2 Users with Special Needs and Related Work

This research aims at improving web accessibility for specific groups of *atypical* users and non-users whose access to web resources is greatly limited due to the way the web is developed and built today. Two groups of users with special needs constitute the main focus of this work. They are: users with difficulty in ***seeing*** web pages and users with difficulty in ***reading*** and ***understanding*** textual contents on web pages. Whilst the interaction of the first group with the Internet is a subject very well explored and there are a number of proposed solutions and guidelines on how to design web pages accessible to them, (since every country has a percent of visually disabled citizens and much has been done to get to know them and their needs), the second group, although representing a large portion of the population in some countries, has been almost forgotten throughout these years of Internet use. This group is usually formed by low-income individuals, and they are highly concentrated in the so called developing countries. Over an astonishing thirty two percent (32%) of Brazil's adult population are estimated to fit in the latter category[3].

Since this research has taken place in Brazil, the examples, experiments and statistics used and shown here are related to Brazilian reality. That doesn't exclude, however, the possibility of other countries with similar problems of benefiting from the contributions presented here.

Below more detailed information about each of these groups in Brazil, and some aspects of their web navigation in present days, are presented.

2.1. People with difficulty seeing web contents

This group comprises individuals with visual impairments. Anyone with incorrigible visual impairment is considered to be visually impaired. The number of visually impaired users in Brazil, according to last IBGE (Geography and Statistics Brazilian Institute) census in 2000, is approximately 16 million people

[3] According to http://www.ipm.org.br/ipmb_pagina.php?mpg=4.02.00.00.00&ver=por, 32% is comprised of 7% illiterate and 25% roughly literate. These concepts will be explained further in the text.

(IBGE, 2000), representing 9.8% of the Brazilian population. This population can be divided into three larger sets, among others that are less commonly encountered:

1) Blind – estimated from 0.4% to 0.5% of Brazilian population, which comprises around 640,000 people, according to Temporini and Kara-José (Temporini, et al., 2004). Blind people are those with substantial, incorrigible loss of sight in both eyes. In order to interact with computers, blind users make use of screen readers, software applications that attempt to identify and interpret the code of what is being displayed on the screen. If a web page is being displayed, screen readers interpret the html code of that page. As screen readers handle only text, blind users are deprived of understanding multimedia information, such as images and videos. That's why some of them use only text-based browsers when navigating the web. The keyboard is the main input device used by them. Mouse devices are of no use (WAI);

2) Low Vision – comprises people with all kinds of partially impaired sight, such as poor acuity, central field loss, tunnel vision, clouded vision, among others. When interacting with computers, low-vision users make use of extra-large monitors, screen magnifiers, and, specifically when navigating the web, they might overwrite the web page Cascading Style Sheet (CSS), a style sheet language used to describe the presentation of a document written in a markup language, with their own CSS. The use of their own CSS allows them to present the contents of the web site in a more proper and easy-to-see way, adjusted to compensate their impairment (WAI);

3) Color Blind – comprises people with a lack of sensitivity to certain colors that others can distinguish. Usually, these people face difficulties in distinguishing between red and green, or between yellow and blue. More rarely they present the inability to perceive any color. Like the low-vision users, color blind users also use their own CSS to navigate the web (WAI);

Although the blind represent the smallest set, I chose to work with them, since they present the most difficult challenge to technology designers among all visually impaired users. In general, one could say that because they face the hardest problems when interacting with computers, contributions to their particular needs should indirectly contribute to other groups as well (e.g. low vision and color blind users).

Below, the way blind users navigate the Internet is presented. It is possible to see that all solutions used by them need not be exclusive to them. And such is the case of this research: aiming at proposing a contribution to blind users, one could say that all other visually impaired users might benefit from it as well (which doesn't mean that a few adaptations won't be required to fully attend to their needs). Once the worst case scenario is identified and "conquered", adapting the provided solution to *less challenged* users might not be of major complexity. This, though, is a hypothesis that needs to be further verified in future work, and is outside of the scope of this dissertation.

2.1.1. Related work (helping web navigation for the blind)

Assistive Technologies

Many tools and devices have been developed to support blind users in web navigation. They make use of a diverse set of mechanisms and artifacts to overcome their disability in order to navigate and access the desired resource in the web. The following is a list of these mechanisms and artifacts:

1) Screen Reader – software that captures the digitalized text or the html code and redirects it to a voice synthesizer (to be output orally) and/or into a refreshable Braille display. In this way, blind users can listen to or read in Braille the textual contents of the web page. Images or videos are kept undisclosed to blind users, and the most they get from it is the description text that sometimes accompanies them. Many screen readers are available to the blind community; some of them with no charge to their users. Examples of screen readers that support the Portuguese language are: JAWS, DosVox, NVDA, Thunder, Virtual Vision, Via Voice among others. All the experiments performed in this research used the JAWS screen reader[4].

[4] JAWS software was kindly lent by Ana M.B. Pavani, associate professor at the Department of Electric Engineering of PUC-Rio.

The way screen readers work is by reading a page from left to right, top to bottom. Users can control what should be read by positioning the cursor in the desired place through the tab key (tabbing moves the cursor to the next element, while shift-tab moves it to the previous one). The screen reader will, then, start reading from the point where the cursor is positioned. Reading html pages (documents structured in tables and cells) does not differ from that. It starts from the left top corner of the code and reads each and every element in the sequence, in a depth-first-search algorithm. Figure 1 shows an html page divided in numbered sections, in red. The numbers represent the order in which the sections are read by screen readers. However, not always is there a strict relation between the position of an html element in the document and its rendered position on the screen. On the contrary, very often elements that are positioned on top of the screen might be well immersed in the html code, causing it to be read only after many other previous html elements. Two examples of that are the numbered sections 8 and 14, in Figure 1. This behavior not only might induce in blind users a different perception of the order of the elements, but also might cause a lack of efficiency in their navigation. They might take many seconds or even minutes to locate resources non-blind users would easily locate with a single eye-pass on the rendered web page.

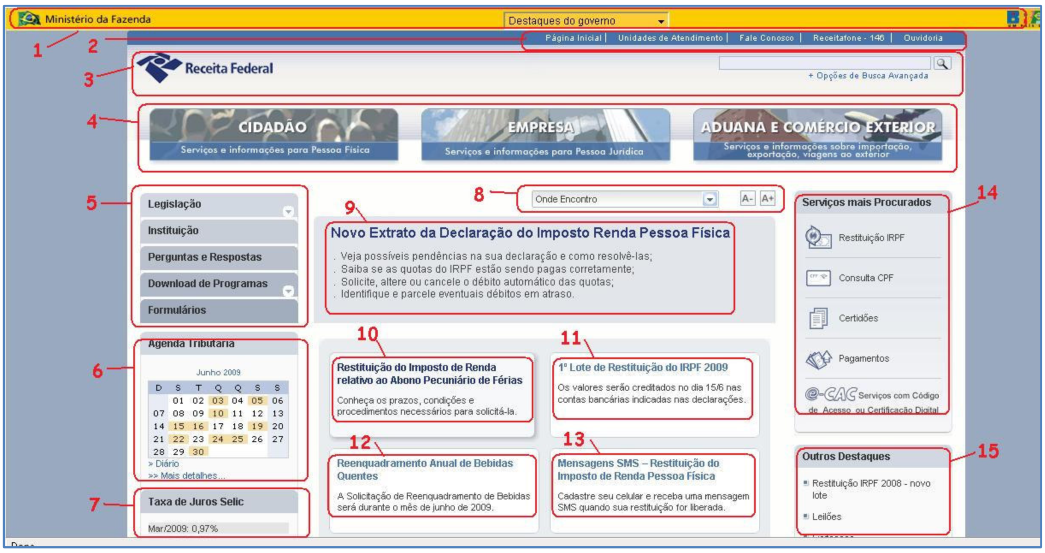

Figure 1: Screen-Readers reading order

2) Text-based browsers – since only textual information is read by the screen readers, text-based browsers were developed to assist this specific population. An example of such a browser is Lynx (Lynx);

3) Refreshable Braille displays – devices composed of moveable small pins that rise and fall to form Braille character. Data read by screen readers (normally, what is exhibited in the monitor screen) is immediately translated into refreshable Braille. After reading one line, users decide upon proceeding to the next line by pressing the advance bar above the display. These devices are used in combination with screen readers, and serve as a way of reading data output to screen (Brown, 1992);

Few Initiatives

In order to make the most of the mechanisms and artifacts presented above, other efforts to help blind navigation were needed. Even though with the aid of screen readers blind users are able to navigate the web, their obstacles have not been totally overcome yet, as shown, for example, in a case study carried out in Brazil by Melo, Baranauskas and Bonilha (Melo, et al., 2004). They performed an experiment where a blind user was asked to locate four specific resources in a web site. Users with no major visual impairment would easily locate these resources, but the blind user showed many difficulties in performing these tasks. The reason for that lies, mostly, in how the web page was built. Unfortunately most of the pages on the web are not built to be fully accessible to users with visual disabilities. Thus the pressing need for an accessible web is evident. According to Tim Berners-Lee, director of the World Wide Web Consortium (W3C), there are more than 750 million people with disabilities worldwide (Berners-Lee, 1997); also, digital space is the most traversed road by people with Internet and computer accesses in search of information, as pointed out by Torres, Mazzoni and Alves (Torres, et al., 2002). For these reasons, several organizations have been working on the accessibility issue aiming both for the diffusion of this group's special necessities and for the spread of web pages design guidelines and best practices to better fulfill them.

Here I survey some of these major initiatives.

1) Web Accessibility Initiative (WAI): a World Wide Web Consortium (W3C) group in charge of defining the standards and developing the Authoring Tools, Web Content and User Agent Accessibility Guidelines. Launched in

1997 to "*promote and achieve web functionality for people with disabilities*" (WAI), WAI contains a series of documents with guidelines and techniques describing accessibility solutions to instruct and orient developers and content providers on how to accomplish their tasks so the result is accessible to users with disabilities (WAI). The WCAG (Web Content Accessibility Guidelines) document explains how to make web content more accessible. Authoring Tools are software and services used to produce web pages and web content, and the ATAG (Authoring Tool Accessibility Guidelines) explains how they should help web Developers produce web content in accordance with the WCAG. User Agents are web browsers, media players and other assistive technologies, and the UAAG (User Agent Accessibility Guidelines) explains how they should be developed in order to be accessible to people with disabilities. Besides these guidelines, the WAI also provides Accessible Rich Internet Applications (ARIA) guidelines, and information about Evaluation Tools and other accessible technologies.

In May 1999 W3C has approved the WCAG 1.0 recommendation, which includes 14 guidelines that are general principles of accessible designs (W3C/WCAG). The WCAG 2.0 was recently released, in April 2008, and is built on top of its previous version. It "…*is designed to apply broadly to different web technologies now and in the future, and to be testable with a combination of automated testing and human evaluation*." (W3C/WCAG)

2) Electronic Government Accessibility Model (e-MAG - Modelo de Acessibilidade do Governo Eletrônico): e-MAG is a "*list of recommendations to be considered such that the Brazilian government site accessibility process is conducted in a standardized and easy way*" (Eletrônico, 2007). e-MAG was first released in January, 2005, a month after the 5296 enactment was published, which stated that every Brazilian governmental site or portal must be accessible within twelve months. Since then, it has been updated once in December, 2005. e-MAG also presents a list of guidelines, some of them very similar to the WCAG ones, each one with a different priority.

3) Validation Methods: in order to automatically check the levels of accessibility of the sites and their conformity with the WAI guidelines (Tangarife, 2005), (W3C), permitting therefore easier ways to design

accessible sites, many validation tools were developed. These automatic tools analyze the html code in search of elements not in accordance to the WCAG guidelines. Although they are quick and accomplish an important part of the work, they still can't perceive subtle nuances, and for this reason cannot substitute human evaluation. Therefore, many other actions are recommended for web site developers, among them are: using a syntax HTML valuator; using a CSS valuator; using a Colors Contrast Analyzer; using spell checkers; reviewing the document for simplicity and clarity; asking disabled users to review the document.

Other Works

Recently, more effort has been put into the development of systems and tools that tackle the web accessibility issue for visually impaired users. Takagi et al. proposes a new approach called *Social Accessibility* based on a collaborative system, which makes use of a community of users to help fixing accessibility problems faced by visually impaired users, in existing web sites (Takagi, et al., 2008). Through this system, end-users would report to a group of volunteer users the accessibility problems they found in web pages, and these volunteers would make use of the *transcoding* technique, originally developed to adapt web pages for mobile devices (Bickmore, 1997) and to personalize pages (Maglio, 2000), in order to *"…transform inaccessible Web content into accessible content on the fly…"*. This technique is also used in *HeadingHunter* (Brudvik, et al., 2008), a Firefox browser extension which aims at automatically identifying headings in web pages and creating their corresponding HTML markups (h1-h6 tags). Blind users that have *HeadingHunter* installed in their browser can, by loading the web page, trigger the generation of these markups and their insertion in the loaded page, thus making their navigation more efficient.

Two other tools were developed focusing on visually impaired users' web navigation efficiency. Both of them identify the critical time needed by these users to be able to read a single page and to decide on the next steps, and they make use of different tools to try to relieve them of this burden. *CSurf* is a context-driven non-visual web browser proposed by Mahmud et al. that tries to firstly present users the relevant information of the pages (Mahmud, et al., 2007). It does that by analyzing the content of the clicked link (the interested context), identifying and rating the related contents from the next page, and presenting users with the web page reorganized in blocks ordered by their rate of relevance according to the context previously identified. Another tool developed by Harper and Patel explores the benefits of summarizations as a means of shortening the process of reading web pages by visually impaired users (Harper, et al., 2005) . They showed that small *Gist* summaries of web pages can be used by these users for deciding if the web page is or not worth reading, saving the time of reading undesired pages.

2.1.2. Difficulties with web navigation for the blind

Blind users come up against a number of barriers that make their surfing in the web difficult or even prevent it altogether. These barriers more often relate to the way the web page is designed. Among them some can be highlighted:

1) The texts used to describe the links are captured by the screen readers and informed by them to the users. Therefore, it is of utmost importance to use representative and useful descriptions. The use of texts such as “Click here” or “Next” constitute an obstacle to users that navigate through screen readers (Ferreira, et al., 2008);

2) Images and/or Videos without the ALT attribute (no alternative text) - as described in the previous section, only textual information can be read by screen readers and therefore interpreted by blind users. When facing an image or a video, screen readers read, instead, the contents of the attribute ALT, which should give an alternative text description for the graphic element being displayed. When these attributes are not filled in, or are filled in with no useful meaning, these elements are not perceived or not understood by blind users (W3C/WCAG);

3) As the structure of html pages is determined by tables, there is no guarantee that reading them sequentially or linearly will make any logic sense to the end-user (Pontelli E., 2002);

4) Poorly designed forms in html pages sometimes cannot be tabbed in a logical sequence. Moving between fields can be a cumbersome activity (WAI);

5) Some browsers do not offer keyboard support for all commands, relying many times on the mouse interaction. As mouse devices are not used by

blind users, these commands cannot be accomplished in this environment (WAI);

6) Some web pages present information in non-standard document format that can't be interpreted by Screen Readers;

It is important to say that the problems listed above are not all of them the same in nature. Some of them are related to *accessibility*, while others are related to *usability*. Accessibility and usability are different concepts. *Usability problems*, as defined by Ferreira and Nunes, are every characteristic observed during any situation that might delay, trouble or prevent a task accomplishment (Ferreira, et al., 2008). In other words, usability determines how *easily* an application is used by its users. While an application might be accessible to every user, but hard to use, the opposite is also true: an application might be easy to use by users with no special needs, but inaccessible to others with special needs. Accessibility could be compared to efficacy, whilst usability to efficiency.

From the list above, items 2 and 3 are barriers concerning usability.

The next section will cover the functionally illiterate user characteristics.

2.2. People with difficulty reading and understanding web contents

Every year the Paulo Montenegro Institute (IPM) and an NGO called Ação Educativa (AE) collect information about the levels of functional literacy among the Brazilian population between the ages of 15 and 64. According to UNESCO's latest definition, one is considered to be functionally literate if "*he/she has the basic reading, writing and mathematics to attend his/her social context demands and to keep learning and self-developing throughout his/her lifetime*" (Educativa, 2007). IPM and AE thus produce an INAF (National Functional Literacy Indicator), which segments the population into four levels of functional literacy in regard to their reading, writing and mathematics skills. The four levels of functional literacy concerning the reading skills are:

1) Illiterate: people that cannot decode words or sentences;

2) Roughly-literate: people able to identify very explicit information in very short portions of text, such as dates, prices, titles, etc;

3) Basically-literate: people able to identify explicit information in short and mid-size texts;

4) Literate: people able to read and understand long texts, correlating parts of it, or correlating two different texts;

According to the latest INAF 2007 report, the Brazilian population consists of 32% functionally illiterate (FI)[5] people (25% of roughly-literate plus 7% of illiterate) (Educativa, 2007).

There are other institutions that measure the levels of functional illiteracy in Brazil, in different ways from the one used by IPM and AE. In this study we chose to work with IPM and AE since they provide important information about functional illiteracy and the different methodologies used to measure the INAF. Some of the articles cited in their study, such as (Ribeiro, 2006) and (Montenegro, 2005), could be interesting in designing assistive browsers for the FI people.

2.2.1. Related work (helping web navigation for the functionally-illiterate)

According to the INAF 2005 report, 82% of the Brazilian illiterate completed up to three years of studies, while 82% of the roughly-literate completed up to seven years (Educativa, 2005). The great majority of these two groups have, thus, less than eight years of studies. As shown in Table1 below (Vargas, 2003), people with up to 8 years of studies are not frequent users of computers and Internet.

[5] Whenever the word "FI" appears in the text, it should be understood as Functionally-Illiterate

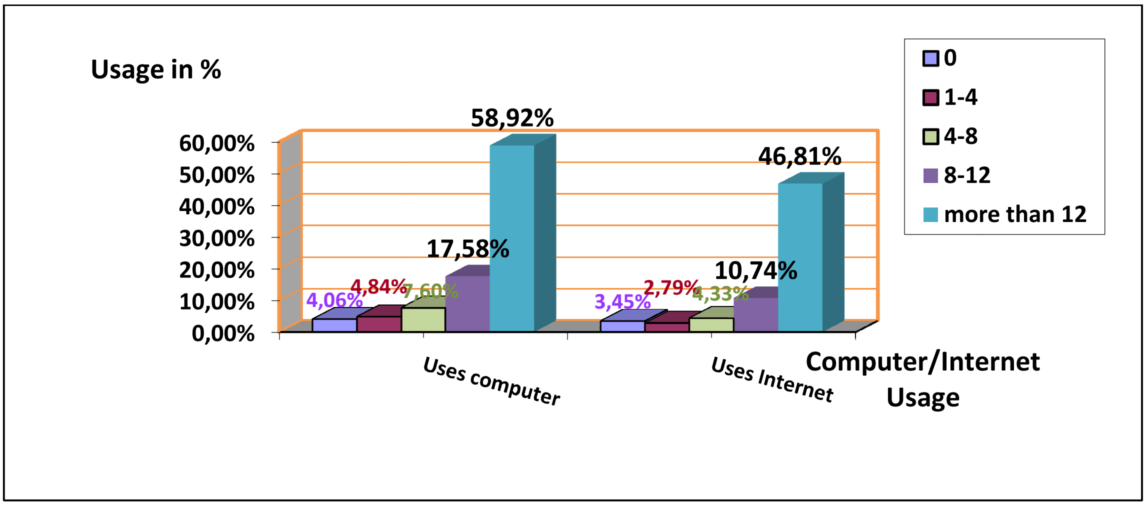

Table1 – Computer and Internet Usage According to Years of Study in Brazil

Also according to the 2005 INAF, less than 1% of the illiterate use computers, compared to 6% of the roughly-literate, 23% of the basically-literate and 54% of the literate (Educativa, 2005).

Regarding other involved factors in this scenario, it is worth mentioning that a reasonable explanation for the current situation is highly related to the economic power of such groups (which is not necessarily true of the blind). As stated in (Pinto, et al., 2000), levels of income and of literacy are strongly connected: more than 50% of the illiterate in Brazil earn up to 3 minimum salaries a month. It is well known that the presence of functional illiterates in *developing* countries is by far much larger than in *developed* countries. As this is the case, one could risk saying that since this is not a problem that impacts the *developed* countries, and since much of the technology research and progress take place in these countries, this group of people has been quite neglected all through during the Internet history and evolution. Sites, as presented today, are certainly not really accessible by them, since a great part of their content is presented in textual form.

As accessibility relating to this type of users is a recent concern, not many references regarding their use of the web was found in the academic literature, and not much is known about how they navigate the web and about techniques to specifically improve their navigation.

A few studies have been done concerning *Text Simplification* (TS) techniques as an attempt to promote the access of complex texts to different types of people. Aluisio et al. have been working in the *PorSimples (Simplificação Textual do Português para Inclusão e Acessibilidade Digital)* project which addresses TS to simplify Brazilian Portuguese texts in the web, enabling both people at the rudimentary and basic literacy level, as well as those with cognitive disabilities to read web content (Aluísio, et al., 2008), (Aluísio, et al., 2008).

The *HAPPI* project, proposed by Devlin and Unthank, shares many similarities with *PorSimples*. Although its main focus group is *aphasic people*[6], they also make use of TS techniques and look for ways of letting people with difficulties in reading and comprehending complex texts gain access to web-based information, such as online news stories (Devlin, et al., 2006).

In addition, a few studies have been done on accessibility in government systems. Hornung and Baranauskas present the challenges for designing eGov (Electronic Government) systems accessible to the population as a whole, and point out three fundamental aspects to be considered regarding interaction in these systems, from which excerpts of the second and third are highlighted: "*Is it sufficient to just 'ask' socially/digitally excluded persons to participate? Certainly not; new methods should be proposed for design and evaluation of interaction in eGov for our context.*" and "*…the degree of interactivity…will depend on our ability to design solutions reachable by people with the diversity of competencies we have in our population.*" (Hornung, et al., 2007). The analysis of the Brazilian digital TV scenario and the recommendations proposed in it (Piccolo, et al., 2008) are another initiative that pursues the same path: making t-GOV (Television Government) applications accessible to the whole Brazilian population.

2.2.2. Difficulties with web navigation for the functionally-illiterate

Although the patterns of web usage by this group of people are still obscure, there are some facts that can help us understand this particular user profile. Functionally Illiterate (FI) people face accessibility difficulties of a different kind than those previously described in section 2.1. They have difficulties not only in the basic reading process (i.e., decoding words and phrases), but also in comprehending and extracting useful information from what was read. One might suggest, however, that functionally illiterate people could adopt the screen reader solution used by blind people in order to retrieve the contents of the web page. Actually, this research also considered this idea in its initial stage. And indeed some other studies are already being conducted with a similar approach. Prasad

[6] Present partial or total loss of the ability to articulate ideas or comprehend spoken or written language, resulting from damage to the brain caused by injury or disease.

et al. question how the email tool might be made accessible to populations with little or no literacy. In their work, they explore the use of video rather than text as the communication medium to promote a video-mail application among these users (Prasad, et al., 2008). Although it is an interesting proposal, sharing the solution adopted by blind users (i.e., screen readers) might not completely solve the problem of functionally illiterate users. Long and/or complex portions of texts, even if read aloud by someone else, might be equally incomprehensible to FI users. The limitations of grasping and identifying the contents of a text do not reside solely in the ability to read, but are intrinsically related to the cognitive skills of the reader as well. According to Petersson et al. "*… the effects of literacy and formal schooling is not limited to language related skills but appears to affect also other cognitive domains*" (Petersson, et al., 2001).

In a research done by Ribeiro, a group of functionally illiterate individuals from four different levels were asked to read a text; the purpose was to evaluate their understanding of the text. The group of individuals from the lowest literacy level had great difficulty in grasping the meaning of the text, and all of them gave up trying to read before reaching the end of the text. The group of individuals from the second lowest literacy level read the proposed text, but had certain difficulty in finding specific information when later asked to do so. "… *they seemed less interested in making a literal interpretation of the text than in evoking their own feelings, experiences and opinions*" (Ribeiro, 2001).

A thorough investigation into the cognitive implications of functionally illiterate adults is out of the scope of this dissertation. Nonetheless, it is known that there is some evidence that the characteristics of these individuals have a considerable impact on the way they navigate the web.

To sum up: on the one hand, there is a group of functionally illiterate users that take a long time to browse a web page because of difficulties in reading (if they read at all). On the other hand, there is a group of blind users that take long time to browse a web page because of accessibility problems on the page. Although the reasons for lack of efficacy and/or low efficiency are distinct, still the same approach can be used to help these two groups of users. As will be shown in section 3, this approach proposes a new technique in which users need not read the whole content of the page in order to reach the desired resource. With the aid of this technique two solutions based on common ground, although considerably different one from the other, are explored in this study.

As will be shown in further sections, it can be said that almost all Internet users, as well as some people that still are not Internet users, can benefit from the tool developed in this research. Even the most advanced or expert ones could take some profit from the benefits provided by it. As said by Vanderheiden, improving accessibility to one group will indirectly improve it to all users (Vanderheiden, 2003). This, however, is left for future work.