dependent on the exact task to be performed and more on the layout of the website.

### 5.3 Results of candidate feedback questionnaire

The experimental exercise was followed by a candidate feedback questionnaire, which was designed to better understand the user's experience while using the e-Government website. The tasks on experimental exercise resembled very closely what a blind user would normally do on a regular basis. Thus it has been assumed that if the website was developed keeping in mind the basic requirements of blind people, the experimental exercise must give satisfactory results for the sample of interviewees selected, irrespective of their IT literacy.

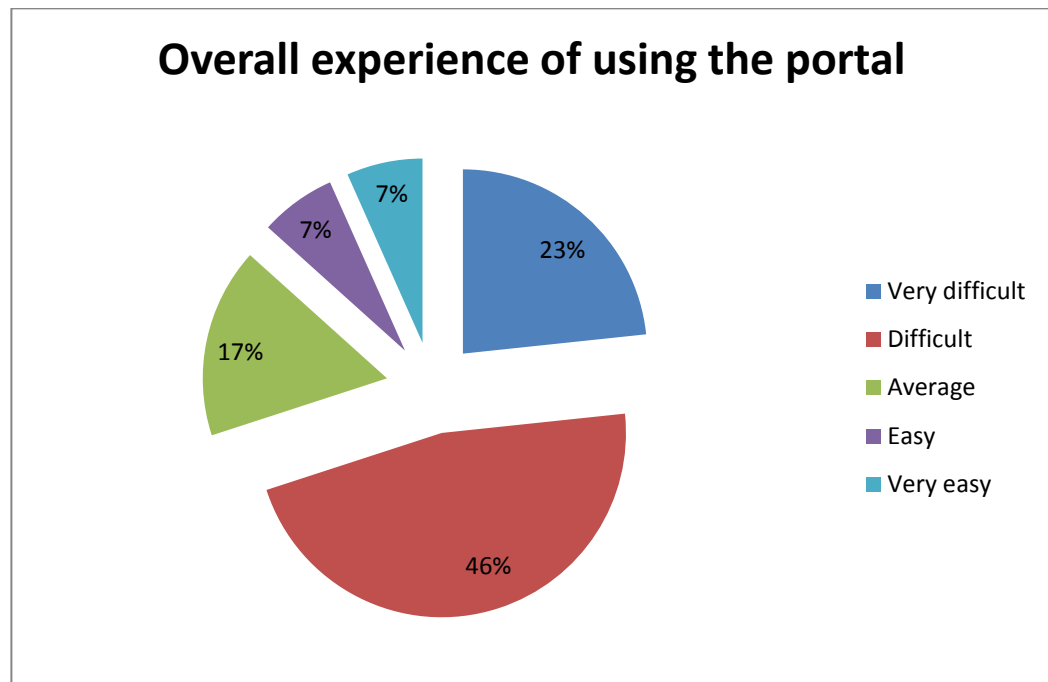
The questions were verbally asked from the author to each individual candidate to avoid communication gap, and allow free flow of thoughts about the web based experience. The interviewees were requested to comment on the questions of feedback form and the answers were noted in the forms by the researcher. The summary of results obtained from candidate feedback questionnaire is shown below. The percentages in brackets indicate the number of interviewees out of 30, which gave the selected response. The rating of overall task performed by the interviewee is given on the scale of (2,1,0). Some questions also required the interviewee to comment on a specific topic. In such cases a general consensus of whether the comment was positive, negative or neutral has been formulated.

The candidate feedback questionnaire given to interviewees after the experimental exercise consisted of the following questions:

- 1) How would you rate the overall experience of using the portal? Was it positive and helpful?

Very Difficult [ **23.33%** ], Difficult [ **46.67%** ], Average [ **16.67%** ], Easy [ **6.67%** ], Very Easy [ **6.67%** ]





**Figure 21: Comparison of interviewees on the basis of overall experience of using the web portal**

An important feedback from most of the interviewees was about FAQs. The FAQ link on the home page of e-Government website is at the bottom of the list of main menu options, which is not very easy to locate. Some participants preferred the location of the FAQs would be at the top right corner of the webpage, where the blind can easily spot the link whenever required.

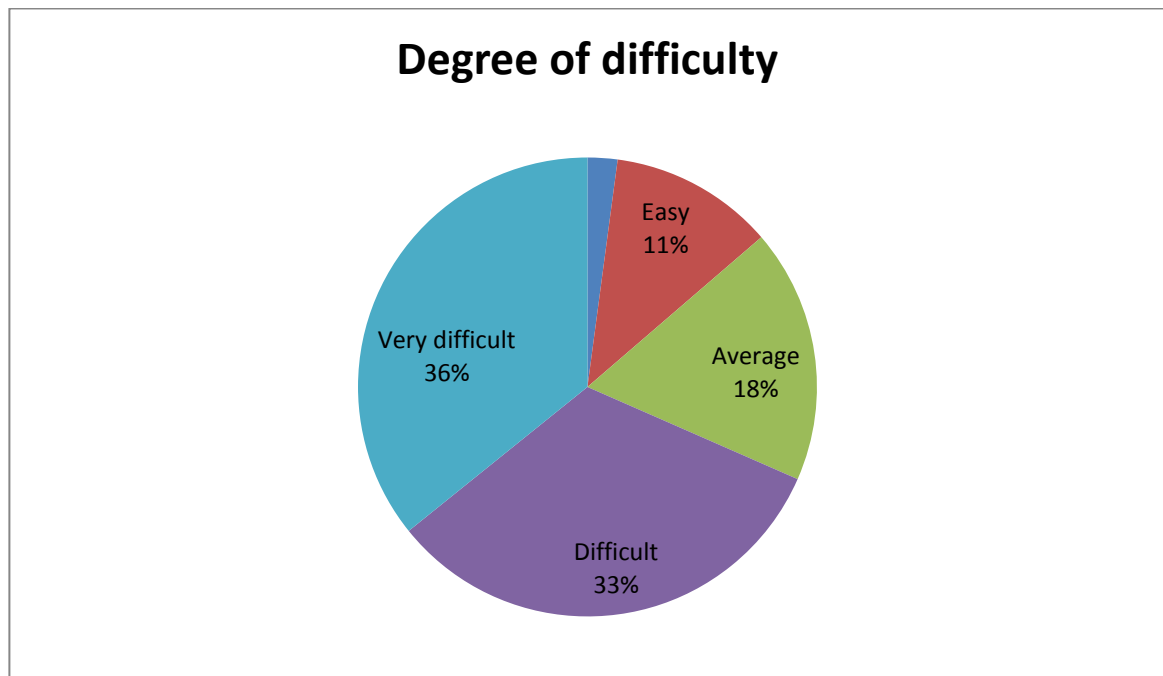
Apart from location of the link, another important feedback on FAQs was on the questions itself. The questions listed were not very helpful if a blind user needs help in

locating some basic features of the website. Some examples of questions could be summarized as follow:

1. Where is the search box on the website?
2. How do I register on the website?
3. Are there any specific instructions for blind users?

All details of the tasks conducted by the interviewees were duly recorded including the time that they took, the number of repetitions if any and the level of difficulty experienced by them. At the end of assessment, the interviewees were asked to comment on the questions of feedback form and the answers were filled by the researcher.

The data from all the thirty feedback forms were brought on a common scale and thereafter the findings were plotted on a pie chart to give a detailed comparative illustration.



**Figure 22: Comparison of interviewees on the basis of overall experience of using the web portal**

The rest of feedback forms is shown in Appendix D

It was expected that the results from the experimental exercise would certainly be different depending on the IT literacy of different interviewees. However, this fact has already been taken into account while developing the questionnaire. The questionnaire for the experimental exercise was developed keeping in mind the basic functionality or feature a blind user would like to access on the e-Government website.

## 5.4 Results of interview with web designers and developers

Three independent web designers from different e-Governments development companies were interviewed to give feedback on the accessibility and usability issues faced by the blind people. The identity of the three companies has been kept confidential for data protection reasons. The questions asked to the web designers and developers of all the three companies have been listed in APPENDIX E. The results of interview have been summarized below.

- 1) What do you think are the toughest challenges faced by BLIND users related to accessibility and usability of web based resources?

First interviewee: **Access of a personal computer and internet.**

Second interviewee: **Lack of IT literacy amongst blind population.**

Third interviewee: **blind users often take much longer to execute a web based task and thus the option is not very attractive to them.**

- 2) Why did a well-designed e-Government portal like the Saudi which conform to the WCAG guidelines receive a low rating by our blind users?

First interviewee: **I think the degree of accessibility of a website is heavily dependent on the literacy background and perception of blind user towards web based services.**

Second interviewee: It could be attributed to many reasons, the user computer literacy, the WCAG guidelines were not implemented properly or there are other factors related to the screen reader used.

Third interviewee: **This is normal. WCAG guidelines are only recommendations. Referring and adhering to WCAG guidelines might not always result in complete user satisfaction.**

- 3) We noticed that many users were not able to follow the screen reader properly; a great deal of their time was wasted on restarting the screen reader every now and then. What do you propose to solve this problem?

First interviewee: **Enhancing the level of IT literacy is the key.**

Second interviewee: **changing the layout of the website to reduce the depth of the site could be a solution. However; this would damage the aesthetics of the website for sighted users.**

Third interviewee: **Running country wide training programmes and improving the content of website.**

- 4) Some users implicitly say that the website is too long and suggested to reduce its length, what is your opinion about this thought?

First interviewee: **The Saudi e-Government website is of average size with standard page heights and width**

Second interviewee: **This could be related to the fact that they are using the website for the first time or due to their computer literacy.**

Third interviewee: **For a sighted user it is ok compared to other website.**

- 5) What are the typical constraints faced by the web designers and developers in making the website universally accessible?

First interviewee: **Aesthetics of the website for normal sighted users.**

Second interviewee: **Aesthetics of the website and lack of understanding of accessibility and usability issues with blind users.**

Third interviewee: **Aesthetic look of the website.**

6) Any further comments?

First interviewee: **The extent to which web designers and developers consider accessibility and usability issues faced by blind users is broadly governed and influenced by the client. Thus the government has a major role to play in improving accessibility and usability for blind users.**

Second interviewee: **The accessibility and usability issues are highly variable and not very well understood in the industry. More research needs to be done in this area to identify the gaps and propose potential solutions.**

Third interviewee: **Accessibility and usability is a major problem and needs to be dealt with seriously. WCAG must take further initiatives to address the issue.**

The result of the interview of the web designers failed to reveal the exact problems that blind experienced. It showed that web designers assume that blind user are ordinary users who deal with the computer in non-visual contact. They did not consider the fact that the requirements of the blind are complex and distinct compared to their sighted counterparts. However; one important point raised by the web developer comments is that the aesthetics of the website for normal users hinder any possible improvement to the blind users.

## 5.5 Results of using accessibility automatic checkers

Three widely accepted tools were chosen to perform the automated accessibility checking to the e-Government portal: Cynthiasays, WAVE and AChcker. The reason for this evaluation process is to reveal any non-conformity of the website to the WCAG standards that may cause dissatisfaction among blind users. Cynthia Says is a free Web accessibility testing tool for validating Web content developed by HiSoftware to evaluate the online content against WCAG accessibility standards. The HiSoftware Cynthia Says accessibility checker is among the recommended portals by World Wide Web Consortium (W3C). The homepage of Cynthia Says is shown in Figure 23



The screenshot shows the homepage of the Cynthia Says accessibility checker. At the top is the logo, which consists of a yellow speech bubble with a blue dot inside, and the text "CynthiaSays" in blue, with "POWERED BY HISOFTWARE" in smaller blue text below it. Below the logo is a dark blue navigation bar with white text links: "HOME", "ABOUT", "HELP", "READING REPORTS", and "TERMS OF USE". The main content area has a white background. It starts with the heading "Welcome to the HiSoftware® Cynthia Says™ Portal". Below this is a paragraph of text explaining the portal's purpose: "The HiSoftware CynthiaSays™ portal is a joint education and outreach project of HiSoftware, ICDRI, and the Internet Society Disability and Special Needs Chapter. Cynthia Says educates users in the concepts behind website accessibility. It is meant for personal, non-commercial use to inform the community on what constitutes accessible web design and content. It helps users identify errors in their Web content related to Section 508 standards and/or the WCAG guidelines for Web accessibility. Cynthia Says allows users to test individual pages on their website and provides feedback in a reporting format that is clear and easy to understand." To the right of this text is a box titled "Download the Accessibility Handbook" with a link and a brief description. Below the text is a section titled "TEST YOUR SITE NOW" which contains a form. The form has two input fields: "Web Page URL:" with a text box containing "http://" and "Compliance mode:" with a dropdown menu showing "Section 508". At the bottom of the form is a checkbox labeled "I agree to the Terms & Conditions."

**Figure 23: Cynthia Says accessibility checker**

The tasks list in section 4.2.6 cover three web pages of the e-Government portal and hence these pages will be examined by the accessibility checkers for their compliance to



WCAG standards. As mentioned earlier, W3C is an international community that integrates and develops open standards, protocols and guidelines for websites aimed to achieve highest standards of accessibility and usability. Two more checkers were used to evaluate e-Government website from all the perspectives.

The other automated accessibility checker used was WAVE Figure 24. WAVE is a product of WEBAIM.org and it checks websites for their browser compatibility, broken links, and accessibility and for web standards validation. It has a separate accessibility checker and validator compatible with the WCAG guidelines and with section 508 of the Rehabilitation Act. It also covers all the three priority standards of WCAG namely Priority A, Priority AA, Priority AAA.



**Figure 24: WAVE accessibility checker**

The last automated accessibility checker used is named 'AChecker Figure 25. It divides the non-conformities and non-compliances issues of a website into separate subheadings (AChecker). This checker was developed in Canada and is especially useful for HTML and CSS validation.

Web Accessibility Checker

Check Accessibility By:

Web Page URLHTML File UploadPaste HTML Markup

Address:

Check It

Options

**Welcome to AChecker.** This tool checks single HTML pages for conformance with accessibility standards for everyone. See the Handbook link to the upper right for more about the Web Accessibility Checker.

Figure 25: AChecker accessibility tool

Upon our self-checking of the three selected web pages it seems that the Saudi e-government portal is well technically designed with care attention to compliance to WCAG standards. The three accessibility checkers were applied into the selected three webpages covered in the study. Given the richness of content and features of each page, every checker generated a long report which shows the result of the analysis. Reports were reviewed and summarized in tabular format for better visibility Table 10.

**Table 10: Result of automatic accessibility checkers**

	Cynthia				AChecker'				WAVE			
	A	AA	AAA	Total	A	AA	AAA	Total	A	AA	AAA	Total
<b>Page 1</b>	0	1	2	3	0	0	1	1	0	2	1	3
<b>Page 2</b>	1	1	2	4	1	2	4	7	0	2	1	3
<b>Page 3</b>	0	1	1	2	2	2	1	5	0	1	1	2

As can be seen from Table 10, all the three examined web pages presented few number of accessibility issues using the three checkers. The total number of accessibility problems ranges from 3 issues in page 1 to 5 issues in pages 3. The maximum number of major (A-level) problems was discovered in page 3 by AChecker, while the remaining problems (AA, AAA) are just alerts or minor layout-related issues. The 3 (A-level) problems discovered by AChecker in the two webpages were that related to java script implemented in the website, whereas the only (A-level) problem found by Cynthia in webpage was the absence of a frame title. The overall accessibility of the three pages is high given the low number of accessibility problems discovered by the three checkers. The most important thing is that none of the discovered problem has direct relation with the tasks list that blind users are asked to do in the experimental exercises. Most importantly, the tools focus on making the content of the website distinguishable, i.e. blind users should be able to read and hear the content including a clear separation from foreground to background, which is the case in the current e-Government portal.

Also, the webpages is designed to convey all the information in coloured or non coloured format based on the user choice. This is specifically useful for people who suffer from colour blindness as they will be able to access the required information

effectively. Also, the layout of the website and the arrangement of documents are styled using CSS technology discussed in section 2.6.1. As the CSS's prime job is to separate content from its structure, it also has the ability to control the spacing of the text and its alignment and positioning so as to make it readable by screen readers

Additionally, the checker also pointed out that redundant text links have not been provided for each active region of the server side image map. Also, if the website requires filling up of an electronic form, it must be designed to allow blind users reads the entered information using their screen readers. Also, field elements, and functionality required for completion and submission of the form must also be supplemented with all the necessary directions and cues that a blind can understand. Another point which has been noticed by the author while manual scanning of the webpage is that the image displayed as caption for inputting the security code on the registration page must also have an audio caption. The reason being that screen reader used by blind people would never be able to decode the letters written or displayed in the image. Thus the letters in the image must also have an audio caption so that a blind user can hear and input the security code in the required box. And as mentioned in the last paragraph, the column must be supplemented with all the necessary information, directions and cues about hearing and entering the security code. In conclusion, apart from the few cosmetic problems that website has, it seems that almost all of the WCAG guidelines were met especially in the three webpages covered in the experiment. We can argue that according to the WCAG standards, the design of the Saudi e-Government web-site is characterized by high accessibility.

## **5.6 Analysis of result of the evaluation methods**

A critical analysis of experimental exercise from section 5.1 to section 5.4 indicates that blind people face several challenges related to web accessibility and usability. These challenges are clearly reflected in the excessive time taken to perform the tasks, repetition of tasks, unable to locate the desired we blink or hyperlinks etc. These

challenges are logical in the case of poorly designed website or with low level compliance to the WCAG standards; however, with nearly level AAA compliant website this issue is totally excluded. Moreover, the selected sample of participants represents the blind population with all factors like age, computer literacy etc., are taken into account. The only main potential reason for the lack of accessibility is something related to what we already discussed in sections 2.8, 2.9 and 2.10 of our literature review, the concept of mental model and problem solving process.

During our close observation to the blind user while performing the given tasks, we noticed that the user faced difficulty going backward and forward from/to the current location of the cursor. The user tends to point the cursor again and again to the beginning of the website to resume the screen reader. The arguments for this behaviour are that similar to what we experience in our life, when we get lost in a new city we consult a map for getting the right orientation. This map will be used as mental model which guides us to traverse through our surrounding attributes (buildings, street etc.). This mental model is also applicable and used implicitly during the online interaction experience. For normal sighted users, the surroundings mental model of the website can easily be built through the visual contact with website pages and links. However, in the case of blind users, this mental map is not existed and hence they face great challenges in navigation efficiently through the website space. The website for a blind users represent a very wide space with richness in attributes (links, images, tabs etc.) without having any idea about the possible paths between these attributes. Therefore, this research is proposing a new cognitive-based solution to the navigation problems faced by blind users. The proposed solutions will aid the blind user construct a virtual map of the website that can be utilised by the screen reader in a way it does not affect the aesthetics of the website for the normal sighted users. The specification of this virtual map is discussed in the following sections.

## 5.7 Navigation process improvement

In order to address the issues of poor navigation discussed in section 5.7, the content and layout of e-Government website was modified. Several amendments were made to the website to facilitate the navigation process and to increase the website accessibility and usability. The major amendments included inserting a short description of the website at the beginning of each page and the inclusion of supportive navigational landmarks to guide the user during his/her interaction with the website. In the following section, we will show the process of building our proposed navigation improvement process. The original web pages of the e-Government portal Figure 26 will be altered in a newly designed web site to include the proposed solution.



Figure 26: Home page of e-Government website of Saudi Arabia

### 5.7.1 Short website's description

In order to help the blind users build a mental map of a visited web page, a short text will be inserted at the beginning of page to serve as a virtual map of the web page boundaries and space. A basic web page consists of text and mark up code. The mark up code is usually HTML (hypertext markup language), which is the language used to render the text to constitute a web page. The process of text rendering is done through tags <> which are markers tell the browser how the text is to be rendered and displayed by the browsers. There are tags for bold text, underlined text, frames, tables etc. A screen reader reads all page elements in the same order as they are placed and appeared in the page's source code. It starts reading web content from the top left-hand side to the bottom right-hand side and from left to right. The inclusion of the short description to the website has to maintain aesthetics of the websites for normal sighted users. Therefore, the description text should exist in the code to be read by the screen reader but has to be made invisible in the rendered webpage displayed by the browser. An html code was adopted to move the inserted text from the viewable area of the browser so that is not apparent visually to the normal user Figure 27. We used 2.6.1 Cascading style sheets (CSS) technology for this purpose. The theory and background of CSS has been explained in section 2.6.1.

```
.hidden
{position:absolute;
left:-10000px;
top:auto;
width:1px;
height:1px;
overflow:hidden;}
```

**Figure 27: Programming code of the navigational landmark .**

Figure 28 shows an example of text used in the programming code for navigational landmark.

```
<div class="hidden">This text is hidden.</div>
```

**Figure 28: Example of text used in the programming code**

The inserted text description will be a short summary of the website main links and tabs, their positioning and an overview of the web page boundaries. An example of the short description applied in this research is shown in Figure 29.

```
<div class="hidden"> من الرئيسية الصفحة من تبدأ تبويب 12 عدد من يتكون الموقع هذا  
خاصة تبويبات يوجد المنتصف في ، اليسار أقصى في المتكررة بالاسئلة تنتهي و اليمين  
الصفحة اسفل وفي الدخول صفحة يوجد اليسار على، (وزوار اعمال ، ومقيمون مواطنون ) من بكل  
</div> الرأي واستطلاعات بالأخبار خاصة متنوعة روابط
```

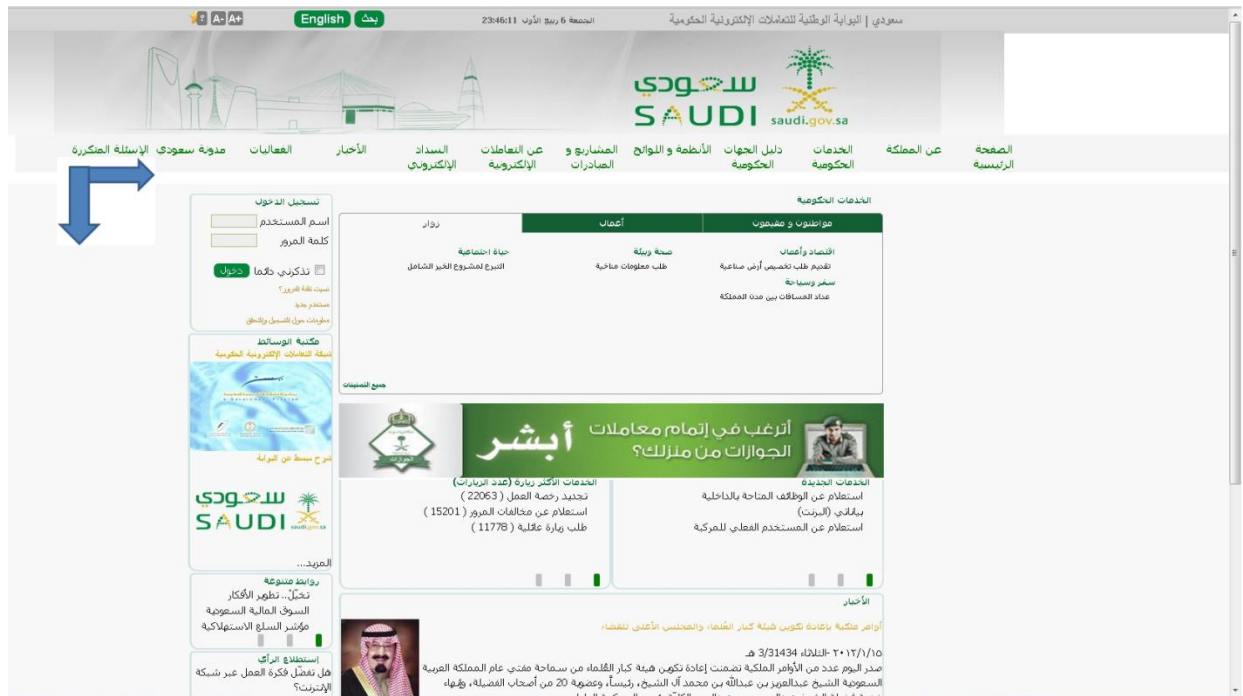
**Figure 29: HTML code of the home page of e-Government website**

### 5.7.2 Navigational landmarks

The most important amendment to the Saudi Arabia e-Government website was introducing the use of navigational landmarks. Navigational errors and problems were one of the key findings in our experimental exercise, which led to increased time consumption for each activity and dissatisfaction amongst blind users. The proposed solution was to introduce navigational landmarks on the web pages to guide the blind users about the website boundaries. These landmarks, which will also be, similar to the website description, invisible to the sighted user provide direction information relative



to the current location where the landmarks are placed. The aim of introducing navigational landmarks was to aid the blind user about the content near his/ her present browsing location and help in constructing a virtual map for them. Figure 30 shows an example of a navigational landmark placed at the end of main menu bar.



**Figure 30: Example of navigational aid on the main menu bar**

The navigational landmark shown in Figure 30 gives the user information about the web content on the right and on the bottom when he/she navigate to the end of the main headings. Figure 31 shows a snapshot of the relative HTML code with the navigational landmark is highlighted.





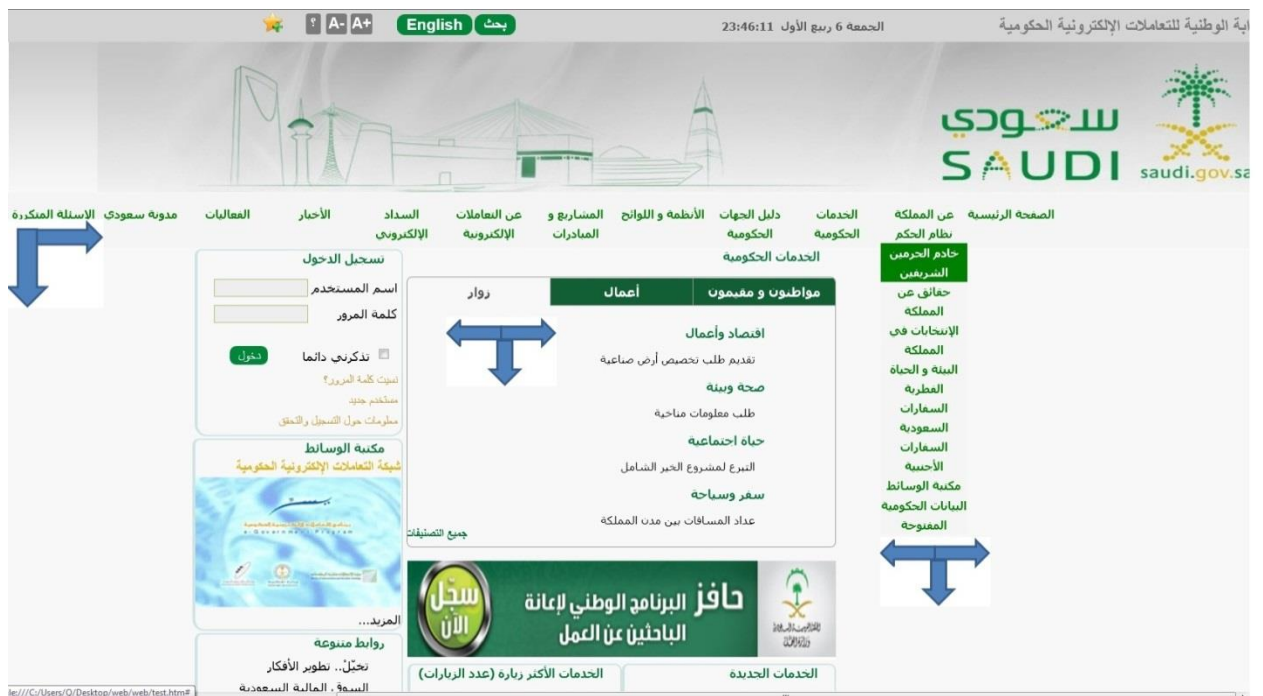


Figure 33: Navigational landmarks placement

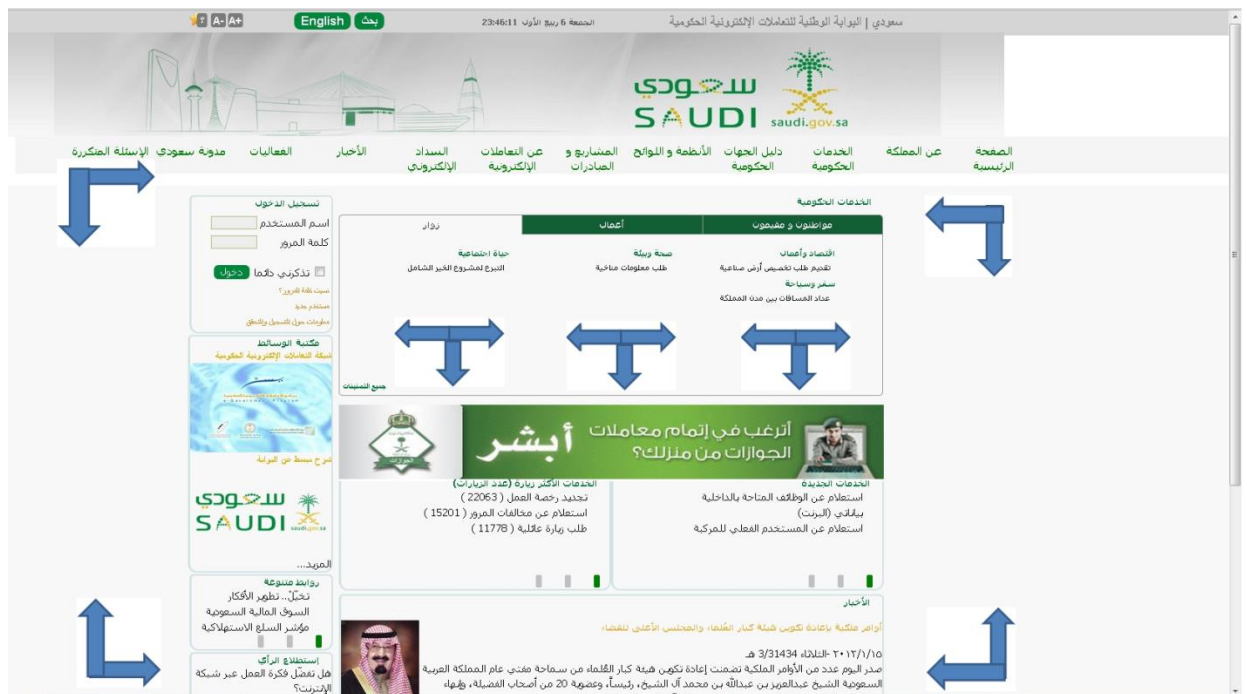


Figure 34: Placement of navigational landmarks on the whole web page

The navigational landmarks were not meant just to help the blind user in navigating through the website, but also to draw their focus, attention and their cognitive sensation to the boundary of the website and hence feel better in their browsing experience.

### 5.7.3 Changing the design pattern

In websites design, there are two main design patterns for navigation: vertical navigation bar and horizontal navigation bar. Each of which has its own characteristics, its advantages and its drawbacks for a normal users. For a blind this issue is neglected due to the fact that the content of the website is transferred into the user via the screen reader not through visual interaction. During the experimental exercise, it was noted that for every task, the majority of the interviewees took a lot of time in finding the second link in the menu to proceed with the a new task. We noticed that the user was overwhelmed with the number of links and sub links nested which led to cognitive overhead. We believe in the fact the horizontal navigation bar is more pleasing to the eye and it mimics a normal reading process where the eyes scan from right to left (in Arabic language) rather than top down. For this respect, the vertical bar navigation layout was changed into top horizontal bar layout to ease the process of navigation and improve web accessibility. An example of the amended layout of webpage has been shown in Figure 35.

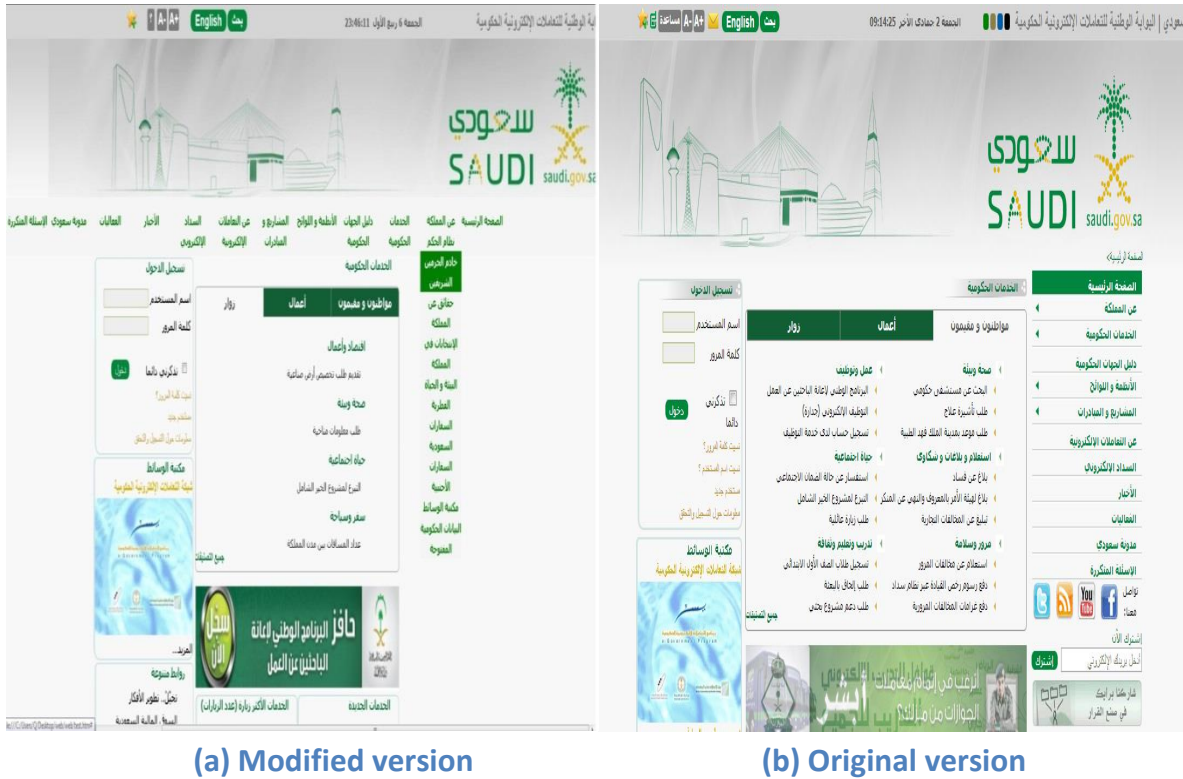


Figure 35: Modified layout of the home page of Saudi Arabia e-Government website

The vertical list of main links shown on the right hand side of the original home page of Saudi Arabia e-Government website were changed to horizontal fashion. The reason for this a amendment is that a screen reader or any other assistive technology devices navigate a website (in Arabic, official language of Saudi Arabia) from right to left. Thus with the original arrangement, right after 'Government Services' the blind reader would move to 'Citizens and Residents', which is neither a major subheading nor a related link. Similarly the web link 'Acts and ByLaws' would be followed by 'Health and Environment'. The above mentioned examples amendments were for the main links on the website. However, the sub-link of 'Labor and Employment' would also be

rearranged in the same manner. We believe in that the original arrangement of web links is a major cause of causing confusion, adding distress, and adding to the problem of poor accessibility and usability.

Another important amendment which goes in same direction of improving the navigation process and reduce cognitive load on the user's memory, was about the location of Frequently Asked Questions (FAQ) link. This problem was already highlighted in the results of candidate feedback questionnaire section were the FAQ link placement was found inappropriate to the users. FAQs link was transferred to top left hand corner of the e-Government website and the layout of its content (questioning/answering) were also paraphrased to help blind users in better navigating through the website.

All the amendments were incorporated to develop a new version of the e-Government website which was believed to be more accessible and usable for blind people. However to evaluate the efficiency of our proposed solutions, it was important to conduct a second experimental exercise to validate the incorporation of amendments and to check whether the e-Government website has now become more accessible and usable for blind people.

The second experimental exercise would ensure that the problems and difficulties faced by blind users during the first experimental exercise are tackled properly and the amendments made to the website would improve the accessibility of the e-Government portal. Another important objective of conducting second experimental exercise was to identify if there were any more accessibility or usability issues to be considered and not covered in the first experiment. The questionnaires, style of interviewing, sampling

technique were kept the same in order to get uniform and comparable results. If the results are not up to the mark and if the blind users still face problems or difficulties in using the e-Government portal, a feedback loop will be generated through which the suggested changes and recommendations will be incorporated in a new design of website and a third experimental exercise would be conducted. The process will be repeated until satisfactory results are obtained from the experimental exercise and blind users are completely satisfied in using the e-Government portal.

The procedure and results of second experimental exercise has been described in the following chapter.



## CHAPTER 6

### EVALUATION

#### OBJECTIVES

- To evaluate the proposed approaches for accessibility improvement.
- To check if any other problems arise.

#### 6.1 Evaluation

In the last chapter, the concept of navigational landmarks which relies on the mental model philosophy and problem solving process discussed in section 2.8 and section 2.10 was proposed to improve the accessibility of the online interaction. In order to evaluate the validity of this concept a second round of experimental exercise was conducted. The main goal of this experiment is to evaluate the improvement this concept may bring to the accessibility of the e-Government website. For that purpose, a new e-Government website was designed which resembles the Saudi e-Government portal used in the first experiment. Due to the time and complexity constraints, the newly designed website included only the web pages that were covered in the first experiment and were modified by incorporating all the changes mentioned in the last chapter.

The second round of experimental exercise was also conducted in the same fashion as the first experimental exercise. A total of 30 interviewees were invited based on the sampling technique used in the first experimental exercise.. An important consideration in the second experimental exercise was to ensure that interviewees are not the same ones in the first experimental exercise. Again, the age of blindness was considered in the

allocation of the second sample of participants. In this round, 3 participants were not born blind but they never used eGovernment services before. The second experimental exercise was also conducted in the premises of PBUNION and AGFUND. However, the number of users in each regional centre was different due to participant's allocation difficulties. The experimental exercise was conducted with the same set of questionnaire and tasks as in the experimental exercise mentioned in section 4.2.

## **6.2 Result of the second experimental exercise**

The result of the participant performance for every task is populated in Table 11, Table 12, Table 14, Table 15. Each table shows the result of participants performing the 14 tasks in association with our performance indicators discussed previously in . The tasks have been rated by the researcher in the same manner and accuracy as in the 1st experiment.

Table 11: Participants results against the 1<sup>st</sup> performance indicator

F1	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14
U1	2	2	0	2	1	1	0	1	2	1	1	1	2	2
U2	1	2	2	2	0	2	2	1	1	2	0	2	1	1
U3	1	1	1	1	2	2	2	1	1	2	2	2	0	1
U4	2	2	1	0	1	0	1	2	2	1	1	2	2	2
U5	0	1	0	2	1	2	0	1	0	2	1	1	1	2
U6	2	2	1	1	0	1	2	2	2	2	2	2	2	2
U7	1	1	2	2	2	1	2	2	1	1	1	1	1	0
U8	2	0	1	1	1	2	1	1	1	2	1	1	2	2
U9	1	1	2	1	0	2	2	1	2	2	0	2	2	2
U10	1	1	1	2	2	1	2	2	1	1	2	2	1	2
U11	1	0	2	1	1	2	2	1	2	1	1	1	2	1
U12	2	1	1	0	1	2	1	2	1	1	2	1	0	2
U13	1	1	2	2	2	2	2	1	0	2	2	1	2	1
U14	2	2	1	0	1	1	2	2	1	0	1	2	0	1
U15	1	2	0	2	0	2	1	2	0	2	2	2	1	2
U16	1	1	1	1	2	1	2	1	1	1	0	2	1	2
U17	0	2	2	1	2	2	2	0	2	2	2	0	2	2
U18	2	2	2	1	1	2	2	2	1	2	0	2	2	1
U19	2	1	1	1	2	1	2	2	1	2	1	2	1	1
U20	1	2	2	0	1	1	1	2	1	2	0	0	1	0
U21	1	2	0	1	2	1	2	2	2	2	2	1	2	2
U22	2	2	1	1	1	1	1	2	0	2	2	1	1	1
U23	2	1	2	1	2	2	1	1	1	2	1	0	2	2
U24	1	2	0	2	1	2	2	2	2	2	2	2	1	1
U25	1	2	2	2	1	1	1	0	2	0	1	2	2	1
U26	0	1	2	2	1	2	1	1	1	2	2	0	1	1
U27	0	1	0	0	2	1	2	2	0	1	2	1	2	2
U28	2	2	2	2	1	2	1	2	1	1	1	1	0	2
U29	1	2	1	0	2	0	2	2	2	0	2	2	2	2
U30	1	1	0	1	0	2	1	1	0	1	1	0	1	2
Average	1.23	1.43	1.1	1.1	1.2	1.46	1.5	1.4	1.1	1.46	1.26	1.3	1.33	1.5

Table 12: Participants results against the 2<sup>nd</sup> performance indicator

F2	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14
U1	1	1	2	2	1	2	0	2	2	1	1	1	2	2
U2	2	2	1	1	0	2	2	2	0	1	1	0	2	1
U3	1	1	2	2	2	2	1	2	1	2	2	2	0	1
U4	2	2	1	2	1	2	0	1	2	1	2	2	2	1
U5	1	2	1	1	2	1	2	2	0	2	1	1	1	2
U6	1	2	1	2	2	1	2	2	2	1	2	2	1	2
U7	1	0	2	1	0	2	1	2	1	1	0	1	2	1
U8	1	0	2	1	2	2	1	2	0	2	2	1	1	0
U9	0	2	1	2	0	1	1	0	2	1	2	2	0	2
U10	2	1	0	1	2	2	2	2	2	0	2	1	2	1
U11	1	2	2	1	1	1	2	1	2	1	2	2	2	2
U12	2	2	1	2	2	2	0	2	2	1	2	1	1	1
U13	1	1	2	1	1	1	2	2	2	1	0	2	2	1
U14	1	2	1	1	1	2	1	1	1	0	1	1	2	1
U15	2	1	1	2	0	2	2	2	0	2	2	2	2	2
U16	1	0	1	1	2	2	1	1	0	2	0	2	1	2
U17	1	1	2	0	1	2	0	2	2	1	1	1	1	0
U18	2	2	2	2	2	2	2	2	2	1	1	1	2	2
U19	1	2	1	0	1	1	2	1	1	2	1	1	1	2
U20	1	2	2	2	0	1	2	2	1	2	2	0	1	2
U21	1	2	1	1	2	2	2	2	0	2	2	2	2	1
U22	1	1	2	2	2	1	0	1	0	1	2	1	2	1
U23	2	2	2	1	2	2	1	1	1	0	2	1	1	0
U24	1	1	2	2	1	1	2	1	2	2	1	0	2	2
U25	1	2	1	2	1	2	2	0	1	2	2	2	2	0
U26	0	1	2	1	2	1	1	2	2	2	2	1	1	1
U27	1	2	0	2	1	1	0	1	2	1	2	2	1	2
U28	2	2	1	0	1	1	2	1	2	1	2	1	2	1
U29	2	1	1	1	2	0	2	1	1	0	2	0	1	2
U30	1	2	0	1	1	2	1	2	1	2	0	1	2	0
Average	1.23	1.46	1.3	1.3	1.2	1.53	1.3	1.5	1.2	1.26	1.46	1.23	1.46	1.26

Table 13: Participants results against the 3<sup>rd</sup> performance indicator

F3	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14
U1	1	2	1	2	0	2	1	1	2	1	2	1	2	2
U2	2	2	1	2	1	2	2	1	1	2	2	2	0	2
U3	1	2	2	2	1	2	1	1	2	2	2	0	1	1
U4	2	1	2	1	2	2	0	2	1	1	2	2	1	2
U5	0	2	0	1	1	1	2	2	2	1	1	1	2	1
U6	2	2	1	1	2	2	1	1	1	1	1	2	1	2
U7	1	2	1	1	1	1	2	2	0	1	2	1	2	1
U8	2	2	2	0	2	2	1	2	1	2	1	2	1	2
U9	1	1	2	1	1	2	1	0	1	2	2	1	2	0
U10	1	1	2	2	2	1	2	2	2	0	1	2	2	2
U11	1	2	2	1	1	2	0	1	2	1	0	2	1	2
U12	2	2	2	2	0	1	1	2	2	1	2	1	0	2
U13	0	1	1	1	2	2	1	2	0	2	2	1	2	1
U14	1	2	2	0	2	1	1	1	2	2	1	2	2	1
U15	2	2	0	2	0	2	1	1	1	0	2	2	1	0
U16	1	0	1	0	0	1	2	1	2	1	2	2	1	2
U17	1	2	1	2	2	2	1	1	1	1	2	1	2	0
U18	0	1	2	2	2	2	2	1	2	2	0	1	2	2
U19	2	2	2	1	1	1	1	2	2	2	2	2	1	2
U20	1	2	2	2	1	1	2	1	1	2	1	0	2	1
U21	2	2	1	2	2	2	1	2	2	1	2	2	2	2
U22	2	1	2	1	1	2	0	2	0	2	2	0	1	1
U23	1	0	1	2	2	1	2	0	2	2	2	2	2	0
U24	2	2	2	2	2	1	0	2	1	2	1	2	2	2
U25	2	2	2	2	0	2	2	0	2	1	1	2	1	1
U26	1	1	2	2	2	2	1	2	1	2	2	2	0	2
U27	1	2	0	2	2	1	2	1	0	1	2	2	2	1
U28	1	2	2	2	2	1	2	2	2	1	2	2	1	2
U29	2	1	1	0	1	1	1	2	0	0	1	2	1	2
U30	1	1	1	2	0	0	1	1	1	1	1	1	2	0
Average	1.3	1.56	1.4	1.4	1.2	1.5	1.2	1.3	1.3	1.33	1.53	1.5	1.4	1.36

Table 14: Participants results against the 4<sup>th</sup> performance indicator

F4	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14
U1	1	2	2	1	0	2	0	2	2	1	2	1	2	1
U2	2	2	0	1	0	2	2	1	1	2	1	2	2	1
U3	1	2	2	2	2	1	2	1	1	1	0	2	0	0
U4	1	2	1	0	2	0	0	2	1	1	2	1	1	2
U5	1	2	0	1	1	1	2	1	0	2	2	0	1	2
U6	1	2	1	1	2	1	1	1	2	1	1	2	2	2
U7	1	1	2	2	0	1	2	0	1	2	0	2	2	1
U8	2	0	2	0	2	2	1	2	0	0	1	2	1	2
U9	0	1	1	2	2	2	1	1	2	2	2	1	2	2
U10	2	1	2	2	0	1	2	1	2	1	2	2	2	2
U11	1	2	1	2	2	2	2	2	2	1	0	2	2	1
U12	1	2	1	1	0	2	0	1	2	1	2	1	1	2
U13	1	1	2	2	2	2	2	2	0	2	2	1	0	0
U14	1	1	2	1	1	2	1	2	2	0	1	2	2	1
U15	1	2	0	2	1	1	2	1	1	2	0	1	2	2
U16	2	1	2	2	0	1	2	2	2	2	2	0	1	2
U17	1	1	0	2	2	2	1	2	1	1	2	1	2	0
U18	1	2	2	1	2	0	1	1	2	2	0	1	0	2
U19	2	1	1	1	1	1	2	2	2	1	1	1	2	2
U20	1	0	2	2	1	1	2	2	1	2	2	1	2	2
U21	2	1	2	2	2	2	2	1	2	2	1	2	1	2
U22	1	1	2	1	1	2	1	1	0	1	0	1	1	0
U23	2	0	2	2	2	1	1	1	1	2	1	2	2	0
U24	2	2	2	2	2	2	2	2	2	1	1	2	2	2
U25	1	1	1	1	0	2	2	0	2	1	2	1	2	1
U26	0	2	0	2	2	1	1	2	2	2	1	2	1	1
U27	1	2	0	2	1	1	2	1	1	1	2	1	2	2
U28	2	1	2	2	2	2	2	1	2	1	2	2	2	2
U29	1	1	1	1	2	0	2	2	2	1	1	1	2	1
U30	0	1	0	1	1	2	2	1	1	1	0	1	1	0
Average	1.2	1.33	1.2	1.4	1.2	1.4	1.5	1.3	1.4	1.33	1.2	1.36	1.5	1.33

Table 15: Participants results against the 5<sup>th</sup> performance indicator

F5	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14
U1	1	2	2	2	0	2	1	2	1	0	1	1	1	2
U2	1	1	0	1	0	0	1	1	1	1	2	0	1	1
U3	1	2	2	2	2	2	2	2	1	2	2	2	1	1
U4	2	2	1	1	1	2	0	2	1	1	2	2	1	2
U5	1	1	0	2	1	1	0	0	2	2	1	1	1	2
U6	1	1	2	1	2	2	1	2	1	2	2	1	2	1
U7	1	2	1	2	0	1	2	0	0	1	0	2	2	1
U8	1	1	2	2	2	0	2	2	1	2	1	1	1	1
U9	0	2	1	1	0	2	1	2	1	2	2	2	2	2
U10	1	2	2	2	0	1	1	1	2	1	2	1	2	0
U11	1	2	2	2	2	1	0	2	1	1	2	2	2	2
U12	2	2	2	1	1	2	1	1	2	2	1	1	1	1
U13	1	2	2	2	1	2	0	2	2	0	1	1	2	1
U14	1	1	2	1	1	1	1	1	1	0	2	0	1	1
U15	1	2	0	1	0	2	2	2	0	2	2	2	1	2
U16	2	1	1	2	2	2	2	2	2	1	0	2	2	1
U17	1	1	2	1	1	0	2	1	2	1	2	1	1	0
U18	1	2	1	1	2	2	1	0	1	1	1	1	1	1
U19	1	1	1	1	2	0	2	2	0	2	1	2	1	2
U20	2	2	0	2	0	1	2	2	1	1	2	1	2	2
U21	2	1	2	1	1	2	0	2	2	2	0	2	2	1
U22	1	1	2	1	2	2	1	2	1	1	2	1	1	1
U23	2	1	2	2	1	2	2	1	1	0	1	2	1	0
U24	1	2	2	1	2	1	2	1	1	2	1	0	2	2
U25	1	1	1	2	0	2	1	0	2	2	2	2	2	0
U26	0	2	2	2	2	1	2	2	1	1	2	1	1	2
U27	2	2	0	1	1	2	1	2	1	0	1	1	2	2
U28	1	2	0	2	2	1	2	2	2	2	2	1	2	0
U29	2	1	2	0	1	1	1	1	2	0	1	2	2	2
U30	1	1	1	2	1	2	2	1	1	1	0	1	1	1
Average	1.2	1.53	1.3	1.4	1.1	1.4	1.2	1.4	1.2	1.2	1.36	1.3	1.46	1.23

## 6.4 Analysis of 2<sup>nd</sup> experiment and measure of improvements

In order to measure the level of improvement that our proposed solution has introduced, the result of the 1st and 2nd experiment were evaluated with respect to all the five performance indicators we adopted in this research. The average values gained for every task in both experiments were plotted in bar charts so as to distinguish the variations within every task separately and in association with our performance indicator in general. As can be seen from Figure 36, Figure 37, Figure 38, Figure 39 and Figure 40, the average values for all tasks in all performance indicators has improved considerably compared with the average values gained in the 1st experiment. The improvement in averages values for some tasks doubled compared to their counterparts in the 1st experiment. It is noted that, the large improvement in average values went for tasks which required the users to navigate from one place in the webpage to another. Such tasks achieved low average values in 1st experiment the thing that was attributed to cognitive load and lack of navigation problems. For example, tasks 1, 5 and 13, which achieved the highest level of improvement in average value ( around 130 %) requires the user to move to the centre of the webpage after being at the bottom of the webpage for the previous task( search for a job). This problem seems to be resolved with the help of our proposed solution which helped the participants performing these task achieve better result. Some other tasks, in which the navigation overhead was same in both experiment, benefited indirectly from our proposed solutions in the sense that it reduced the load on their cognition and helped them build better mental map of the website they interact with. This indicates that the users benefitted from the navigational landmarks placement and were able to perform the task better. General improvement in other tasks is clearly reflected in better response time taken, less problems faced and less number of trials performed by the participants.



Figure 36: tasks performance distribution of 1st and 2nd experiment (1<sup>st</sup> performance indicator)

F1	Experiment 1	Experiment 2
T1	0.66	1.23
T2	0.73	1.43
T3	0.73	1.16
T4	0.63	1.16
T5	0.46	1.2
T6	0.83	1.46
T7	0.63	1.5
T8	0.83	1.46
T9	0.73	1.13
T10	0.53	1.46
T11	0.76	1.26
T12	0.7	1.3
T13	0.6	1.33
T14	0.9	1.3

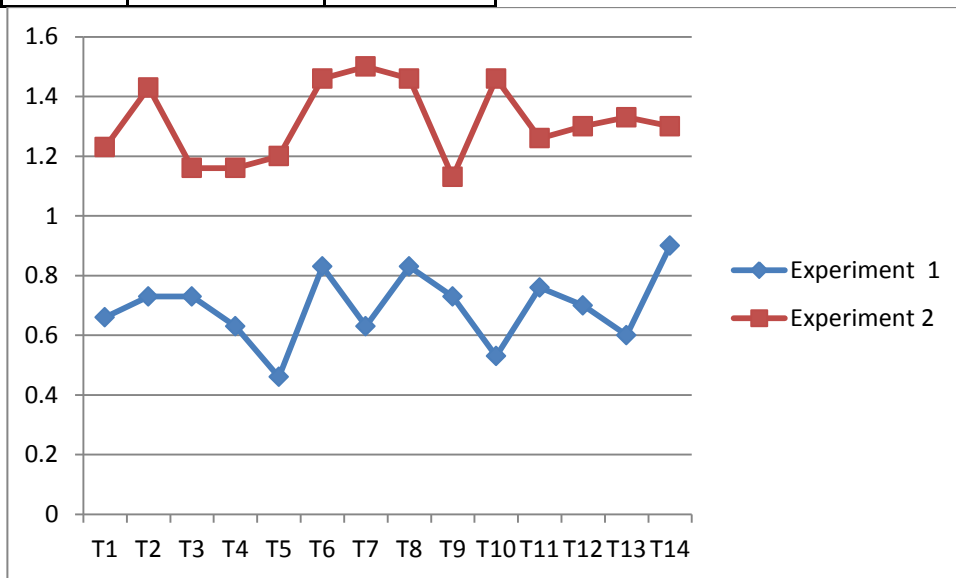


Figure 37 tasks performance distribution of 1st and 2nd experiment (2<sup>nd</sup> performance indicator)

F2	Experiment 1	Experiment 2
T1	0.73	1.23
T2	0.63	1.46
T3	0.66	1.33
T4	0.73	1.33
T5	0.5	1.26
T6	0.73	1.53
T7	0.76	1.3
T8	0.76	1.5
T9	0.66	1.23
T10	0.66	1.26
T11	0.66	1.46
T12	0.8	1.23
T13	0.63	1.46
T14	0.83	1.26

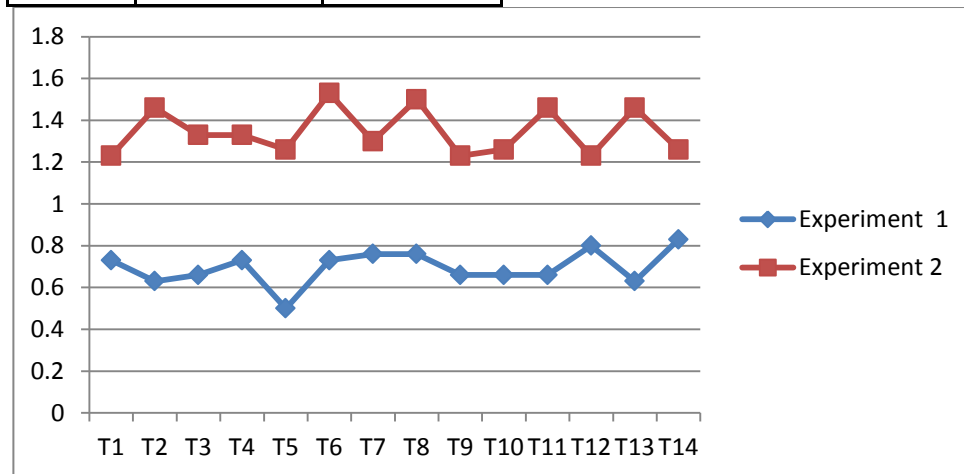


Figure 38: tasks performance distribution of 1st and 2nd experiment ( 3<sup>rd</sup> performance indicator).

F3	Experiment 1	Experiment 2
T1	0.7	1.3
T2	0.86	1.56
T3	0.9	1.43
T4	0.63	1.43
T5	0.76	1.26
T6	0.8	1.5
T7	0.8	1.23
T8	0.8	1.36
T9	0.7	1.3
T10	0.73	1.33
T11	0.73	1.53
T12	0.73	1.5
T13	0.63	1.4
T14	0.63	1.36

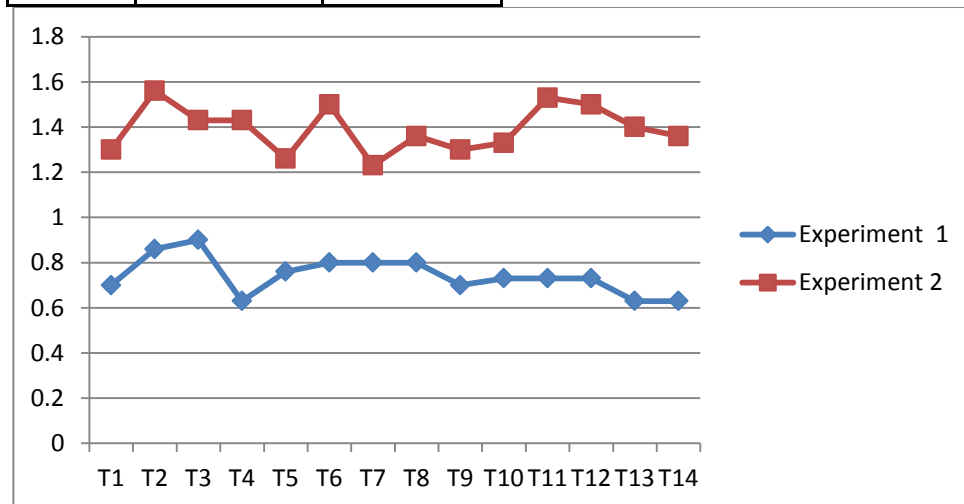


Figure 39: tasks performance distribution of 1st and 2nd experiment ( 4<sup>th</sup> performance indicator).

F4	Experiment 1	Experiment 2
T1	0.76	1.2
T2	0.7	1.33
T3	0.76	1.26
T4	0.66	1.46
T5	0.76	1.26
T6	0.66	1.4
T7	0.73	1.5
T8	0.76	1.36
T9	0.83	1.4
T10	0.63	1.33
T11	0.73	1.2
T12	0.8	1.36
T13	0.66	1.5
T14	0.86	1.33

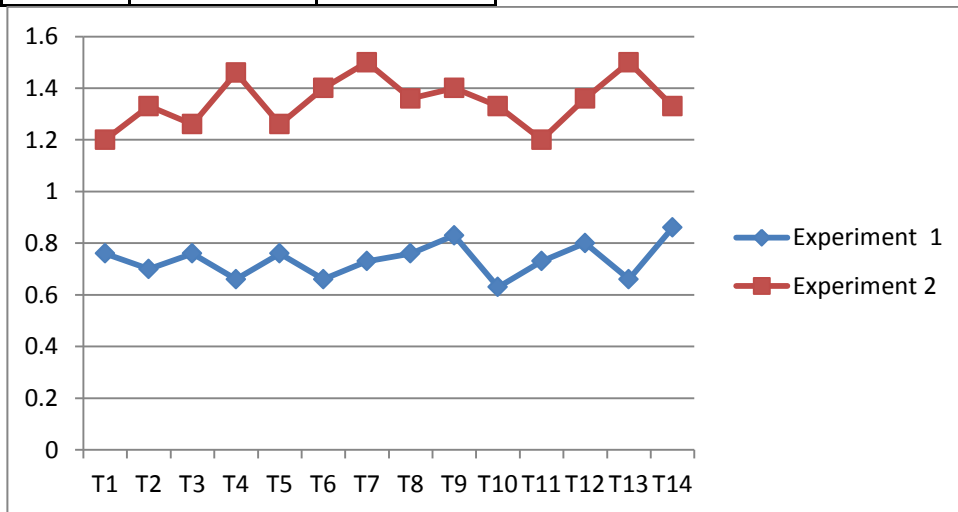
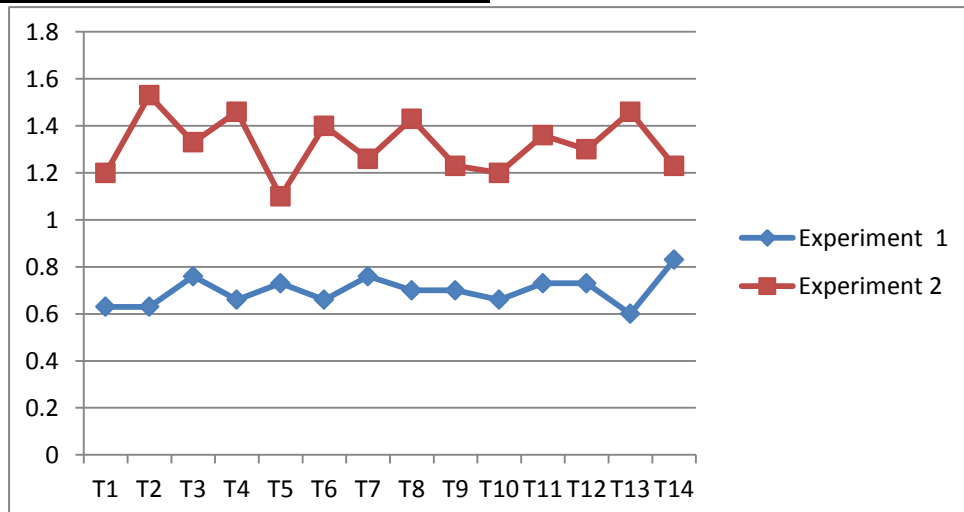


Figure 40: tasks performance distribution of 1st and 2nd experiment ( 5th performance indicator).

F5	Experiment 1	Experiment 2
T1	0.63	1.2
T2	0.63	1.53
T3	0.76	1.33
T4	0.66	1.46
T5	0.73	1.1
T6	0.66	1.4
T7	0.76	1.26
T8	0.7	1.43
T9	0.7	1.23
T10	0.66	1.2
T11	0.73	1.36
T12	0.73	1.3
T13	0.6	1.46
T14	0.83	1.23



Based on foregoing, it can be argued that proposed approach in this research of navigational landmark placement and the virtual map approach has improved the mental map of the participants and made navigate more freely and expediently compared to the old layout.

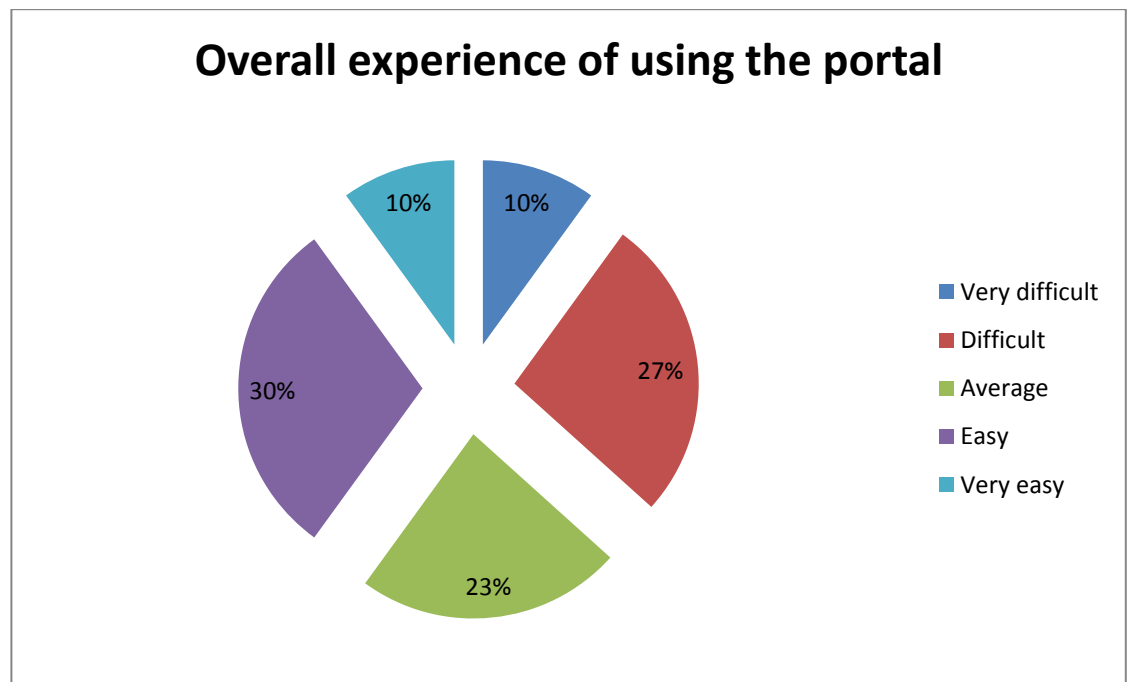
### **6.5 Post experiment user satisfaction survey**

The results from the second experimental exercise have been analysed in the same way as the first experimental exercise. Similar to the first experimental exercise, the candidate feedback questionnaire given to interviewees after the experimental exercise consisted of the following questions:

- 1) How would you rate the overall experience of using the portal? Was it positive and helpful?

Very Difficult [ **10%** ], Difficult [ **26.67%** ], Average [ **23.33%** ], Easy [ **30%** ],  
Very Easy [ **10%** ]

Yes [ **26.67%** ], No [ **73.33%** ]



**Figure 41: Comparison of interviewees on the basis of overall experience of using the web portal**

2) How would you rate the degree of difficulty for each task?

- I. Very Difficult [ **26.67%** ], Difficult [ **13.33%** ], Average [ **20%** ], Easy [ **30%** ], Very Easy [ **10%** ]
- II. Very Difficult [ **20%** ], Difficult [ **23.33%** ], Average [ **26.67%** ], Easy [ **20%** ], Very Easy [ **10%** ]
- III. Very Difficult [ **23.33%** ], Difficult [ **20%** ], Average [ **30%** ], Easy [ **13.33%** ], Very Easy [ **13.33%** ]
- IV. Very Difficult [ **23.33%** ], Difficult [ **26.67%** ], Average [ **16.67%** ], Easy [ **30%** ], Very Easy [ **3.33%** ]
- V. Very Difficult [ **20%** ], Difficult [ **33.33%** ], Average [ **20%** ], Easy [ **16.67%** ], Very Easy [ **10%** ]
- VI. Very Difficult [ **23.33%** ], Difficult [ **20%** ], Average [ **30%** ], Easy [ **16.67%** ], Very Easy [ **10%** ]

- VII. Very Difficult [ **23.33%** ], Difficult [ **13.33%** ], Average [ **26.67%** ], Easy [ **30%** ], Very Easy [ **6.67%** ]
- VIII. Very Difficult [ **26.67%** ], Difficult [ **10%** ], Average [ **26.67%** ], Easy [ **20%** ], Very Easy [ **16.67%** ]
- IX. Very Difficult [ **30%** ], Difficult [ **6.67%** ], Average [ **20%** ], Easy [ **30%** ], Very Easy [ **13.33%** ]
- X. Very Difficult [ **20%** ], Difficult [ **33.33%** ], Average [ **20%** ], Easy [ **16.67%** ], Very Easy [ **10%** ]
- XI. Very Difficult [ **20%** ], Difficult [ **23.33%** ], Average [ **26.67%** ], Easy [ **16.67%** ], Very Easy [ **13.33%** ]
- XII. Very Difficult [ **16.67%** ], Difficult [ **23.33%** ], Average [ **30%** ], Easy [ **20%** ], Very Easy [ **10%** ]
- XIII. Very Difficult [ **23.33%** ], Difficult [ **16.67%** ], Average [ **20%** ], Easy [ **16.67%** ], Very Easy [ **13.33%** ]
- XIV. Very Difficult [ **30%** ], Difficult [ **20%** ], Average [ **16.67%** ], Easy [ **20%** ], Very Easy [ **13.33%** ]

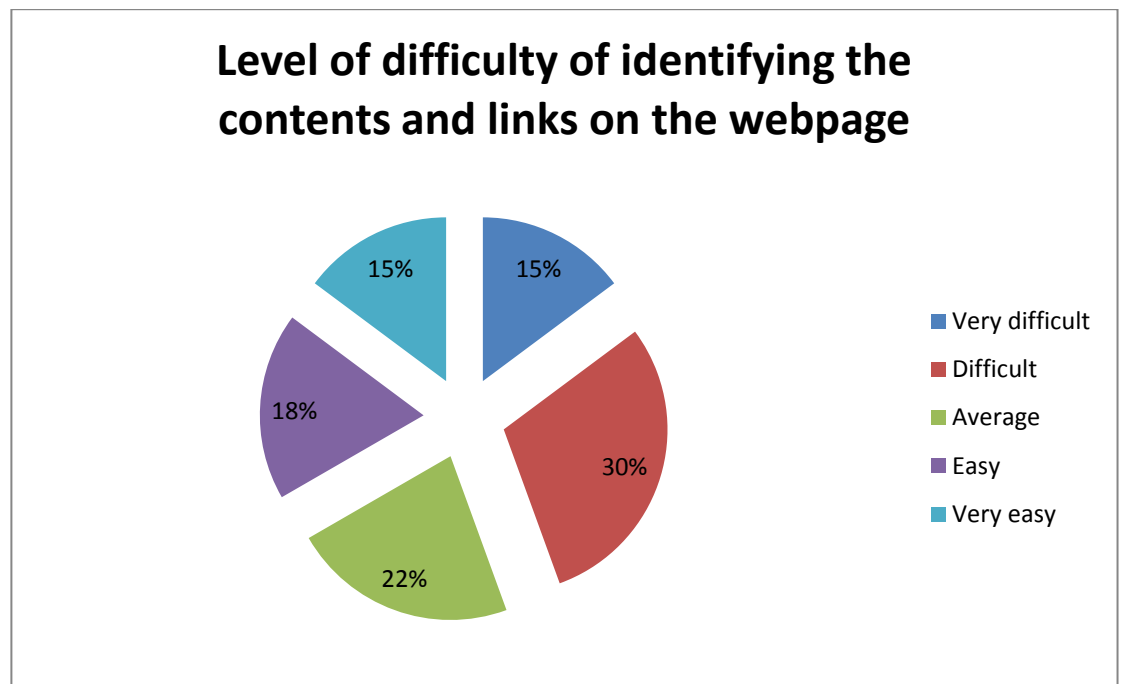
It is important to note that in question number 2, the interviewee was asked to comment on the degree of difficulty of each of the 14 tasks.

- 3) Were all the contents and links easy to be identified and understood? How would you rate the level of difficulty?

Yes [ **56.67%** ], No [ **43.33%** ]

Very Difficult [ **13.33%** ], Difficult [ **26.67%** ], Average [ **20%** ], Easy [ **16.67%** ], Very Easy [ **13.33%** ]

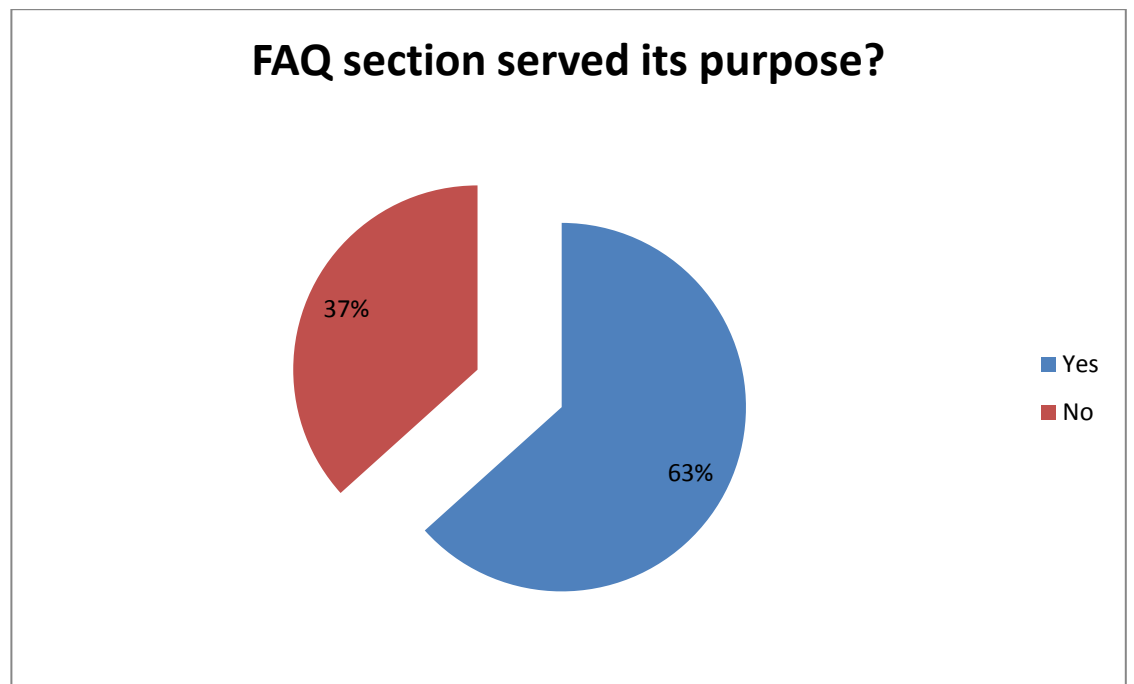




**Figure 42: Comparison of interviewees on the basis of level of difficulty of identifying the contents and links on the webpage**

- 4) Was the FAQ (frequently asked questions) section able to help you in finding answer to your query during the session?

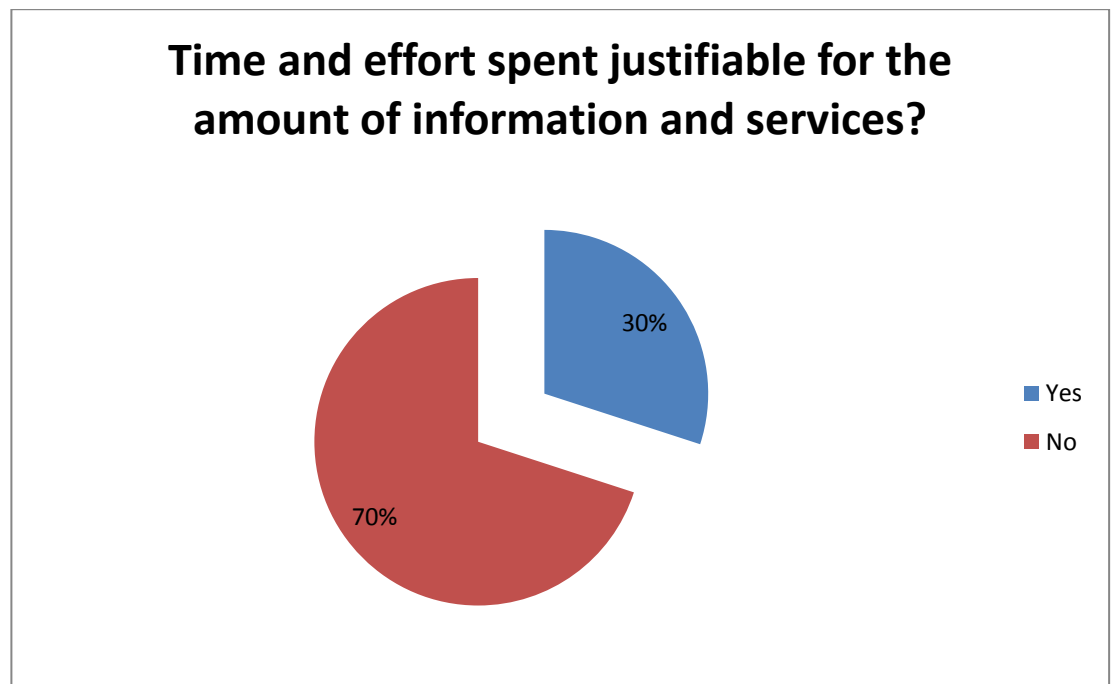
Yes [ **63.33%** ], No [ **36.67%** ]



**Figure 43: Comparison of interviewees on the basis of FAQ section**

5) Do you think that the information and services from web portal were enough to justify your time and efforts spent on the task?

Yes [ **30%** ], No [ **70%** ]



**Figure 44: Comparison of interviewees on the basis of justification for the time and efforts spent**

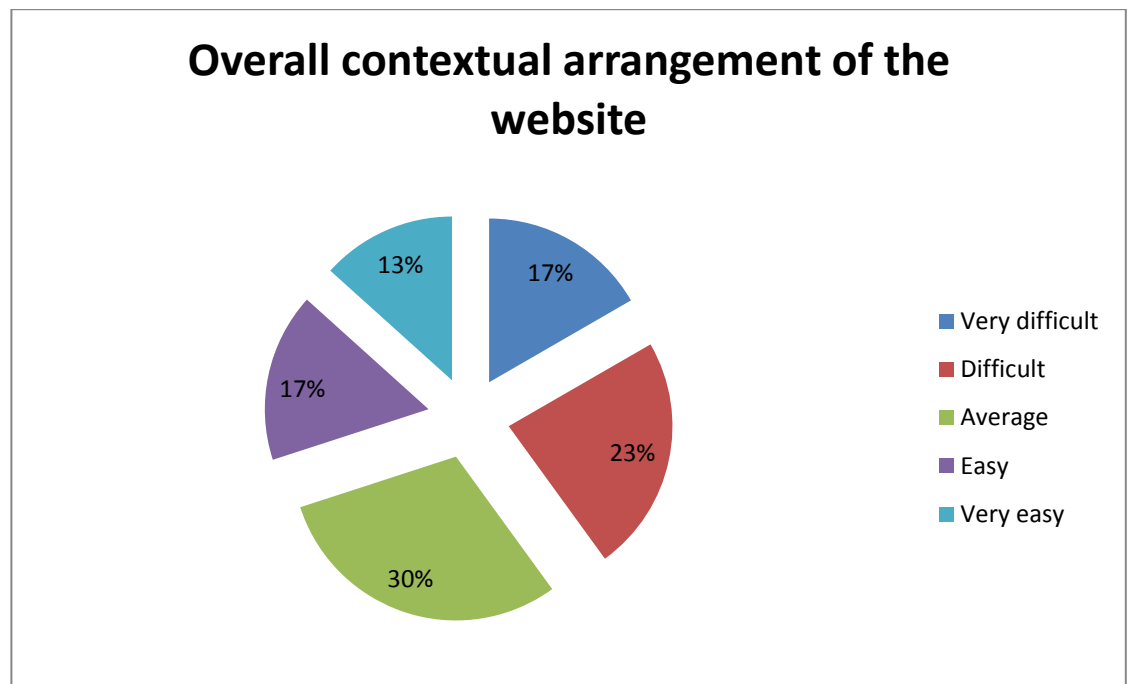
- 6) How would you rate the overall contextual arrangement of the website? Would you like to recommend any changes to enhance its usability for blind users?

Very Difficult [ **16.67%** ], Difficult [ **23.33%** ], Average [ **30%** ], Easy [ **16.67%** ], Very Easy [ **13.33%** ]

Yes [ **96.67%** ], No [ **3.33%** ]

A summary of the received comments is:

**Better accessibility and usability of the website. Shorten the number of sub links in one menu. The screen reader is not efficient in Arabic language.**

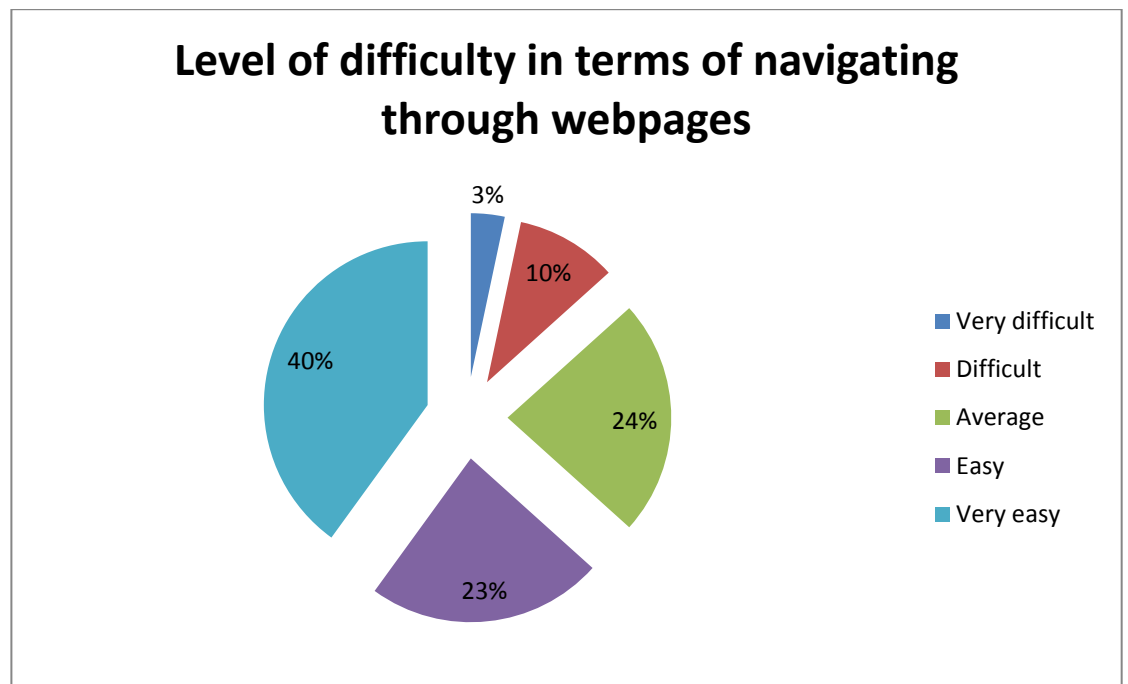


**Figure 45: Comparison of interviewees on the basis of overall contextual arrangement of the website**

7) Were the webpages easy to navigate through? How would you rate the level of difficulty?

Yes [ **83.33%** ], No [ **16.67%** ]

Very Difficult [ **3.33%** ], Difficult [ **10%** ], Average [ **23.33%** ], Easy [ **23.33%** ], Very Easy [ **40%** ]



**Figure 46: Comparison of interviewees on the basis of level of difficulty in terms of navigating through webpages**

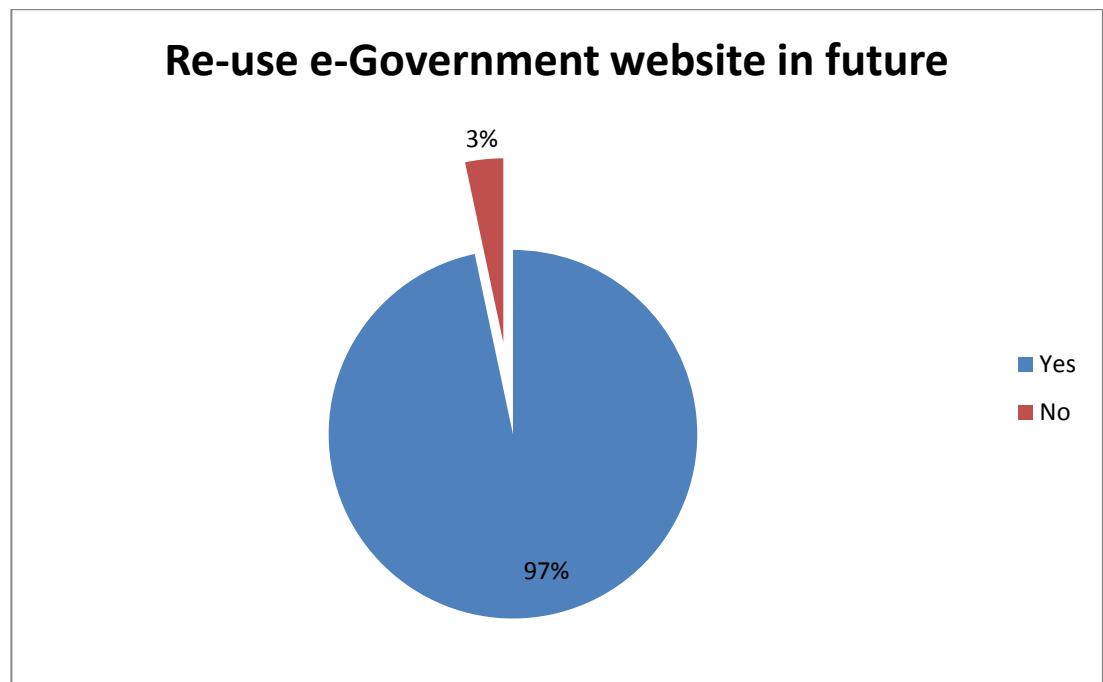
- 8) Did you find the list of services too long? Would you also recommend the name of service providers to be arranged alphabetically?

Yes [ **83.33%** ], No [ **16.67%** ]

Yes [ **83.33%** ], No [ **16.67%** ]

- 9) Would you like to use the e-Government website for accessing information or services in future?

Yes [ **96.67%** ], No [ **3.33%** ]



**Figure 47: Comparison of interviewees on the basis of re-using the web portal for accessing information and services in future**

10) How useful was the information on the website?

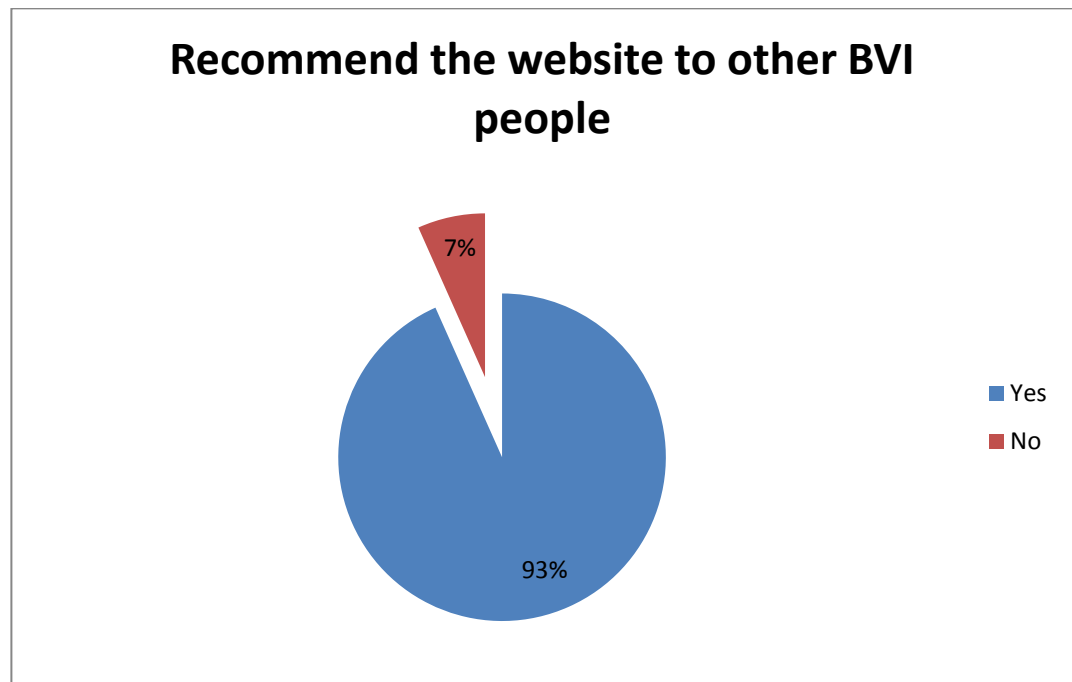
Not useful at all [ **3.33%** ], Not very useful [ **10%** ], Average [ **33.33%** ], Useful [ **30%** ], Very Useful [ **23.33%** ]

11) Was the final outcome of exercise able to meet the goals set at the beginning?

Yes [ **73.33%** ], No [ **26.67%** ]

12) Would you recommend using the website and services to other blind people?

Yes [ **93.33%** ], No [ **6.67%** ]



**Figure 48: Comparison of interviewees on the basis of recommending the website to other blind people**

13) Any further comments.

A summary of the main points in the received comments is:

**There must be some type of help available on the website in the form of audio to assist blind users in browsing through the webpage and getting to the required information source. There could be some online help provide support in case it is needed. The webpage with FAQ is also not very useful. It could be updated and made much more user oriented.**

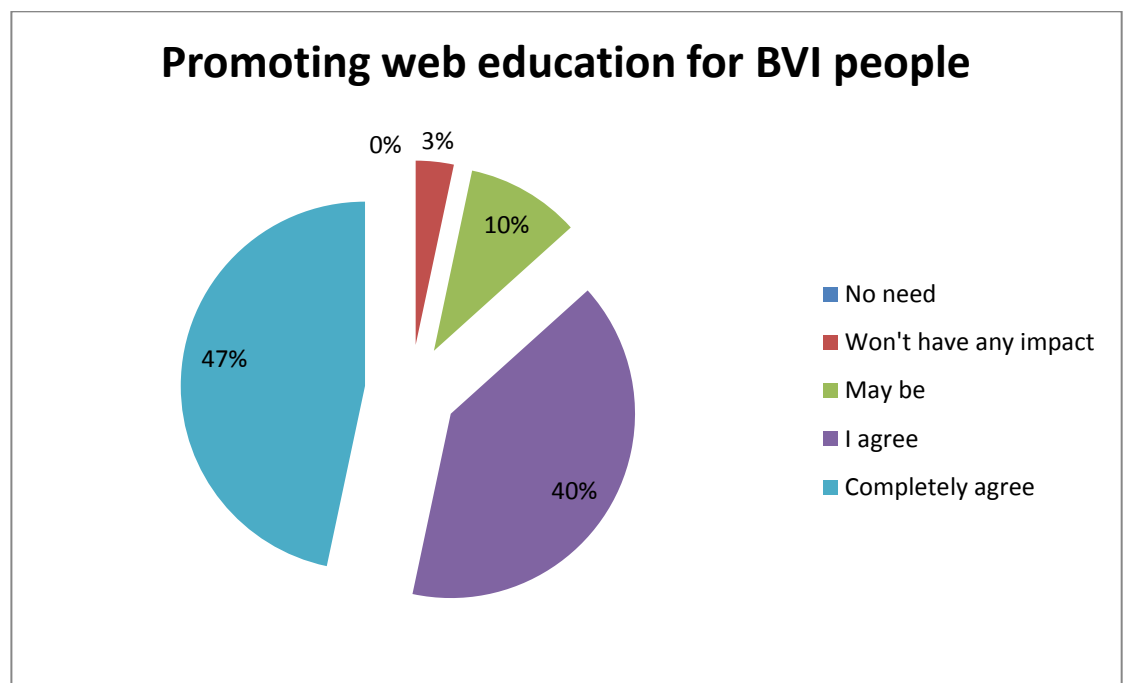
14) What do you think of government efforts towards blind people?

A summary of the main points in the received comments is:

**The Government is putting efforts however they could be better targeted in solving specific IT and web related issues.**

15) Do you think web education for blind people should be promoted?

No need [ 0% ], Won't have any impact [ 3.33% ], May be [ 10% ], I agree [ 40% ], Completely agree [ 46.67% ]

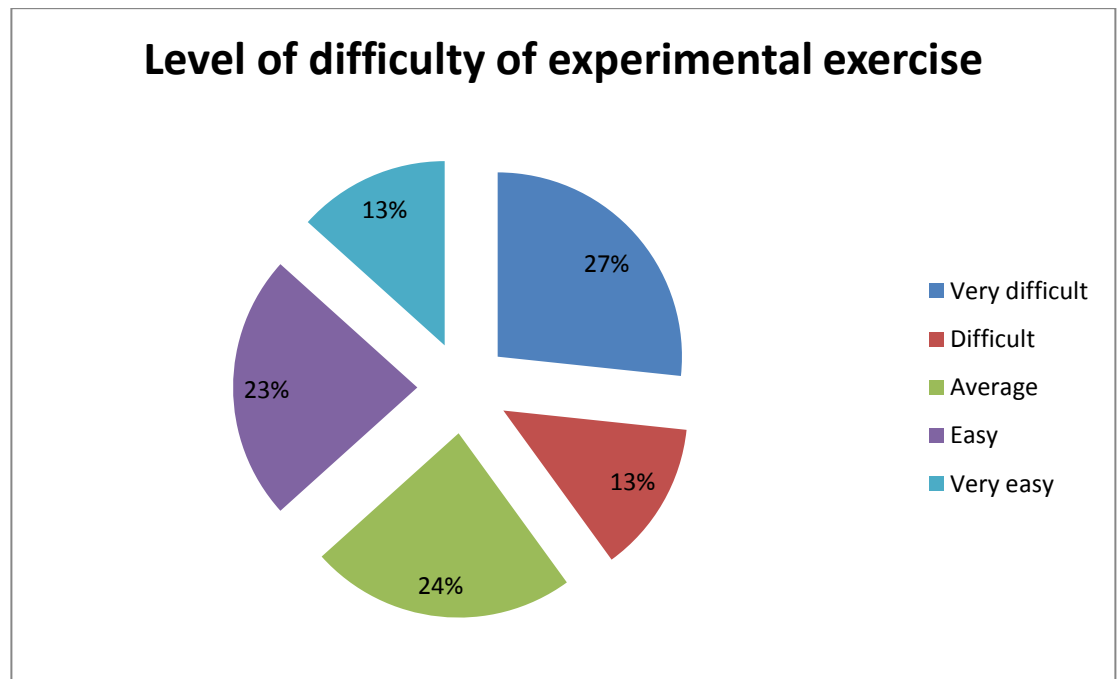


**Figure 49: Comparison of interviewees on the basis of promoting web education for blind people**



16) Was the experimental exercise simple and easy?

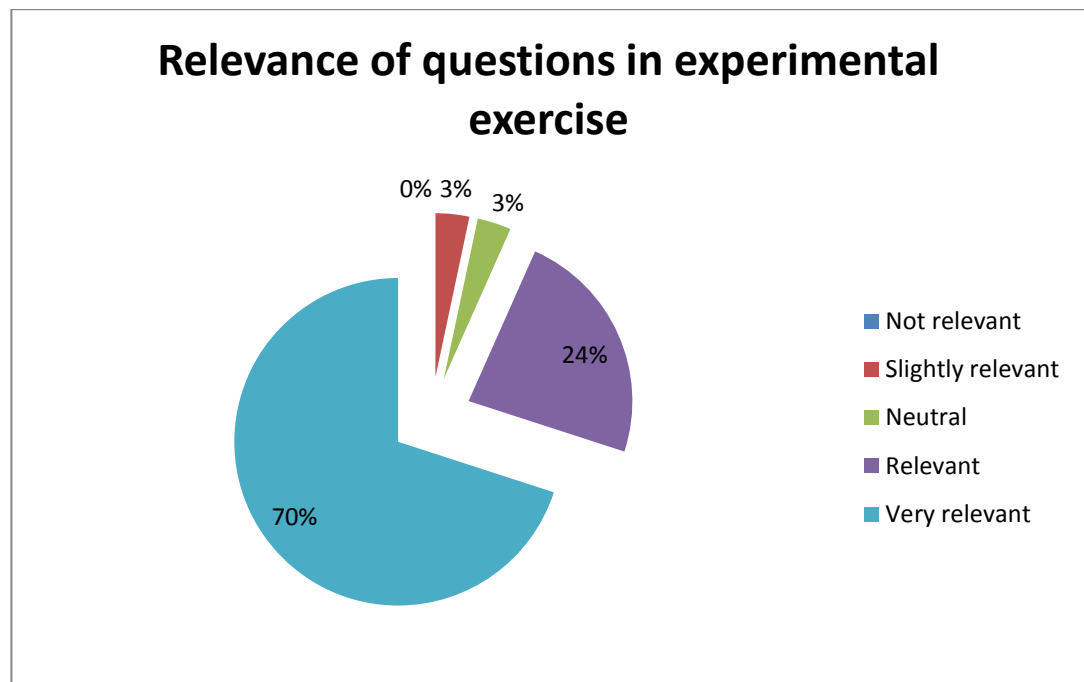
No it was very difficult [ **26.67%** ], No it was difficult [ **13.33%** ], Average [ **23.33%** ], Yes it was easy [ **23.33%** ], Yes it was very easy [ **13.33%** ]



**Figure 50: Comparison of interviewees on the basis of level of difficulty of experimental exercise**

17) Were the questions in this exercise related to what an average blind person would search for?

Not related at all [ **0%** ], Slightly related [ **3.33%** ], Neutral [ **3.33%** ], Yes they were related [ **23.33%** ], Yes they were exactly what an average blind person would search for [ **70%** ]



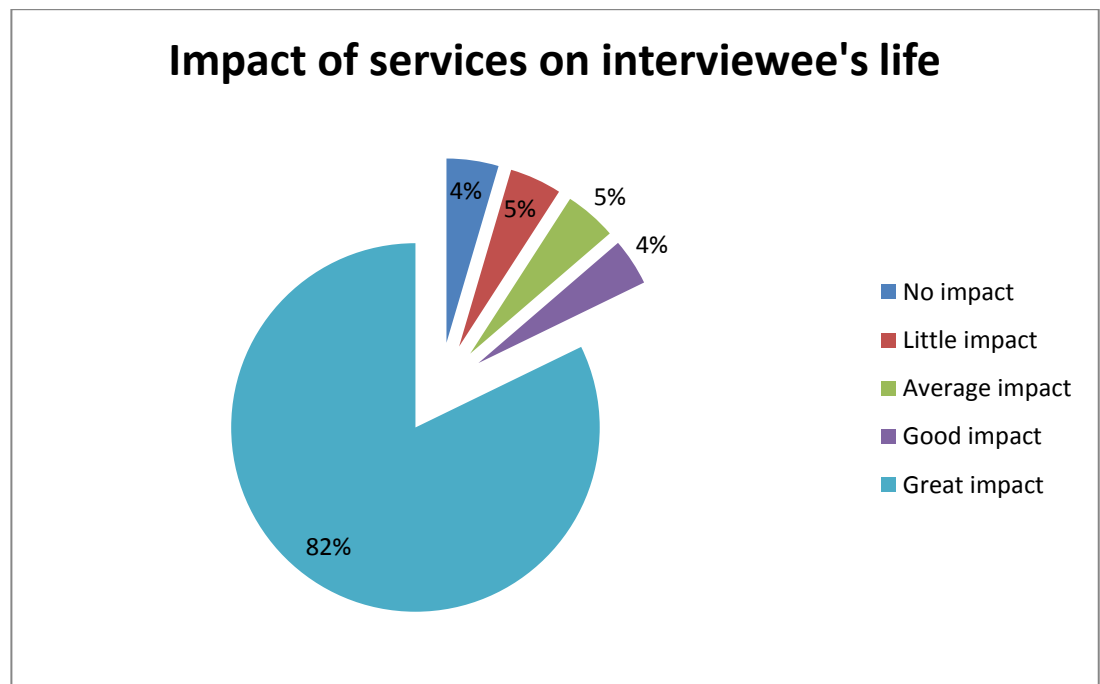
**Figure 51: Comparison of interviewees on the basis of relevance of questions in experimental exercise**

18)How will the services on web portal affect your life ? Please comment?

Will not affect at all [ **3.33%** ], Will not affect too much [ **3.33%** ], Will affect on an average level [ **3.33%** ], Will affect to good extent [ **30%** ], Will affect greatly [ **60%** ]

A summary of the main points in the received comments is:

**The e-Government services would help blind users in better connecting to the outside world and government activities. Disabled users would feel normal and not a burden on the community.**



**Figure 52: Comparison of interviewees on the basis of impact of services on interviewee's life**

19)How frequently would you be using it, if all your proposed changes are implemented and the website is made more accessible and usable?

Not at all [ **3.33%** ], Not very often [ **3.33%** ], Sometimes [ **6.67%** ], Regularly [ **36.67%** ], Very often [ **50%** ]

20)What is your view about m-Government? Please comment?

Extremely negative [ **10%** ], Negative [ **20%** ], Neutral [ **30%** ], Positive [ **33.33%** ], Extremely positive [ **6.67%** ]

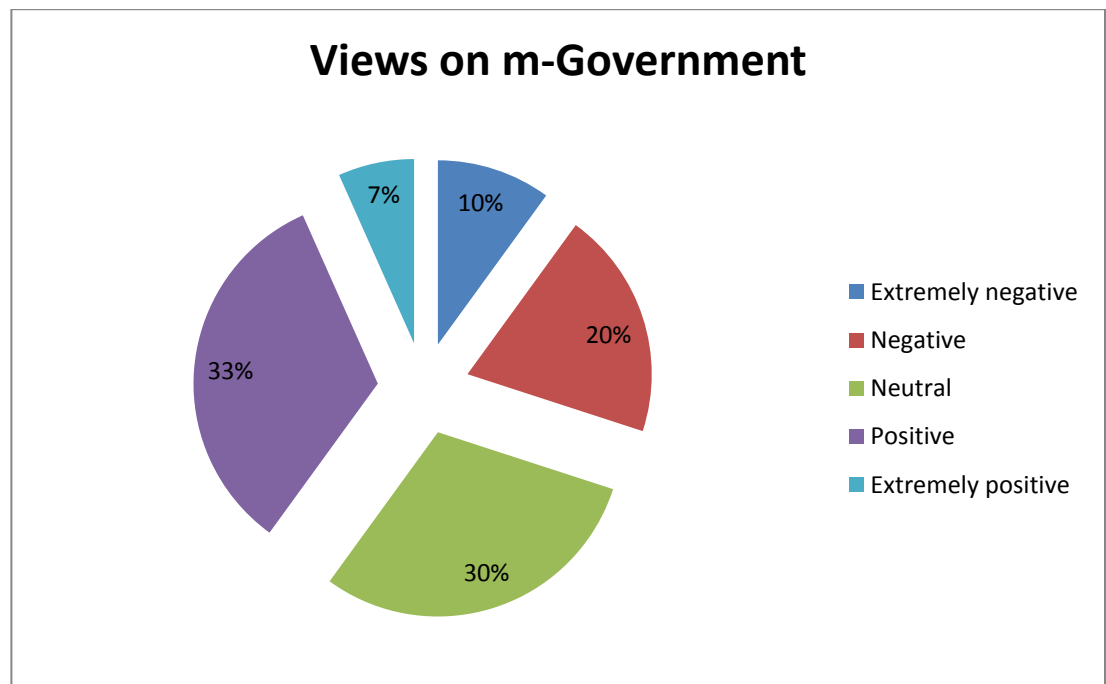


Figure 53: Comparison of interviewees on the basis of views on m-Government

## **CHAPTER 7**

### **CONCLUSIONS AND RECOMMENDATIONS**

#### **7.1 Introduction**

The aim of this doctorate thesis was to evaluate the unknown and hidden accessibility issues faced by blind users while using online applications like the e-Government services. The findings of this evaluation process revealed the reasons behind the notable dissatisfaction of disabled people towards well designed and highly invested at e-Government applications.

The government of Saudi Arabia launched an extensive project aimed at improving ICT and internet infrastructure to facilitate the delivery of services to its citizens and businesses. The establishment of e-Government website was aimed to enable its citizens to take the advantage of growing telecommunication and internet technology in using government based services. However, a critical analysis of the published literature in this aspect revealed that the existing website failed to take into account the wide variety of population, especially the group of blind people. A practical experiment conducted on a varied group of blind people also concluded that the website was not user friendly and has poor accessibility and usability standards. Although the website conforms to all major WCAG requirements and satisfies other technical standards, it failed to satisfy the requirements of blind people the thing that contradicts with the concept 'Universal Design' which e-Government application are meant to fulfil.

The basic aim of having an e-Government website is to provide an effective and efficient way of accessing various government services. However, it was revealed that the e-Government website could not be satisfactorily used by blind people who

contribute to about 0.7% of the whole population, and expected to double by 2020 . Out of the whole group of blind people, the most affected are the ones who are not competent in using IT and web based resources, and those with inadequate level of literacy.

From the practical experiment on blind people, it has been found that the most appealing and important issue to be considered is to ensure that the web based experience results in an output as a service or information, which is worth the time and efforts spent by the blind people. The aim of having a successful implementation of e-Government website cannot be fulfilled until and unless it provides an effective and efficient way to blind people in utilizing the government's services.

The adoption of e-Government website by blind people is very difficult to imagine if they can do the same task or get the same information from other sources like phone, TV or newspaper more easily. Thus it was necessary to measure the degree of accessibility among blind people in order to design a more effective and efficient framework that could successfully meet their requirements.

## **7.2 Contribution**

The result of our research revealed that there is an issue related to the problem solving process for blind which were not taken into consideration in the current accessibility standards. It showed that web designers assume that blind user is ordinary users who deal with the computer in non-visual contact without carefully considering other aspects like their cognitive load and their complex problem solving process. Our contribution in this regard was derived from the concept of cognitive process and theories of environmental boundaries which help the blind create a realistic mental model of the

online interaction task in their minds. The concept of navigational landmarks was introduced to help blind users create their mental map of the visited website and which in turn improves their navigation. The results from second experimental exercise prove that incorporation of recommended changes significantly improved accessibility and performance of blind users in the online environment. The participants performance in the 2<sup>nd</sup> experiment increased by around 60% compared to the 1<sup>st</sup> experiment with a notable increase in the participant overall satisfaction of using the portal. The participants in the second experiment required less time and low number of trials to perform the test with a notable reduced level of confusion and increased satisfaction.

A detailed set of technical recommendation were also laid out as a conclusion from the practical experiment on blind people which were incorporated in a simplified updated version of the website. Some of the important recommendations made about e-Government websites which could significantly improve the web based experience of blind people simplified and coherent design of web pages layout.

### **7.3 Limitations & Future Work**

In our research, the following limitations were identified. The research methodology applied in this research covered Arabic online application and did not account for other left to right languages which may/may not cause some variations in the proposed solutions. Also, this research selected the e-Government applications as one type of online interactions; however, other online interaction application like mobile phones, electronic stores, online games, etc., can be considered in future research.

## Appendices



## **APPENDIX A**

### **A. Pre-user testing session questionnaire**

Candidate information

Name:

Address:

Demographic profile:

Age:

Marital status:

Educational qualification:

Nature of disability:

Applicant form ID:

Questions:

- 1) Do you have a personal computer at home?
- 2) Do you have access to internet connection at home?
- 3) If you don't have internet connection, do you have access to internet by any other means?
- 4) How many internet users are there in your family?

- 5) How would you rate your level of confidence with the use of blind reader?
- 6) Do you have any previous experience with online or web based interaction? If yes, have you visited the e-Government website before?
- 7) How would you rate your level of computer literacy?  
Not applicable [ ], Basic [ ], Intermediate [ ], Advanced [ ], Frequent user [ ]
- 8) If you are an internet user, what kind of websites do you normally visit? And how much is the average time that you spend on internet?

## APPENDIX B

### A. Experimental Exercise

The online tasks given to applicants to be conducted on the e-Government portal consisted of:

- 1) Find a health facility by distance. Ministry of Health
- 2) Find a private medical facility. Ministry of Health
- 3) Inquiry about Social Security Status. Ministry of Social Affairs
- 4) Search the form for filling up “Subscription and Registration in Social Insurance” [“Government services” - “Government forms”] or “Car Registration Form”
- 5) “Inquiry and updating of family member medical records, appointments, details and mobile numbers” - “Health and Environment”
- 6) “Renewal of medical certificate” – “Health and Environment”
- 7) Check the current Government policy
- 8) "Projects and Initiatives" - "National Plans and Initiatives" - find info about "The Eighth Development Plan 1425/26 – 1429/30 AH 2005 – 2009 AD"
- 9) The Internet Awareness Project “SALEEM”
- 10) Check latest IT events
- 11) Register on the website. Log in and comment on a BLOG of your interest.
- 12) Search for job with Government
- 13) Participate in polls.

14) Give feedback.

## APPENDIX C

### A. Experimental exercise evaluation form

The form was to be filled out by the researcher while the interviewee is doing the tasks.

The online tasks given to applicants to be conducted on the e-Government portal consisted of:

1) Find a health facility by distance. [Ministry of Health]

I. How much time did this task consume?

**Average time taken for all participants: 4 minutes 28 seconds**

II. Did the interviewee found it easy to locate the correct page?

**[ 20% ] Yes [ 80% ] No**

III. Did the interviewee face any problems with the task?

**[ 13.33% ] Yes [ 86.67% ] No**

IV. Did the interviewee found it easy to write his/her feedback on the website ?

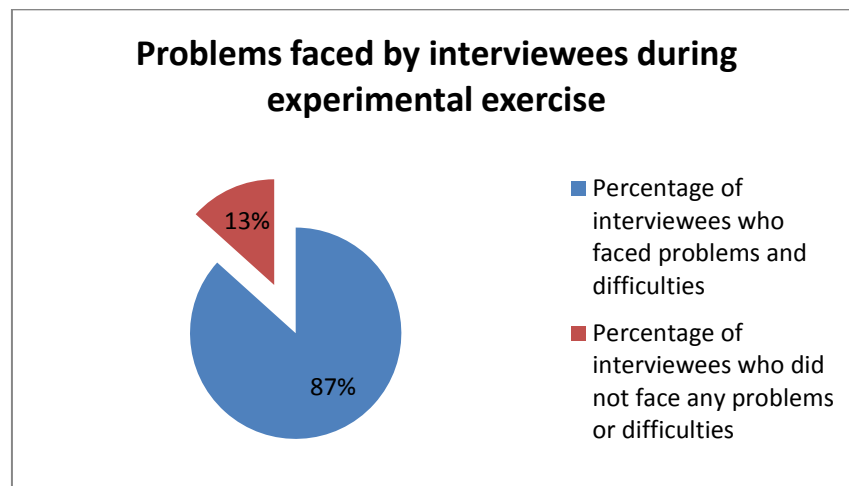
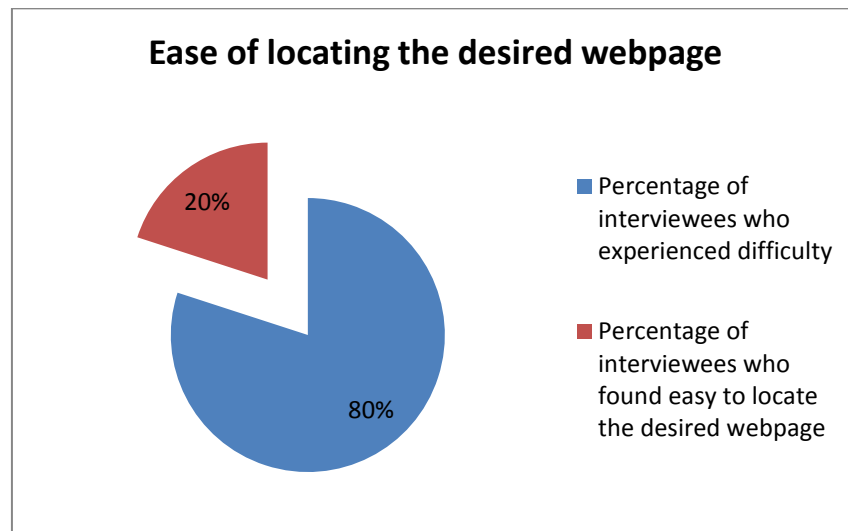
**[ 39.8% ] Yes [ 60.2% ] No**

V. Was the feedback entered by the interviewee free of any error? [ 30% ] Yes [

**70% ] No**

VI. Comments: **Very difficult to navigate from the home page. Poor accessibility.**

VII. Rate the overall task performed by the interviewees ?



2) Find a private medical facility. [Ministry of Health]

I How much time did this task consume?

**Average time taken for all participants: 4 minutes 05 seconds**

II Did the interviewee found it easy to locate the correct page?

[ 33.33% ] Yes [ 66.67% ] No

III Did the interviewee face any problems with the task?

[ 26.67% ] Yes [ 74.4% ] No

IV Did the interviewee found it easy to write his/her feedback on the website ?

[ 54.9% ] Yes [ 45.1% ] No

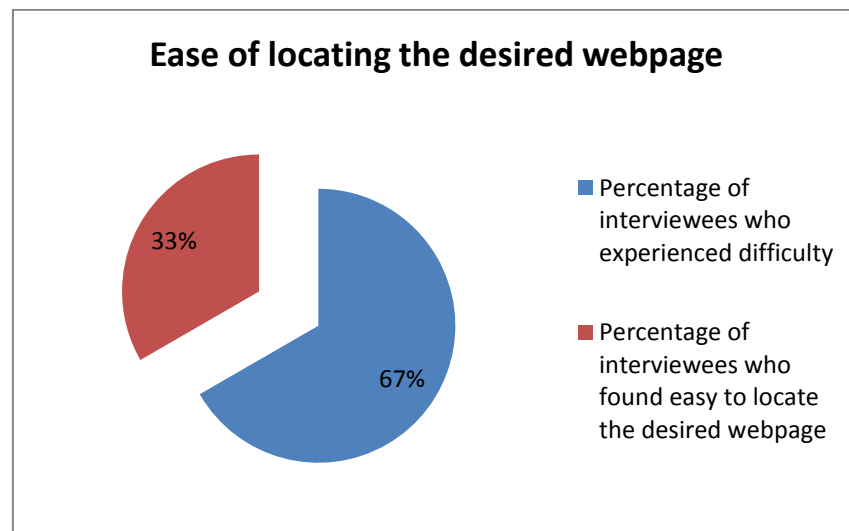
V Was the feedback entered by the interviewee free of any error? [ 13.44% ] Yes

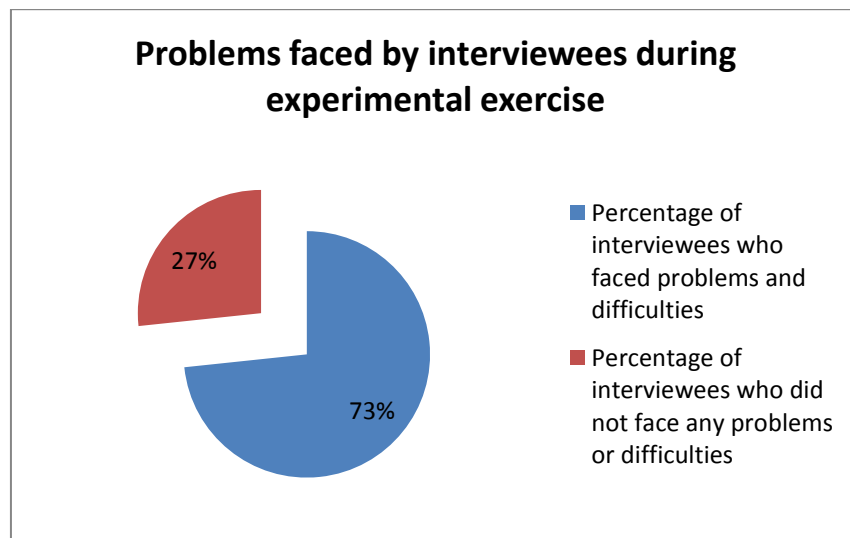
[ 86.66% ] No

VI Comments: **Time spent on restarting the screen reader.**

VII Rate the overall task performed by the interviewees?

4

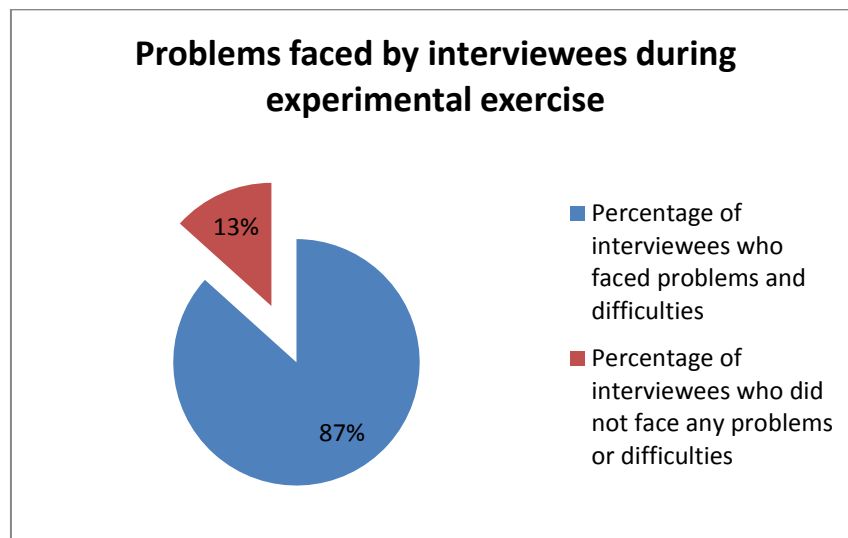
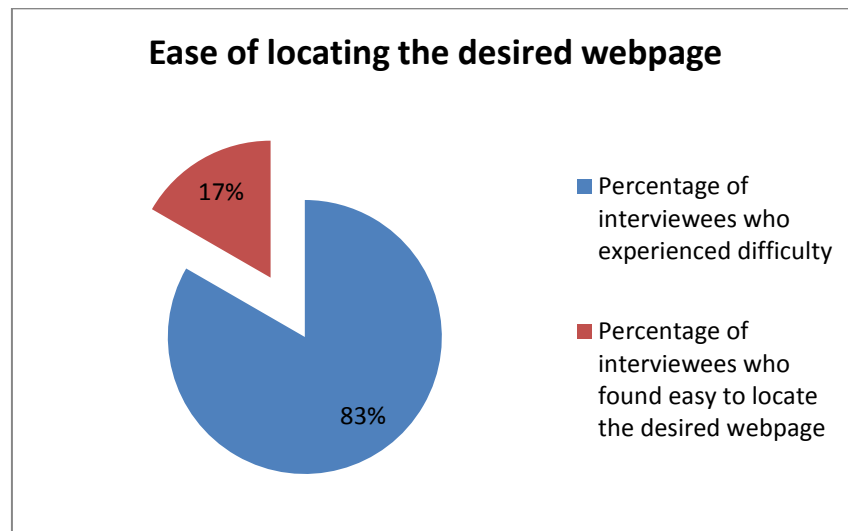




### 3) Inquiry about Social Security Status. [Ministry of Social Affairs]

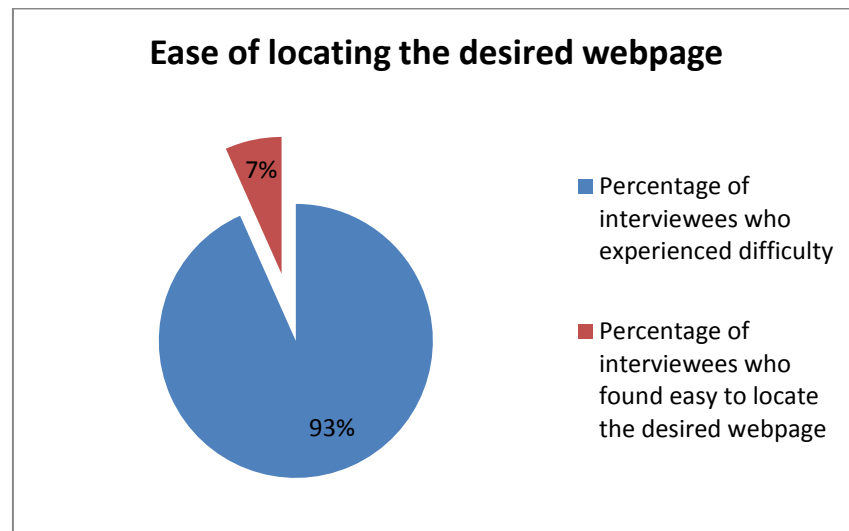
- I. How much time did this task consume?  
**Average time: 4 minutes 55 seconds**
- II. Did the interviewee found it easy to locate the correct page?  
[ **16.67%** ] Yes [ **83.33%** ] No
- III. Did the interviewee face any problems with the task?  
[ **13.33%** ] Yes [ **86.67%** ] No
- IV. Did the interviewee found it easy to write his/her feedback on the website ?  
[ **54.9%** ] Yes [ **45.1%** ] No
- V. Was the feedback entered by the interviewee free of any error? [ **33.5%** ] Yes  
[ **66.5%** ] No
- IV. Comments: **Time wasted going backward and forward**
- V. Rate the overall task performed by the interviewees?

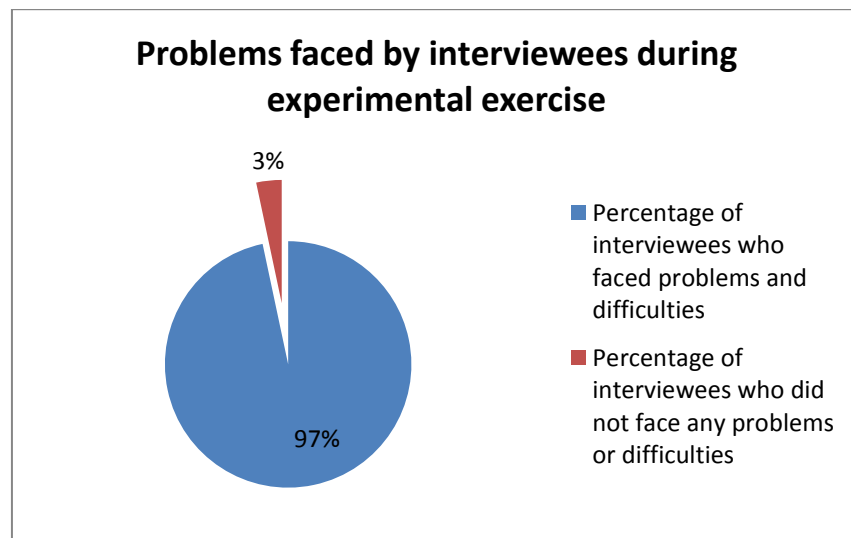




- 4) Search the form for filling up “Subscription and Registration in Social Insurance” [“Government services” - “Government forms”] or “Car Registration Form”.

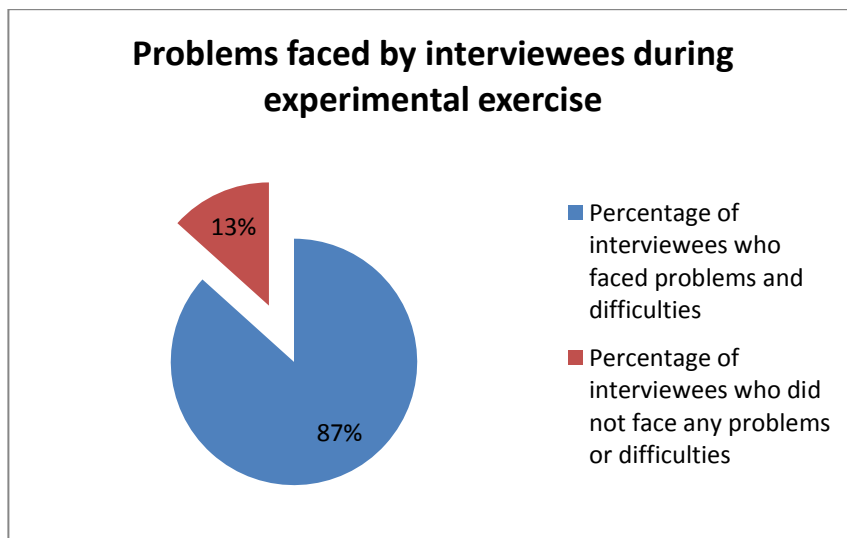
- I. How much time did this task consume? **Average time: 5 minutes 31 seconds**
  - II. Did the interviewee found it easy to locate the correct page? [ **6.67%** ] **Yes**  
[ **93.33%** ] **No**
  - III. Did the interviewee face any problems with the task? [ **3.33%** ] **Yes** [ **96.67%** ] **No**
  - IV Did the interviewee found it easy to write his/her feedback on the website ?  
[**70.6%** ] **Yes** [**29.4%** ] **No**
  - V Was the feedback entered by the interviewee free of any error? [**13.5%** ] **Yes**  
[**86.5%** ] **No**
- IV. Comments: confused with other middle tabs
- V. Rate the overall task performed by the interviewees?
- 2





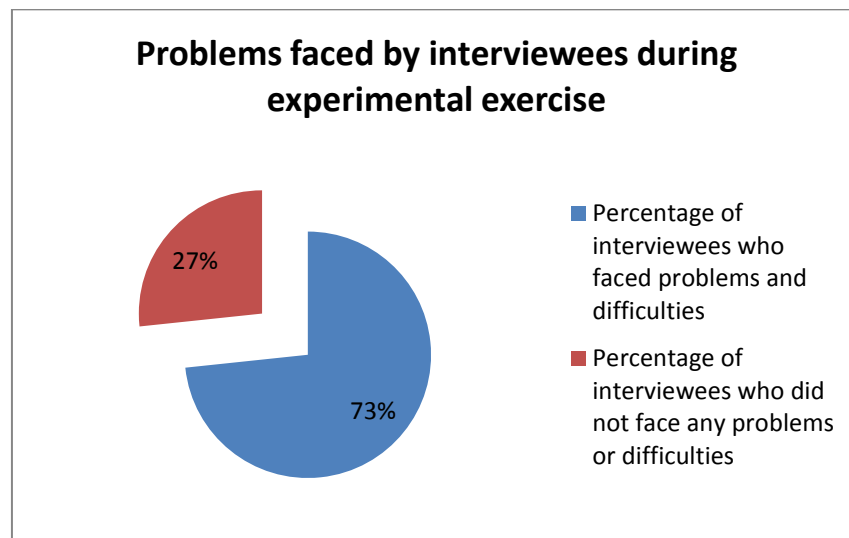
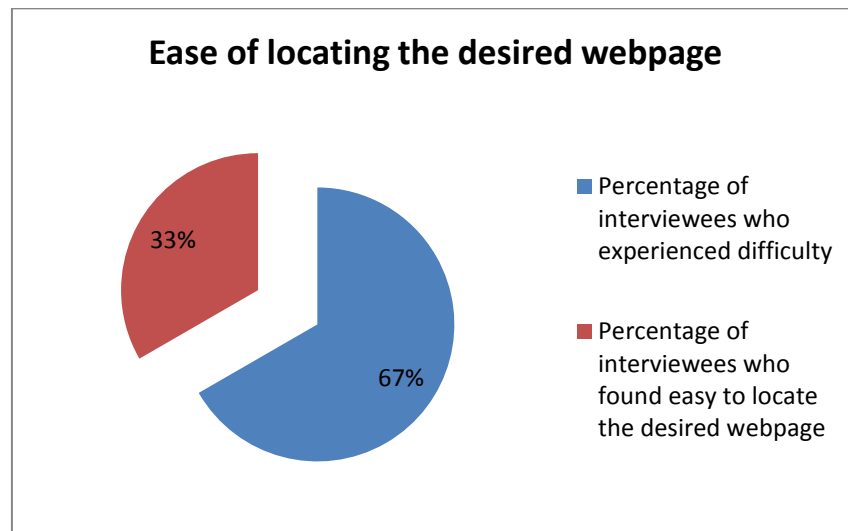
5) Inquiry and updating of family member medical records, appointments, details and mobile numbers.

- I. How much time did this task consume? **Average time: 4 minutes 2 seconds**
- II. Did the interviewee found it easy to locate the correct page? [ 20% ] **Yes [ 80% ] No**
- III. Did the interviewee face any problems with the task? [ 13.33% ] **Yes [ 86.67% ] No**
- IV. Did the interviewee found it easy to write his/her feedback on the website? [ 23.9% ] **Yes [ 76.1% ] No**
- V. Was the feedback entered by the interviewee free of any error? [ 45.5% ] **Yes [ 54.5% ] No**
- IV. Comments: **poor accessibility**
- V. Rate the overall task performed by the interviewees? **3**



#### 6) Renewal of medical certificate

- I. How much time did this task consume? **Average time: 3 minutes 47 seconds**
- II. Did the interviewee found it easy to locate the correct page? [ **33.33%** ] **Yes** [ **66.67%** ] **No**
- III. Did the interviewee face any problems with the task? [ **26.67%** ] **Yes** [ **73.33%** ] **No**
- IV. Did the interviewee found it easy to write his/her feedback on the website ? [ **29.9%** ] **Yes** [ **70.1%** ] **No**
- V. Was the feedback entered by the interviewee free of any error? [ **45.3%** ] **Yes** [ **54.7%** ] **No**
- IV. Comments: **difficulties faced to find the right tab**
- V. Rate the overall task performed by the interviewees? **4**

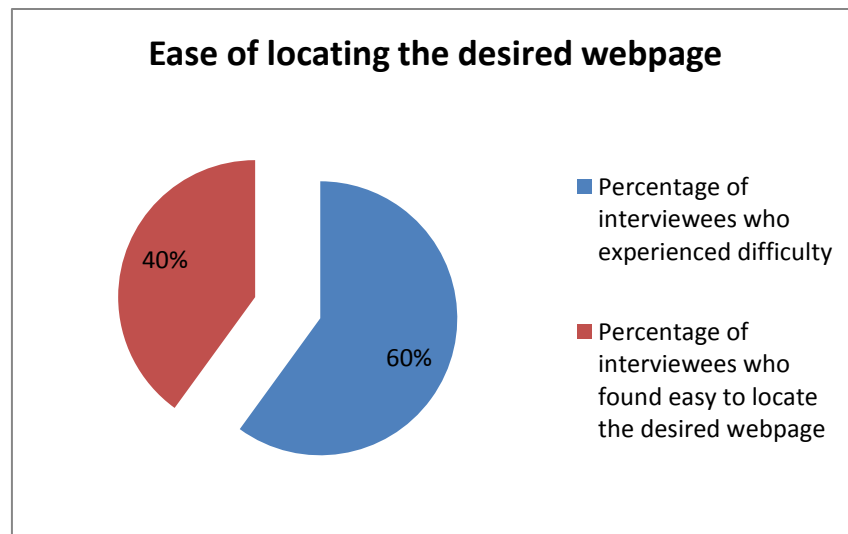


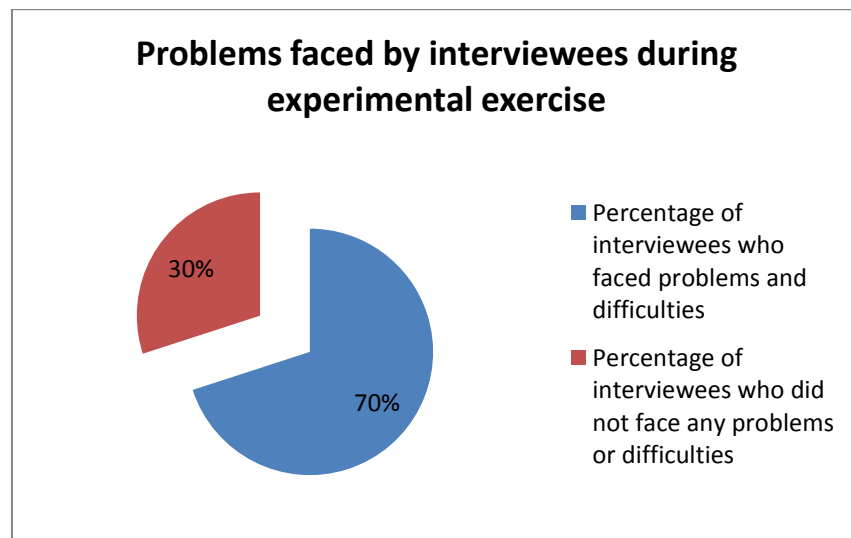
#### 7) Check the current Government policy

- I. How much time did this task consume? **Average time: 3 minutes 58 seconds**
- II. Did the interviewee find it easy to locate the correct page? [ **40%** ] **Yes** [ **60%** ] **No**
- III. Did the interviewee face any problems with the task? [ **30%** ] **Yes** [ **70%** ] **No**

- IV Did the interviewee found it easy to write his/her feedback on the website  
[ 28.9% ] Yes [71.1% ] No
- V Was the feedback entered by the interviewee free of any error? [ 63.5% ] Yes  
[36.5% ] No

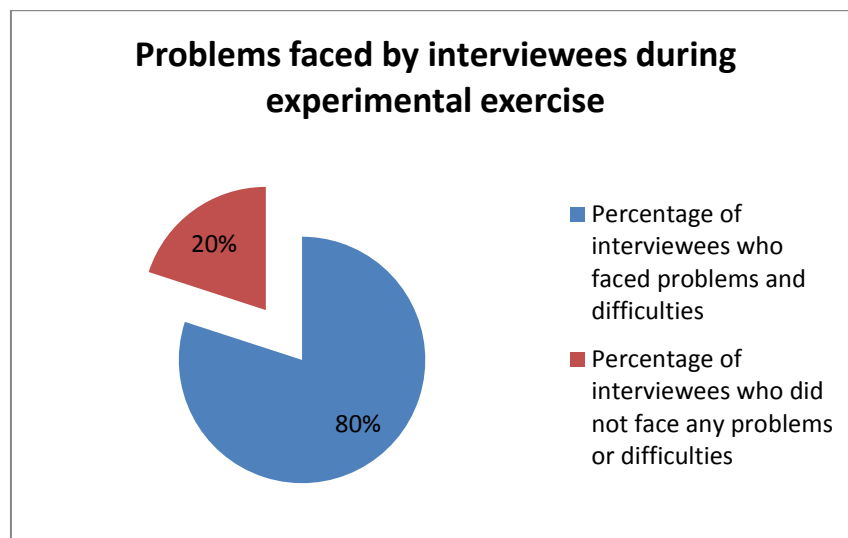
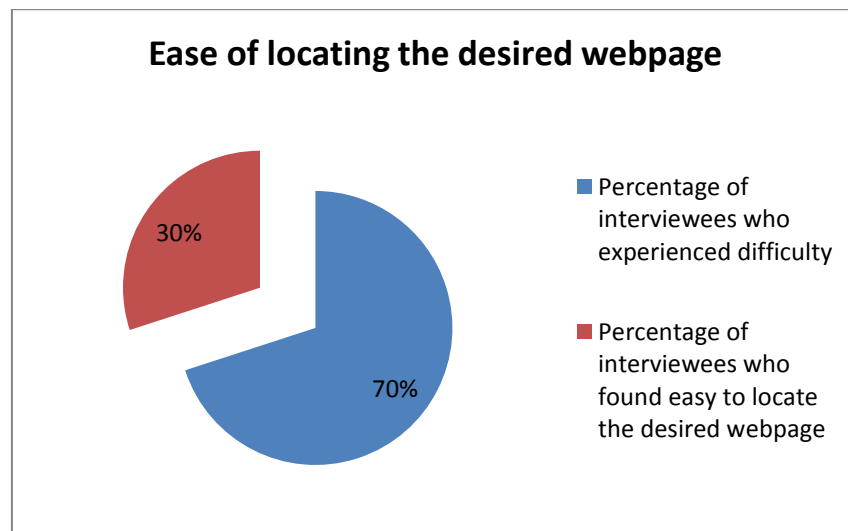
- IV. Comments: **difficulties to find the right button**
- V. Rate the overall task performed by the interviewees? **4**





8) "Projects and Initiatives" - "National Plans and Initiatives" - find info about "The Eighth Development Plan 1425/26 – 1429/30 AH 2005 – 2009 AD".

- I. How much time did this task consume? **Average time: 3 minutes 15 seconds**
- II. Did the interviewee found it easy to locate the correct page? [ 30% ] **Yes** [ 70% ] **No**
- III. Did the interviewee face any problems with the task? [ 20% ] **Yes** [ 80% ] **No**
- IV. Comments: **difficulties to find the right tab.**
- V. Rate the overall task performed by the interviewees? **3**

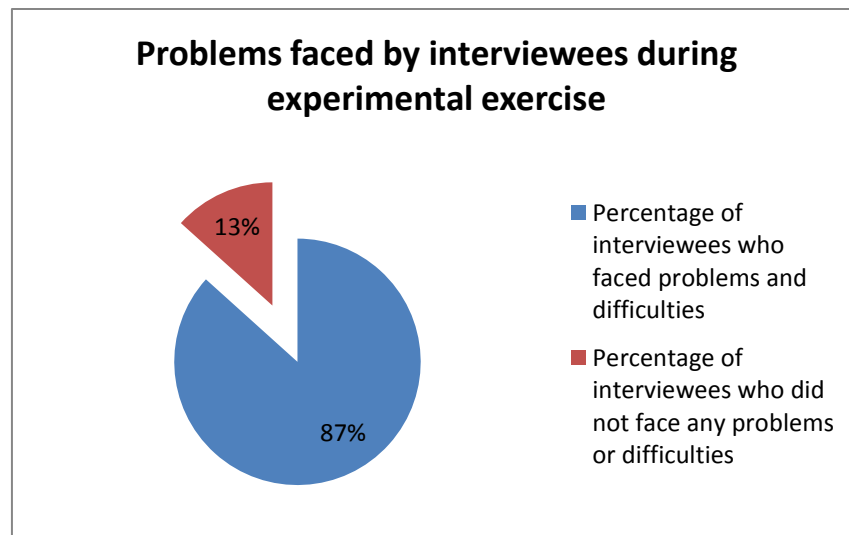
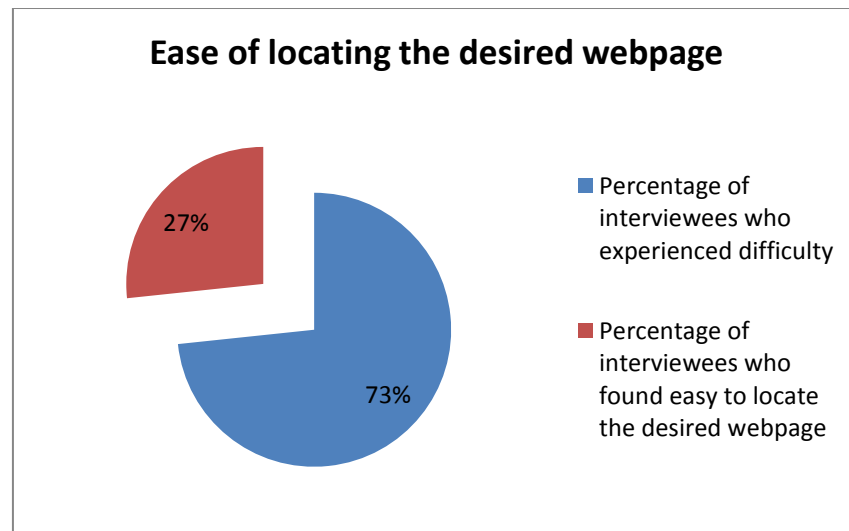


9) Check the details of “The Internet Awareness Project “SALEEM””.

I. How much time did this task consume? **Average time: 3 minutes 31 seconds**

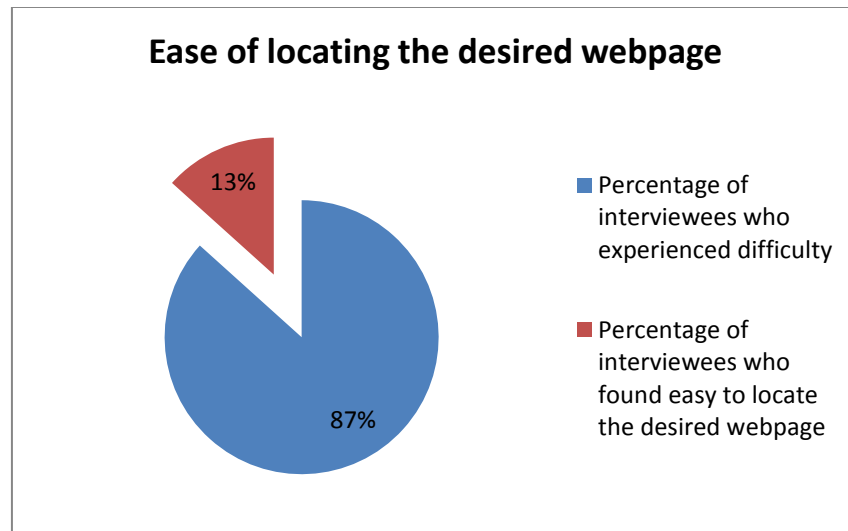


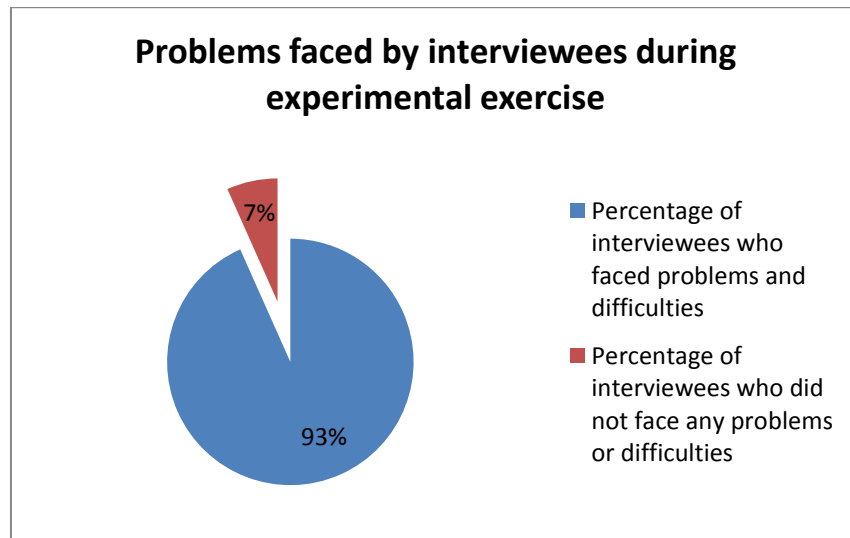
- II. Did the interviewee found it easy to locate the correct page? [ **26.67%** ] **Yes** [ **73.33%** ] **No**
- III. Did the interviewee faced any problems with the task? [ **13.33%** ] **Yes** [ **86.67%** ] **No**
- IV. Comments: Not clear why they could not find it even though it very accessible
- V. Rate the overall task performed by the interviewees? **3**



10) Check latest IT events on the website.

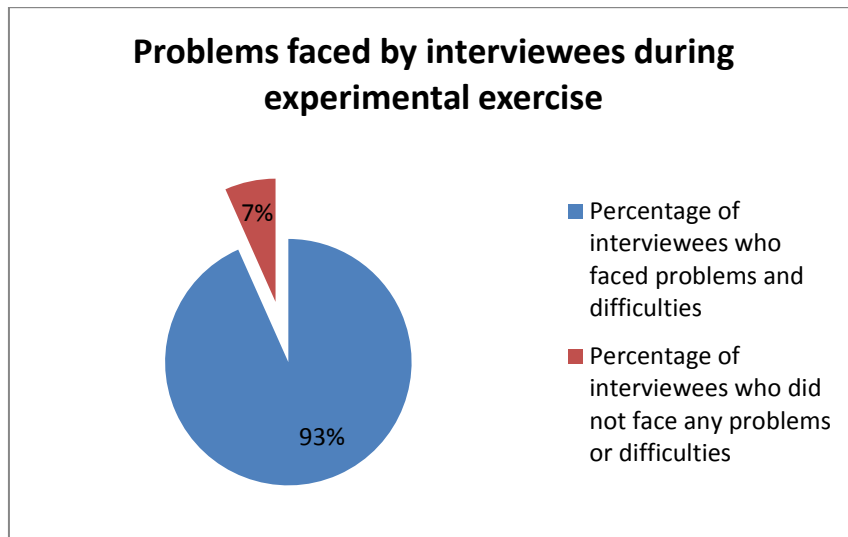
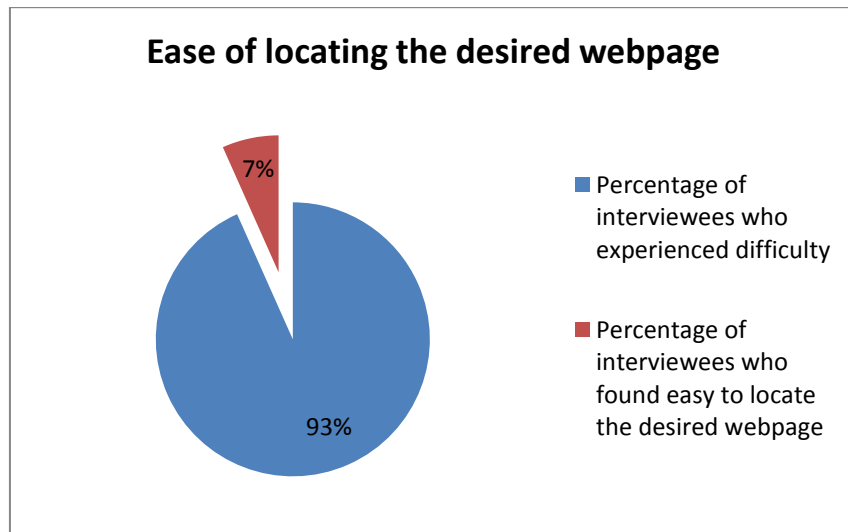
- I. How much time did this task consume? **Average time: 3 minutes 42 seconds**
- II. Did the interviewee found it easy to locate the correct page? [ **13.33%** ] **Yes**  
[ **86.67%** ] **No**
- III. Did the interviewee face any problems with the task? [ **6.67%** ] **Yes** [ **93.33%** ] **No**
- IV. Comments:
- V. Rate the overall task performed by the interviewees? **4**





11) Register on the website. Log in and comment on a blog of your interest.

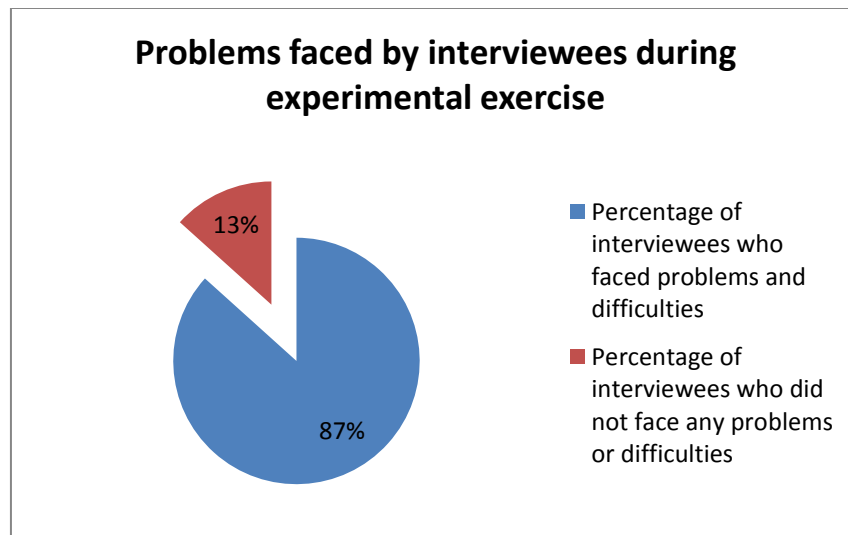
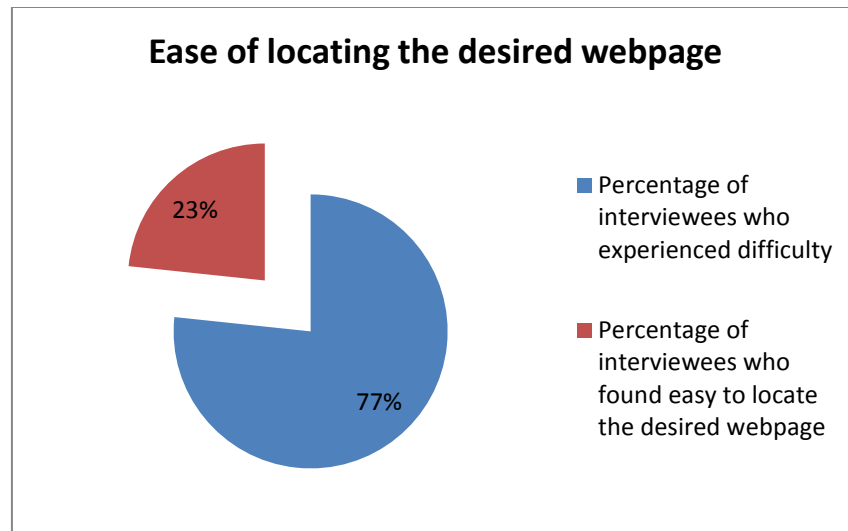
- I. How much time did this task consume? **Average time: 9 minutes 16 seconds**
- II. Did the interviewee found it easy to locate the correct page? [ **6.67%** ] **Yes**  
[ **93.33%** ] **No**
- III. Did the interviewee found it easy to use comment on the blog? [ **6.67%** ] **Yes**  
[ **93.33%** ] **No**
- IV. Was the comment entered by the interviewee free of any error? [ **3.33%** ] **Yes**  
[ **96.67%** ] **No**
- V. Did the interviewee face any problems with the task? [ **96.67%** ] **Yes** [ **3.33%** ] **No**
- VI. Comments: \_\_\_\_\_
- VII. Rate the overall task performed by the interviewees? **1**



12) Search for job with Government.

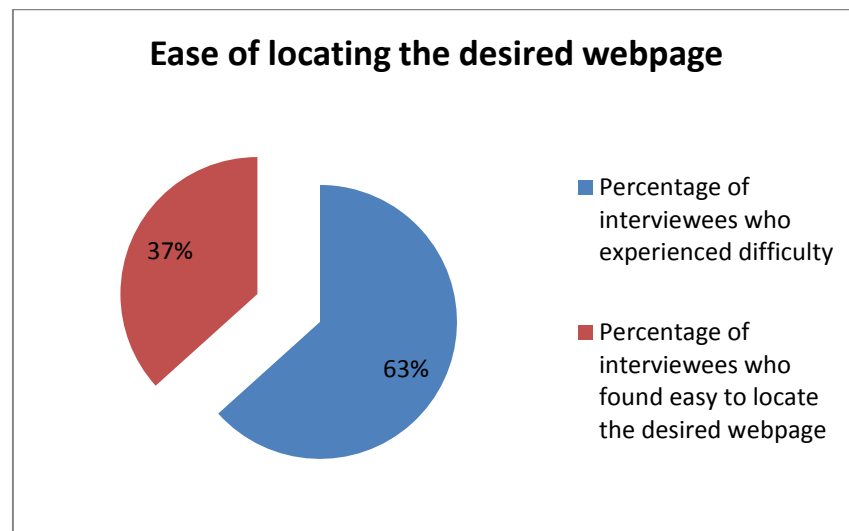
- I. How much time did this task consume? **Average time: 5 minutes 16 seconds**
- II. Did the interviewee find it easy to locate the correct page? [ **23.33%** ] **Yes**  
[ **76.67%** ] **No**

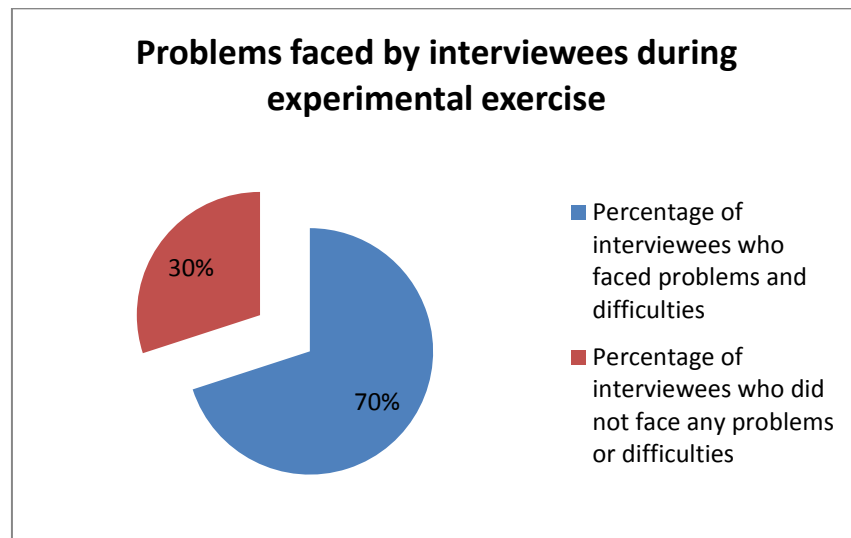
- III. Did the interviewee face any problems with the task? [ 13.33% ] Yes [ 86.67% ] No
- IV. Comments: none
- V. Rate the overall task performed by the interviewees? 3



13) Participate in one of the public polls.

- I. How much time did this task consume? **Average time: 5 minutes 44 seconds**
- II. Did the interviewee found it easy to locate the correct page? [ **36.67%** ] **Yes**  
[ **63.33%** ] **No**
- III. Did the interviewee face any problems with the task? [ **30%** ] **Yes** [ **70%** ] **No**
- IV. Did the interviewee found it easy to use comment on the public polls? [ **23.33%** ] **Yes**  
[ **86.67%** ] **No**
- V. Was the comment entered by the interviewee free of any error? [ **6.67%** ] **Yes**  
[ **93.33%** ] **No**
- VI. Comments: **Most of the interviewees experienced difficulties in commenting on the website. Also the text was too much to aid navigation on the webpage.**
- VII. Rate the overall task performed by the interviewees? **4**

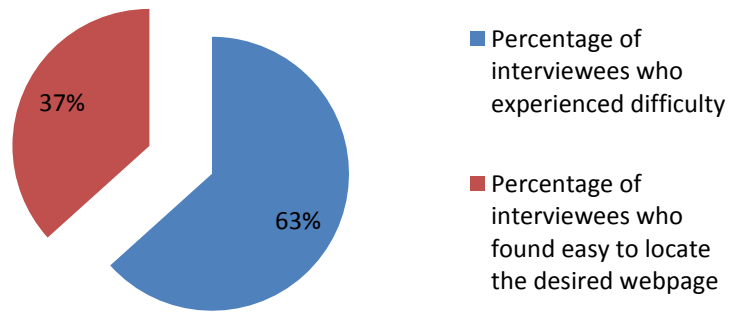




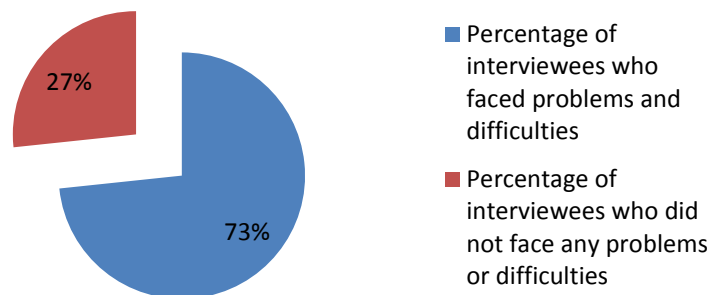
14) Give feedback on the website.

- I. How much time did this task consume? **Average time: 3 minutes 13 seconds**
- II. Did the interviewee find it easy to locate the correct page? [ **36.67%** ] **Yes**  
[ **63.33%** ] **No**
- III. Did the interviewee face any problems with the task? [ **26.67%** ] **Yes**  
[ **73.33%** ] **No**
- IV. Did the interviewee find it easy to use write his or her feedback on the website? [ **20%** ] **Yes** [ **80%** ] **No**
- V. Was the feedback entered by the interviewee free of any error? [ **10%** ] **Yes**  
[ **90%** ] **No**
- VI. Comments: **Most of the interviewees experienced difficulties while entering feedback on the website.**
- VII. Rate the overall task performed by the interviewees? **2**

### Ease of locating the desired webpage



### Problems faced by interviewees during experimental exercise





## **APPENDIX D**

### **A. Candidate feedback questionnaire**

The questionnaire is designed to understand the user's experience while using the e-Government website. The questions were verbally asked from the author to each individual candidate to avoid any sort of communication gap, allowing free flow of thoughts about web experience.

The questions were designed to get user's feedback on a scale of 1 to 10 ranging from strongly agree (positive) to agree, neutral, disagree and strongly disagree.

The candidate feedback questionnaire given to interviewees after the experimental exercise consisted of the following questions:

2) How would you rate the degree of difficulty for each task?

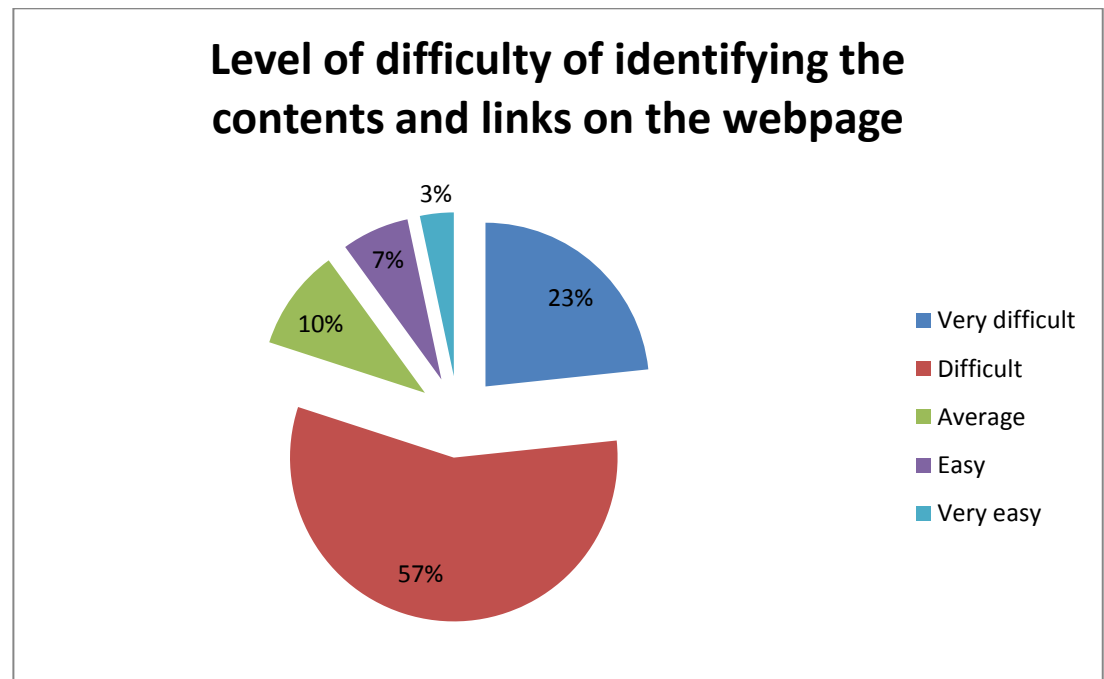
- I. Very Difficult [ **46.67%** ], Difficult [ **23.33%** ], Average [ **16.67%** ], Easy [ **10%** ], Very Easy [ **3.33%** ]
- II. Very Difficult [ **40%** ], Difficult [ **30%** ], Average [ **20%** ], Easy [ **6.67%** ], Very Easy [ **3.33%** ]
- III. Very Difficult [ **43.33%** ], Difficult [ **30%** ], Average [ **20%** ], Easy [ **3.33%** ], Very Easy [ **3.33%** ]
- IV. Very Difficult [ **36.67%** ], Difficult [ **36.67%** ], Average [ **16.67%** ], Easy [ **10%** ], Very Easy [ **0%** ]
- V. Very Difficult [ **40%** ], Difficult [ **36.67%** ], Average [ **13.33%** ], Easy [ **6.67%** ], Very Easy [ **3.33%** ]
- VI. Very Difficult [ **33.33%** ], Difficult [ **30%** ], Average [ **20%** ], Easy [ **13.33%** ], Very Easy [ **3.33%** ]
- VII. Very Difficult [ **43.33%** ], Difficult [ **33.33%** ], Average [ **13.33%** ], Easy [ **10%** ], Very Easy [ **0%** ]
- VIII. Very Difficult [ **56.67%** ], Difficult [ **13.33%** ], Average [ **16.67%** ], Easy [ **13.33%** ], Very Easy [ **0%** ]
- IX. Very Difficult [ **53.33%** ], Difficult [ **10%** ], Average [ **23.33%** ], Easy [ **10%** ], Very Easy [ **3.33%** ]
- X. Very Difficult [ **36.67%** ], Difficult [ **43.33%** ], Average [ **13.33%** ], Easy [ **3.33%** ], Very Easy [ **3.33%** ]
- XI. Very Difficult [ **40%** ], Difficult [ **33.33%** ], Average [ **16.67%** ], Easy [ **6.67%** ], Very Easy [ **3.33%** ]
- XII. Very Difficult [ **46.67%** ], Difficult [ **33.33%** ], Average [ **20%** ], Easy [ **10%** ], Very Easy [ **0%** ]
- XIII. Very Difficult [ **53.33%** ], Difficult [ **16.67%** ], Average [ **20%** ], Easy [ **6.67%** ], Very Easy [ **3.33%** ]
- XIV. Very Difficult [ **30%** ], Difficult [ **40%** ], Average [ **16.67%** ], Easy [ **10%** ], Very Easy [ **3.33%** ]

It is important to note that in question number 2, the interviewee was asked to comment on the degree of difficulty of each of the 14 tasks.

- 3) Were all the contents and links easy to be identified and understood? How would you rate the level of difficulty?

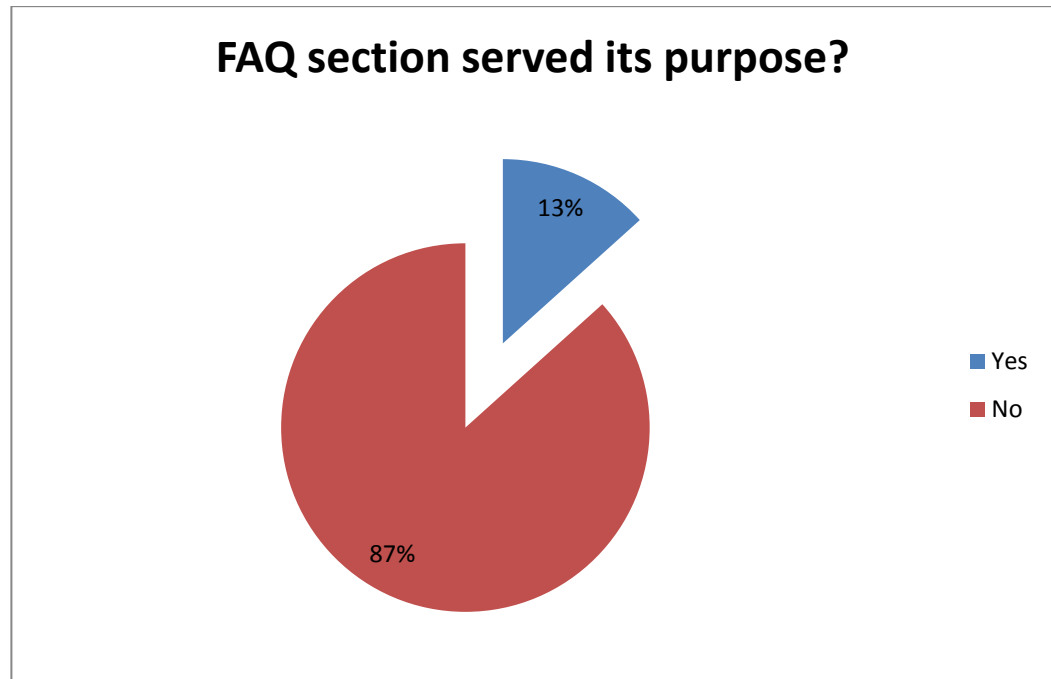
Yes [ **16.67%** ], No [ **83.33%** ]

Very Difficult [ **23.33%** ], Difficult [ **56.67%** ], Average [ **10%** ], Easy [ **6.67%** ], Very Easy [ **3.33%** ]



- 4) Was the FAQ (frequently asked questions) section able to help you in finding answer to your query during the session?

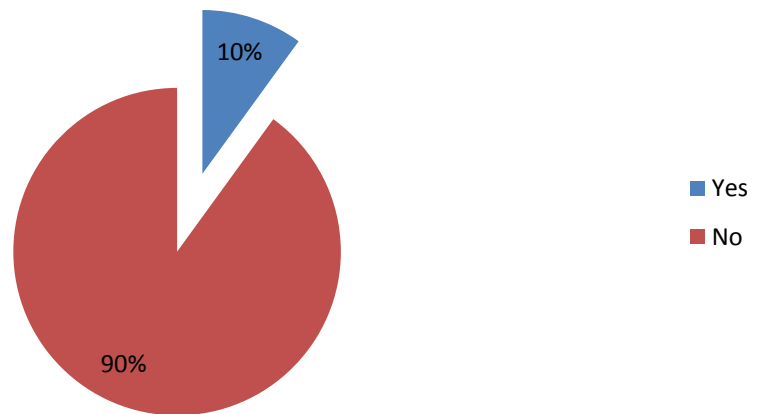
Yes [ **13.33%** ], No [ **86.67%** ]



- 5) Do you think that the information and services from web portal were enough to justify your time and efforts spent on the task?

Yes [ **10%** ], No [ **90%** ]

### Time and effort spent justifiable for the amount of information and services?

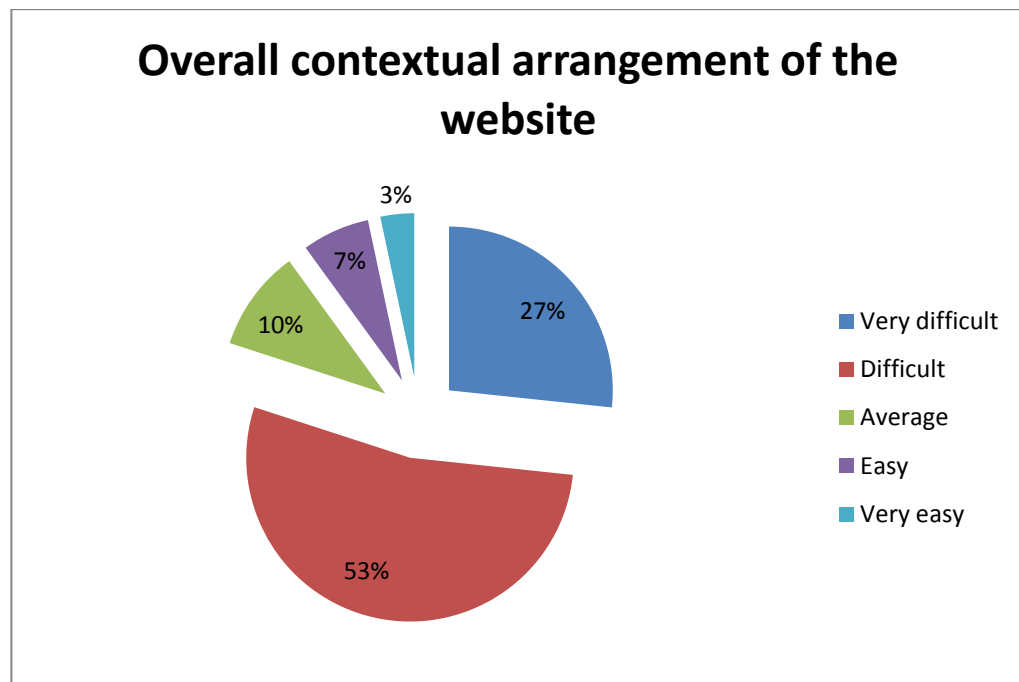


- 6) How would you rate the overall contextual arrangement of the website? Would you like to recommend any changes to enhance its usability for blind users?

Very Difficult [ **26.67%** ], Difficult [ **53.33%** ], Average [ **10%** ], Easy [ **6.67%** ], Very Easy [ **3.33%** ]

Yes [ **96.67%** ], No [ **3.33%** ]

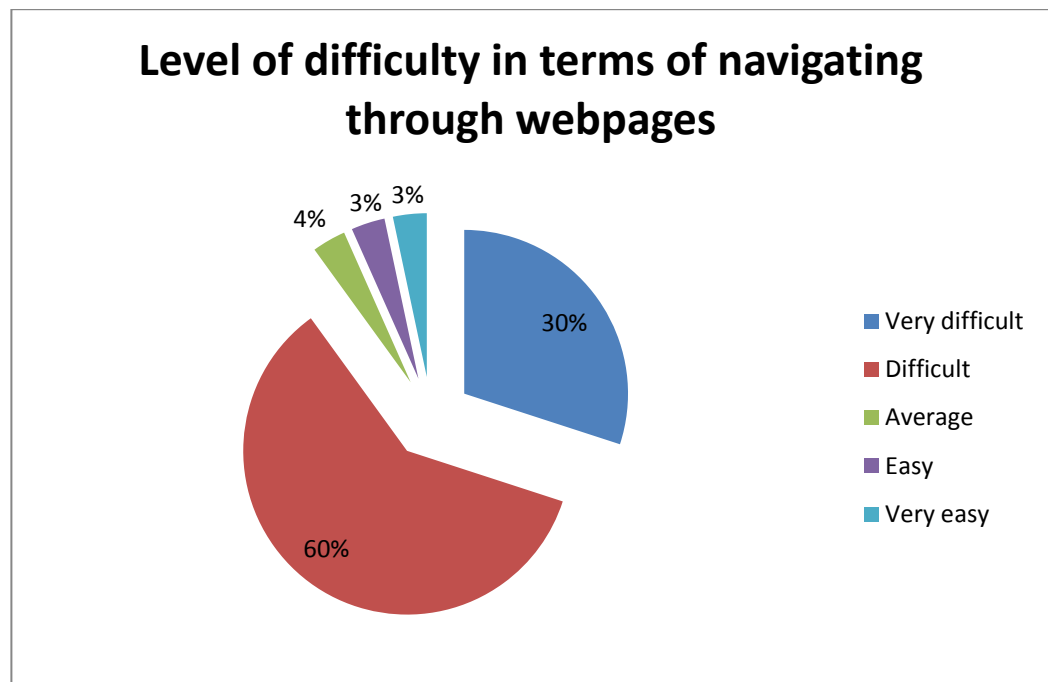
One repetitively mentioned comment was like (reduce the size of the website).



7) Were the webpages easy to navigate through? How would you rate the level of difficulty?

Yes [ **3.33%** ], No [ **96.67%** ]

Very Difficult [ **30%** ], Difficult [ **60%** ], Average [ **3.33%** ], Easy [ **3.33%** ],  
Very Easy [ **3.33%** ]



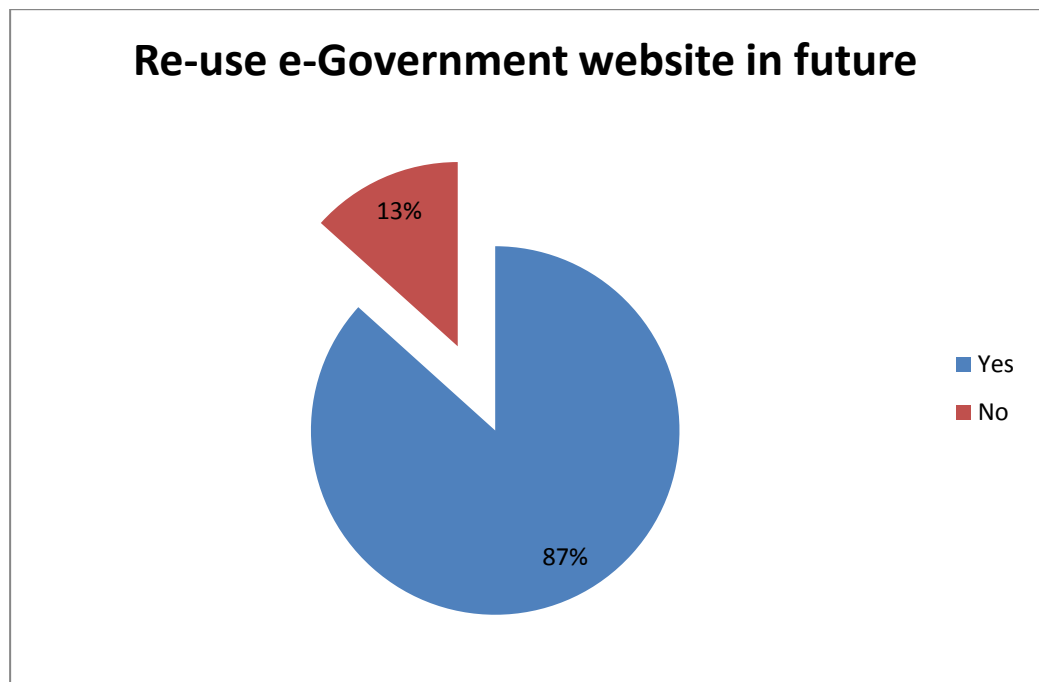
- 8) Did you find the list of services too long ? Would you also recommend the name of service providers to be arranged alphabetically?

Yes [ **93.33%** ], No [ **6.67%** ]

Yes [ **93.33%** ], No [ **6.67%** ]

- 9) Would you like to use the e-Government website for accessing information or services in future?

Yes [ **86.67%** ], No [ **13.33%** ]



10) How useful was the information on the website?

Not useful at all [ **10%** ], Not very useful [ **16.67%** ], Average [ **30%** ], Useful [ **20%** ], Very Useful [ **23.33%** ]

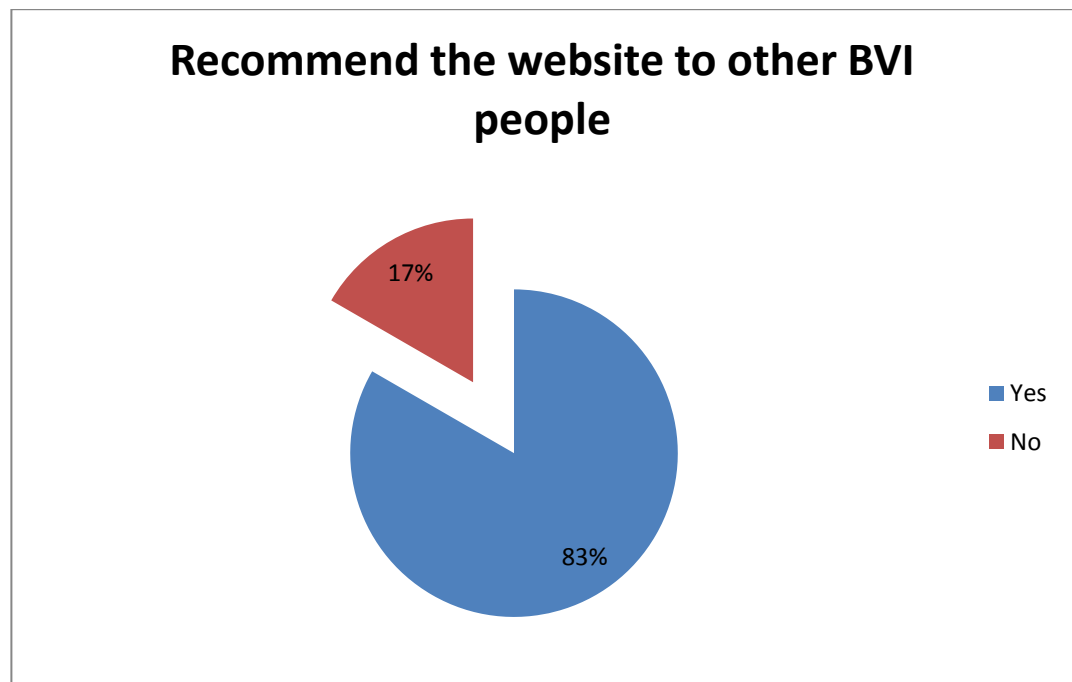
11) Was the final outcome of exercise able to meet the goals set at the beginning?

Yes [ **13.33%** ], No [ **86.67%** ]

12) Would you recommend using the website and services to other blind people?

Yes [ **83.33%** ], No [ **16.67%** ]





13) Any further comments.

A summary of the received comments is:

*There must be some type of help available on the website in the form of audio to assist blind users in browsing through the webpage and getting to the required information source. Also the design of website is complex and incoherent. The webpage with FAQ is also not very useful. It could be updated and made much more user oriented.*

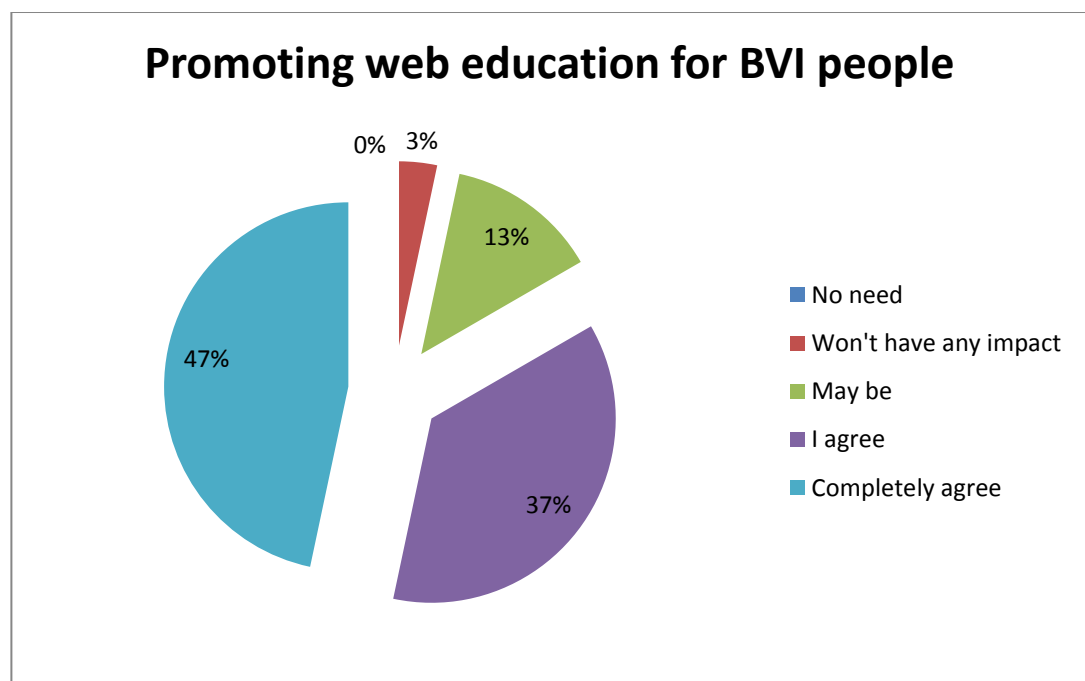
14) What do you think of government efforts towards blind people?

A summary of the received comments is :

*The Government is putting efforts however they could be better targeted in solving specific IT and web related issues.*

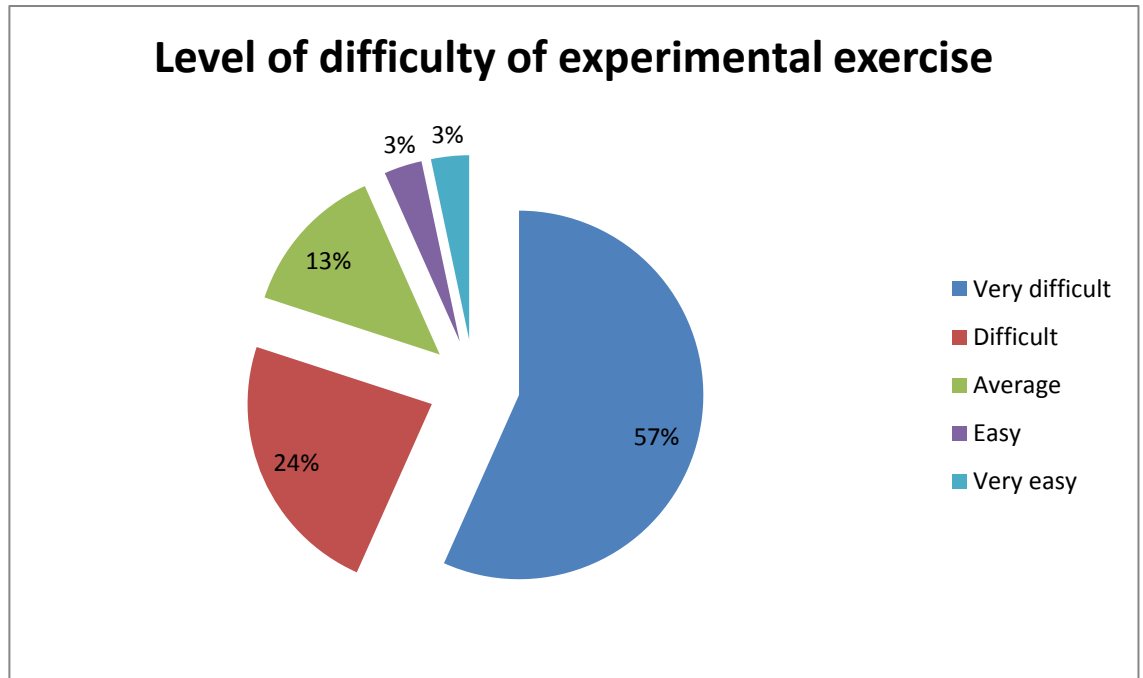
15) Do you think web education for blind people should be promoted?

No need [ 0% ], Won't have any impact [ 3.33% ], May be [ 13.33% ], I agree [ 36.67% ], Completely agree [ 46.67% ]



16) Was the experimental exercise simple and easy?

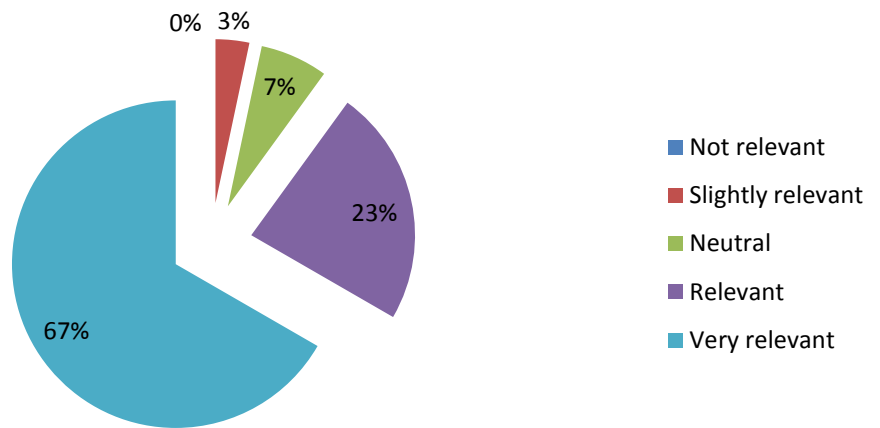
No it was very difficult [ **56.67%** ], No it was difficult [ **23.33%** ], Average [ **13.33%** ], Yes it was easy [ **3.33%** ], Yes it was very easy [ **3.33%** ]



17) Were the questions in this exercise related to what an average blind person would search for?

Not related at all [ **0%** ], Slightly related [ **3.33%** ], Neutral [ **6.67%** ], Yes they were related [ **23.33%** ], Yes they were exactly what an average blind person would search for [ **66.67%** ]

### Relevance of questions in experimental exercise

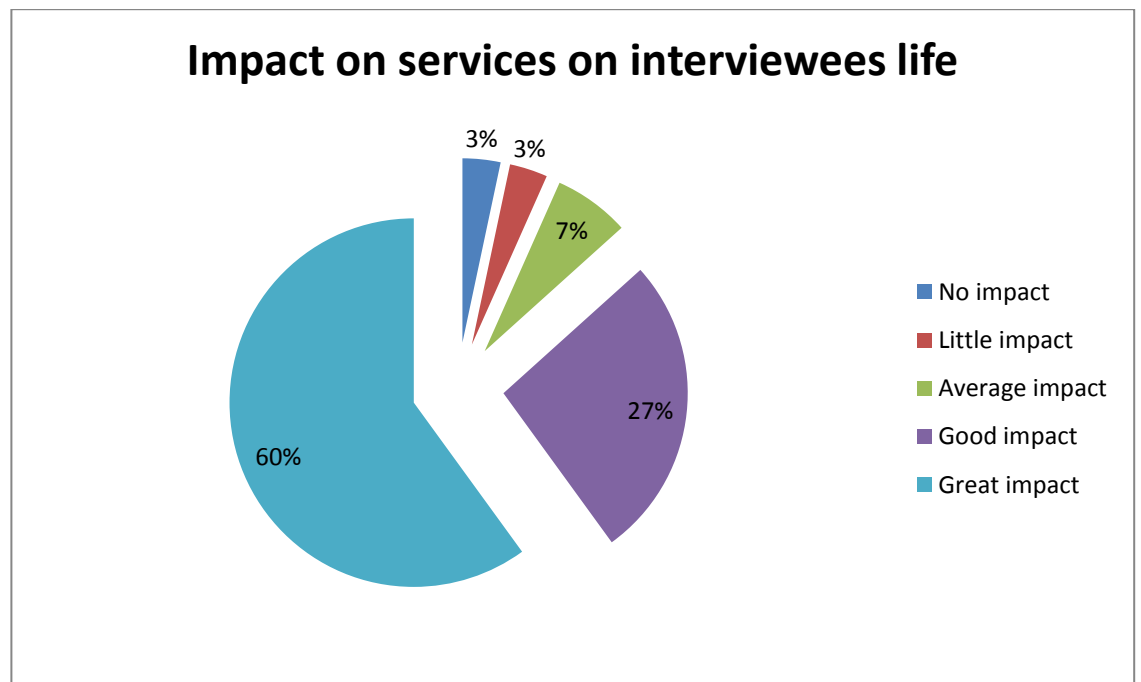


18) How will the services on web portal affect your life? Please comment?

Will not affect at all [ **3.33%** ], Will not affect too much [ **3.33%** ], Will affect on an average level [ **6.67%** ], Will affect to good extent [ **26.67%** ], Will affect greatly [ **60%** ].

A summary of the given comments is:

*The e-Government services would help blind users in better connecting to the outside world and government activities.*



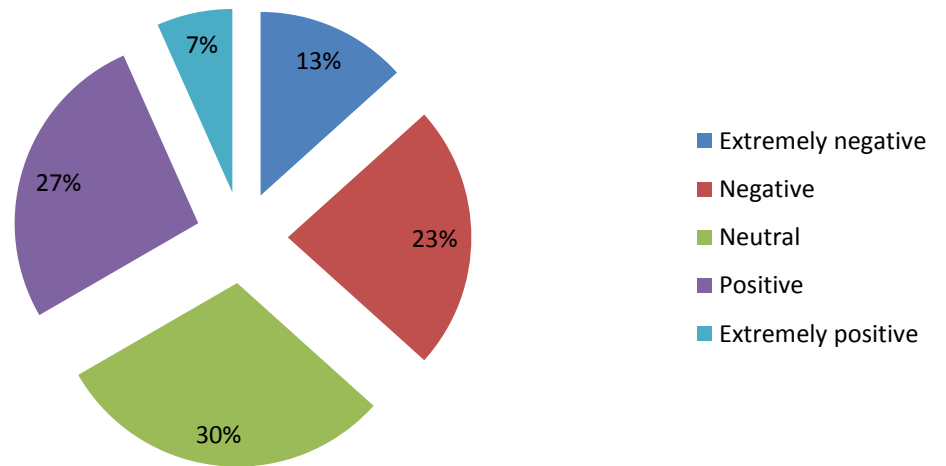
19)How frequently would you be using it, if all your proposed changes are implemented and the website is made more accessible and usable?

Not at all [ **3.33%** ], Not very often [ **6.67%** ], Sometimes [ **6.67%** ], Regularly [ **43.33%** ], Very often [ **40%** ]

20)What is your view about m-Government? Please comment?

Extremely negative [ **13.33%** ], Negative [ **23.33%** ], Neutral [ **30%** ], Positive [ **26.67%** ], Extremely positive [ **6.67%** ]

## Views on m-Government



## APPENDIX E

### A. Questionnaire for interviewing of web designers and developers

The following questionnaire was compiled for interviewing of web designers and developers.

- 1) What do you think are the toughest challenges faced by BLIND users related to accessibility and usability of web based resources?
- 2) My research suggests that even a well-designed website which conforms to WCAG guidelines does not result in a good degree of user satisfaction amongst blind people. By how far do you agree with this point?
- 3) How can the web based experience for blind users be improved?
- 4) A very common perception of adapting a design to suit the requirements of disabled users is the idea that all that is needed for such group of people is to acquire special assistive technology that will replace missing accessibility information on Web sites. With this reference, what additional steps do you think should be taken which could result in a better degree of accessibility and usability amongst blind people?

- 5) What are the typical constraints faced by the web designers and developers in making the website universally accessible?
- 6) Any further comments?



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