Disability and technology: building barriers or creating opportunities?

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Abstract

In this chapter, the authors explore the relationship of technology to disability, and how technology can be both a source of liberation and an agent of exclusion for disabled people. The impact of the 'digital divide' on people with specific access needs, is examined and discussed, while the physical, cognitive and environmental factors that can contribute to exclusion as a result of technology design and implementation are examined in some depth. Demographic, moral and economic reasons as to why all those involved in the development of technology should take accessibility seriously are presented, while drivers for inclusive design – legislative, technical and economic - are discussed. A review of accessible and inclusive design practice, and the kinds of support that are available from a wide variety of sources for inclusive design is presented - showing that there *are* ways to minimise exclusion and to promote access. Finally, in looking towards a world where the true potential of technology to enhance the lives of disabled people can be fully reached, an overview is provided of research and development in supporting inclusive design, along with those challenges that remain to be overcome.

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1 Introduction

Information technology has undoubtedly had an enormous impact on almost every aspect of society in the developed world. A more detailed examination of statistics, however, indicates that some groups are not benefiting as much as they might from these advances. This situation has been referred to as the Digital Divide – the divide between those groups of people who benefit from Information Technology and those who do not or cannot access it. (Pieper, Morasch and Piela, 2002)

The Digital Divide has many causes, including economic disadvantage, but inappropriate software and human factors engineering has also played a part in exacerbating the gap between those people who benefit greatly from computer technology and those who are excluded. Much software appears to have been designed by and for young men who are besotted by technology, and are more interested in playing with it, and exploring what the software can do, rather than achieving a particular goal in the simplest way.

For example, most office software has a very extensive range of functionality, but in practice few users access more than a small percentage of this. This over-provision of functionality encourages complex screen layouts, very small icons and buttons and often requires users to memorise large numbers of difficult-to-remember commands. These requirements are particularly arduous for older and disabled people.

Many older people and people with disabilities lack the visual acuity, manual dexterity, and cognitive ability successfully to operate much modern technology. Many find window-based environments and the software associated with them very confusing and difficult or impossible to use; most mobile telephones require good vision and a high level of dexterity and video tape recorders are well known for providing many usability problems for older people. In addition to standard software needing to be more accessible for older people, the needs and wants of people who are in the "autumn" of their lives are not necessarily the same as those of younger people for whom software has traditionally been designed. Specialised software is thus also needed which will enhance independence and quality of life of older and disabled people.

There is little evidence that older and disabled people are particularly technophobic - they are most often excluded because the design of the technology has not taken into account their needs. This exclusion is becoming increasingly problematic as the developed world relies more and more on this technology. Older and disabled people also form a significant and growing proportion of the population and many older people have control of substantial wealth and/or disposable income. This changing distribution of economic influence is creating expanding markets for products which can be used by people with a wider range of functionality and a much broader spectrum of needs and wants than has been the case in the past.

The requirement to address the needs of disabled people has also been enshrined in legislation in many countries. Such legislation is often implemented to protect against discrimination against people on account of their disability, but increasingly legislation is also directly or indirectly shaping technology markets as specific sectors are obliged to procure and provide optimally accessible software and information systems for use by its employees, and electronic information and services to the public.

While there are economic, demographic and legislative arguments for adopting inclusive design of technology - taking into account the needs of older and disabled people is likely to produce systems which are more usable by everyone. This point was made in emphatic form by Microsoft, who published the startling results of research carried out in 2003 into accessible technology and computing (Microsoft

2003 a & b). The most significant finding of their research was that 57% of computer users are likely to benefit from the use of accessible technology. Making software and web content accessible for older and disabled people is therefore not an option - it is an essential requirement for good design.

In this chapter, the authors point out the dangers inherent in the digital divide and the breadth of exclusion which failure to address its effects could cause. They describe the factors, physical, cognitive and environmental, which can contribute to exclusion and point out the demographic, moral and economic reasons for designers taking their contribution to exclusion, and the opportunities to promote accessibility, more seriously. The drivers for inclusive design – legislative, technical and economic are discussed, followed by a review of accessible and inclusive design practice and the kinds of support that are available from a wide variety of sources for inclusive design. Finally, they examine the developments and challenges in promoting accessible design and development.

2 Technology and the Digital Divide

2.1 The potential of technology for disabled and elderly people

There are clear social and ethical arguments for the need for technology to be developed using inclusive design principles. Technology can make essential and non-essential services more accessible to disabled and elderly people who traditionally receive a poorer than average level of service, or may be excluded altogether from receiving these services.

Services, which are particularly relevant to older and disabled people, many of whom may have reduced mobility, and thus would benefit greatly from electronically delivered services, include:

- e-Government – technology is increasingly being seen as a way of reducing costs and increasing efficiency of government, and at the same time a way of increasing participation in democracy by excluded or disaffected groups. On-line public information and electronic voting systems are examples of technologies that can enhance social inclusion.
- Healthcare – e-health applications can facilitate remote care and monitoring for disabled and elderly people, who are likely to need a higher than average level of care. At the same time, enhanced accessibility to on-line quality health information and decision support tools can lead to a more informed patient, who can as a result play an increasingly active role in their own care.
- Banking – on-line banking facilities can allow people to manage finances from home, reducing the need for a potentially difficult journey to a bank. Automatic telling machines (ATMs) allow direct and independent access at any time of the day to account information and cash, and increasingly offer additional banking-related facilities.
- Education – at a basic level, the Internet allows independent access to an enormous amount of information on a myriad of topics. Through e-learning applications, formal education, whether primary, secondary or tertiary may be made accessible to a wider section of society, and delivered in a way best suited to a learner with specific access needs.
- Commerce –through e-commerce web sites, independent access can be gained to on-line grocery stores, bookshops, clothing retailers; tickets for rail, bus, air or sea travel can be bought in advance. On-line auction services allow for an almost unimaginable variety of real - and virtual - products to be bought or sold.

A major user of government services are older and disabled people, and if the software provided for e-government is not usable by this group of people, it will have a low up-take, and alternative manual systems will have to be in place, which will be expensive and inefficient. Also, a less widely considered aspect of technology is its ability to enhance accessibility to information and entertainment to previously excluded groups. Social exclusion may result from an inability to gain equitable access to entertainment, yet enhanced access to entertainment can be achieved through technology such as digital interactive television, on-line chat rooms, multi-user gaming environments and web sites offering information such as the latest gossip on television soap operas or the outrageous behaviour of celebrities!

A further example of how technology can reduce social exclusion is in its ability to allow people to express their feelings and opinions, and contribute to human knowledge. While the advent of the World Wide Web eases the task of publishing information by effectively bypassing the role in printed media of editors in selecting, tailoring and publishing information, electronic solutions can also act as an effective replacement for the traditional method of pen-and-ink, which can be inaccessible to many. Such technology can range from word processing software and content management systems to web-logs and web authoring tools to facilitate publishing of digital information, allowing fuller participation in debate particularly by people with visual, manual or cognitive impairments.

With this potential in mind, it would seem folly to enhance provision of these services using technology, whilst at the same time increasing exclusion for those who would benefit most from such service; yet this has all too often become reality.

2.2 Technology and exclusion

The authors do not believe that the creation of the Digital Divide represents purposeful discrimination by designers. Few designers set out deliberately to exclude certain groups of people from using their systems. We believe that it is done more from ignorance, or from accepting inaccurate stereotypes.

There is, however, strong anecdotal evidence that some companies either do not wish to sell their products to less able customers and or that they believe that people with disabilities are undesirable customers. The reasons given include insufficient time and resources to produce accessible software, coupled with the company's inexperience in dealing with users and inadequate understanding of the needs and wants of people with disabilities.

The final and, to many, the conclusive reason, is that they believe that there is a lack of demand for accessible technology and this will not change. This view, however, ignores historical precedents. For example, safety in cars used not to be a selling point, but those manufactures who produced safe cars were in a very strong position to take advantage of the change in people's perception of what was important in the decision to buy a car. Similar trends are being seen in the organic food market. The requirement for easy to use and accessible systems is very likely increase rapidly as the population ages, and as legislation takes effect.

Designers often believe that it is very difficult and expensive to design accessible systems, and thus do not make any attempt to reduce exclusion. In practice, however, there are many good examples of accessible technology. Windows, and other software products contain a range of accessibility options, but designers could be excused from not being aware of their existence, because, in a similar way to the Ford Focus car (more of which in Section 1.2.8) these aspects of the software are not widely advertised.

Similarly there are a number of excellent examples of web sites, which are accessible to older and disabled people, as well as being comfortable for able-bodied users and aesthetically pleasing. These however are more the exception than the rule. The reasons why inaccessible software is so widespread will be discussed in the following sections.

2.3 Lack of understanding of the full range of potential customers

Human beings have a tendency to assume that everyone is the same as themselves and their friends, and computer system designers are no exception. Unless they are developing very specialised software, their concept of a user is usually someone not too different from themselves. Older and disabled people are less well represented in the work force than their statistical presence in the community, and those with mobility and communication difficulties are not very visible. This can produce an "out of sight – out of mind" situation in software designers, reinforcing the assumption that all customers are roughly the same as the designer's immediate colleagues.

There is a very powerful economic motivation to assume that all potential users have essentially the same characteristics. This not only makes the design task simpler, but also saves much effort in testing and evaluating what has been produced. This misconception about the actual range of characteristics of potential users of software is often strengthened - sometimes inadvertently - by well-established design guidelines.

Even within the User Centred Design community, where there is a strong focus on understanding the users, it has been recommended (Nielsen 2000) that, in a majority of circumstances, five users is an optimum number of participants for usability evaluations. Clearly a sample of people which truly represented the wide range of characteristics of human beings would have to be very large and thus obtaining a truly representative sample is not feasible. It would at least, be helpful, however, if designers were made to realise that a sample of five could only scratch the surface of the characteristics of all potential users, and the results from any such tests should be interpreted with very great care.

2.4 Lack of awareness of the needs of older and disabled people

Computer systems designers form a very specialist section of the population. Their knowledge of computers is deeply embedded, and because of their educational and employment background, most have forgotten what a wealth of detailed knowledge they have of computer systems. Many metaphors and operational techniques are so second nature to them that they assume everyone is fully conversant with them. For example, in a recent research project, in which the authors assisted with the design of an email system for novice users, very experienced software designers were astounded that most of their potential customers did not know what a scroll bar was, and when its action was explained, half of the older users thought that it should operated in the opposite way (i.e. it should appear to control the paper).

Young software engineers generally have good eyesight (although some may need spectacles), and they may forget that most people's eyesight deteriorates as they grow older, and that some of this deterioration cannot be corrected. There are also a significant number of visual impairments which cannot be corrected by lenses. In addition, because their use of the keyboard and mouse is almost a reflex action, designers do not often realise that this requires a level of manual dexterity which is significantly greater than many of their potential customers.

Software engineers are accustomed to the need to remember complex series of actions, and their understanding of the way computers operate helps them to re-create a set of commands the details of which may have slipped their memory. In contrast many people in the population have never had the need for these skills and thus are much less well equipped to operate the systems which designers find "intuitively easy".

An interesting example is in Windows, where to turn off the system, one has to follow a path which begins with the "Start" instruction. This is logical if one has the background knowledge to understand that, in order to exit from Windows software, one has to start the application which shuts-down the system. This level of sophisticated understanding is only found in a very small percentage of the users of Windows – the rest have to try to remember by rote the seemingly bizarre requirement to "press start" to "stop the computer".

2.5 Lack of engagement with disabled people

Related to the above problem of a lack of understanding – or perhaps the cause of a lack of understanding, is an unwillingness for organisations, who do acknowledge the importance of accessible design, to engage directly with disabled and elderly people. This may be due to a perception that such people are not part of the target audience, or a perception that there is little point in engaging with users with such extreme needs, for fear that a product will result that is excessively skewed towards a specific user group.

Another challenge, identified by the authors through personal contact with developers and designers, is a fear of the consequences of being responsible – unwittingly or not – for discrimination. This can range from a worry over what is considered appropriate terminology, and the dreaded phrase 'political correctness' can cloud the judgement of some with regards to actual or perceived attitudes of others towards accessibility. While the authors do not condone discriminatory, abusive or dismissive attitudes towards people with functional impairments, the frequent changes in what is acceptable terminology have not made it easy for a designer with aspirations towards inclusive design; unfortunately, neither has the over-zealous attitudes of some well meaning individuals concerned with reducing discrimination. This is further complicated by there being fundamental differences in currently acceptable disability terminology between the UK and the US – for example, 'disabled person' is preferred in the UK, while 'person with disabilities' is preferred in the US.

Thus requests for feedback and advice from novice designers can lead to them being drowned in a sea of critical replies attacking their best efforts or their use of inappropriate terminology. There is a need for education, but at the same time, increased support and encouragement in accessible design from accessibility advocates would avoid disaffection and potentially hostility towards the idea of inclusive design. At the same time, increased engagement with disabled people and disability organisations would help to reduce the misconceptions and misinterpretations of best practice.

2.6 Lack of willingness and motivation

Designers sometimes justify their unwillingness to consider the needs of older and disabled people on an assumed, rather than demonstrated, basis that it is not economically practical to take these people into account. Such an attitude may be in contravention of legislation – discussed in more depth later – but can be used as an excuse not even to consider the possibilities of extending the design to cater for a wider range of user needs.

It is clearly impossible to design systems which can be easily operated by absolutely everyone in the population regardless of age or disability, and in many case it would be acceptable, and legal, to decide to exclude certain categories of disability. However, this should only be done after an assessment has been made that the costs of including these disabled people is un-reasonable in terms of the overall project. Some adjustments necessary to cope with certain disabilities may be very expensive to include, but some, which are virtually cost-free, can make an enormous difference to the accessibility of a device.

2.7 Assumed Technophobia and low expectations of older and disabled people

Many people have developed very low expectations of older and disabled people for similar reasons to those adduced above. In certain situations this is realistic – it would be unreasonable to design a motor car with Braille symbols for driver controls.

However, the authors have met senior, well educated people who believe, for example, that blind people neither watch television nor use computers - in fact blind people's viewing habits are virtually identical to those of sighted people, and given appropriate assistive technology, blind people can use a very wide range of software.

Similar stereotypes can be applied to much technology. It is widely believed that older people are technophobic. If that was the case, however, older people would not be prepared to drive motor cars - the modern versions of which have many computers within them. The difference between motor cars and other new technologies is that designers have been careful to ensure that the interface to the car does not change significantly from that which customers are used to; where they have fallen short in this aim, as in the introduction of digital speedometers in some models during the 1980s, but consumer reaction and fear of legal comeback have caused the rapid withdrawal of the unacceptable features. Thus, in general, the problem is not that older people are not prepared to use "new technology", but are frightened by the manifestations of technology which have not been designed by people who understood the needs and abilities of older people.

2.8 Perceived Economic burden

In addition to overestimating the costs of taking into account the needs of older and disabled people in design, there is a tendency to underestimate the benefits of providing more inclusive products. The basic outcome of inclusive design is in fact likely to result in economic benefit. If a product or technology that can be accessed and used by a wider audience than would have otherwise been possible, then it follows that the potential customer base for that technology is increased. The numbers of disabled people in the community are shown below and these are often much greater than many people would predict. There will also be a major growth in these figures due to the aging of the population.

For example, in the Western world the numbers of people over 65 are already larger than the numbers of people under 16 and there are many people over 65s with a large disposable income and significant wealth. Not only do such people have age related impairments, but approximately 50% have a significant disability. The fact that the "baby boomers" are joining this cohort also means that many older people will have significantly different expectations of life-style and the need for technology to support this life-style. Designers who, in the future, restrict their markets to young able-bodied people will be exposing their companies to significant risks of losing market share.

The design of an accessible e-commerce web site is the digital equivalent of ensuring that a supermarket is wheelchair-accessible – in each case allowing access to more potential customers. On-line shopping, however, has significantly more benefits for disabled people than for able bodied people. The independence of being able to shop on-line in the comfort of their own home has enormous attraction over making a potentially difficult trip, which may require assistance from a number of other people.

There are many examples of products developed with accessibility in mind that have become significant economic successes (Keates and Clarkson, 2004):

- In the motor industry, the Ford Focus was designed to take account of the older user. The designers were provided with special suits and spectacles which reproduced the reduction in mobility and sight which comes with old age. The result was a motor car was easier to operate by older adults, but also provided many benefits for young drivers such as large easy to use controls, and better access for parents with small children. The car thus became very popular amongst all age groups, and regularly features highly in UK sales tables.

- British Telecom (BT) developed a large button telephone for disabled people and this quickly became popular with many, so much so that this feature was introduced into other products from the company.

Economic benefit may also result from the avoidance of potentially adverse publicity arising from a high profile example of a member of the public being unable to use the product in question due to accessibility problems. Keates and Clarkson (2004) argue that adverse publicity resulting from an organisation defending a case of alleged discrimination may result in reduced revenue, and at the same time the cost of defending the case may be greater than the cost of addressing the problems that caused the alleged discrimination in the first place. They further point out that by failing to consider accessibility in product design, an increasing proportion of customer base may be lost in terms of organisations that are legally or contractually bound to procure only technology that meets a specific level of accessibility. For example, US federal agencies are obliged by Section 508 of the Rehabilitation Act (discussed in more detail in Section 5) to purchase technology that complies with Section 508 technical standards. Thus any company that does not consider accessibility in the design of their products will effectively rule themselves out of competing in this economically significant market sector.

2.9 Inappropriate Tools and Technologies

Accessibility, when it is considered, is often considered as an afterthought rather than at the beginning of any design process. This situation includes the design of software tools used by designers.

Development tools and authoring tools do not tend to promote or encourage design of optimally accessible technology, and rarely if ever give any indication of whether or not the system which will be produced using these tools will have an adequate level of accessibility. Some standard operating systems involve small fonts and buttons, and provide default options, such as automatically appearing small scale scroll bars, which can be difficult or impossible to remove. The libraries of widgets provided with prototyping equipment often predominantly contain widgets which are inappropriate for anyone without excellent vision and dexterity – with no warning that this might cause a problem.

Web authoring software has promoted the democracy of the web as a publishing medium by aiding experienced designers in the creation of highly functional, graphically rich web content, and at the same time provided a way for less technically able authors to quickly and easily publish web resources that are often valuable and interesting. Such authoring software, however, has traditionally enabled, if not positively encouraged, the creation of web pages with significant accessibility barriers. Authoring packages have also traditionally helped to exacerbate the problem of web accessibility by generating non-standard and bloated code, using code that may introduce accessibility problems for people with visual and manual impairments, and by failing to alert authors of the need to insert information required to avoid the introduction of accessibility barriers. As a result web content is often unwittingly published containing serious accessibility barriers.

2.10 Inaccessible accessibility options and assistive technologies

A number of operating system and software applications do provide accessibility options and utilities, which enable disabled people to vary the input and output properties of software. For example the Windows operating system has a large range of *options* that enable the user to enhance the accessibility of the system through, for example:

- Adjustments to text and background colour schemes;
- Features that facilitate mouse usage, for example enlargement of the mouse pointer or reduction in the on-screen pointer movement relative to movement of the mouse;
- Features that facilitate keyboard access – for example "sticky keys", which enables one fingered typists to operate multiple key combinations, such as the shift, control and alt keys;
- Specification of visual alternatives to audio alerts.

Such additions can be of great value to expert users, but they are often very difficult for the new user to find. Research with older adults has indicated that, despite considerable demand for help and support, the existing facilities built into computers are rarely used. Syme et al (2003), using evidence from their work with older adults, argue that this is because such facilities are often hard to find, hard to use and inappropriate. Reconsidering the ways in which support is presented to an increasingly diverse population of computer users would benefit not only older users, but everyone.

More advanced than the accessibility options discussed above, *utilities* may be offered by an operating system, such as screen magnification and screen reading functions, or an on-screen keyboard. Although useful, the functionality of these options is often limited in comparison to specialised assistive software. Awareness of such utilities is low, Microsoft (2003b) finding that only 38% of computer users with mild or severe difficulties/impairments were aware of such utilities, and only 14% of users actually used them.

There is also a problem in terms of awareness of, and use of, assistive technology that would be required by someone with a severe impairment to successfully use computer technology (Microsoft 2003b):

- Only 24% of computer users with severe difficulties/impairments currently use assistive technology;
- 39% of computer users with severe difficulties/impairments are not aware that assistive technology exists and could enhance their computing experience.

It is apparent that significant challenges exist for disabled people in firstly discovering the existence of an assistive technology that might help them, where to get hold of it, and how to install it and use it. This often requires a significant amount of technical expertise and confidence, and many assistive devices are significantly more expensive than standard software and hardware.

A similar problem exists when considering access to web content. Many widely used web browsers – most notably Microsoft's Internet Explorer with its current large market share – fall disappointingly short of supporting potentially very useful accessibility features, such as the ability to enlarge the text size of any web page, regardless of how that page has been designed. The ability to change aspects of a web page's appearance through a user-defined style sheet is a very powerful tool in enhancing the accessibility of web content for people with dyslexia and specific visual impairments. In reality however, very few people know how to achieve these effects, and to do so using any of today's popularly used web browsers is likely to be extremely difficult.

A feature of many accessibility options is thus that they themselves are inaccessible, and have many usability problems A significant proportion of users who could benefit from accessible technology features do not even know of their existence, let alone how to access and use them.

3 Disabled people?

A variety of impairments – sensory, mobility-related and cognitive - can separately or together result in computer users encountering accessibility barriers, and, as alluded to in the previous section, the number of users with such impairments is much higher than might be expected.

This section looks in more detail at the specific impairments affecting accessibility of technology, and why there are many more people who may experience accessibility difficulties than an initial examination suggests.

3.1 Some statistics

If we examine population statistics, the low level of interest in issues of this nature is somewhat surprising. It is not easy to obtain a globally consistent definition of a specific disability, and thus accurate estimates are difficult, (this problem will be addressed later in the chapter), but commonly accepted figures are that, in the “developed world”, between 10% and 20% of the population have disabilities.

More specific estimates include:

- 1 in 10 of the world’s population has a significant hearing impairment and 1 in 125 are deaf.
- 1 in 100 of the world’s population has a visual impairment, 1 in 475 are legally blind, and 1 in 2000 totally blind.
- 1 in 250 people are wheelchair users, with over 300,000 in the USA alone being under 44 years old (there are 10,000 serious spinal injuries per year in the USA alone).
- There are 6 million mentally retarded people in the USA with 2 million living in institutions.
- It has been estimated that 20% of the population have difficulty in performing one or more basic physical activities, with 7.5% being unable to walk, lift, hear, or read alone or without help. 14% of these are aged between 16 and 64.
- In the UK, 800,000 people are unable to express their needs in a way that close relatives can understand and 1.7 million people struggle to communicate

There is a direct effect on the working economy, with disability affecting the working lives of some 12% of the population and 5% being prevented from working entirely, due to their disabilities. There is also an even wider population which is affected by disabilities. As a rule of thumb, every person has at least three other important people in their lives with whom they interact regularly. Thus the population affected directly by disability is at least a factor of three greater than the numbers quoted above.

It is a sobering thought that, within the next year, almost one in 500 of the readers of this chapter will suffer a stroke which will render them partially paralysed, and a third of those will experience some degree of speech, language or cognitive impairment caused by that stroke.

Demographic data concerning disabilities can vary, because of the exact definitions used, but the data in **Table 1**, from USA and European sources (UNESCO 1996) provide useful guidelines. It can be seen that the numbers of people with disabilities are significant and these figures are increasing. People with disabilities are very diverse, and due to improved life expectancy and medical care, there is likely to be an increase in both the severity and diversity of disabilities in the workplace.

USA		**Europe**	
Illiteracy	3%		
Blind & Low Vision	3%	Blind	0.2%
		Low vision	2.0%
Deaf & hard of hearing	8%	Deaf	0.2%
		Hard of hearing	14.9%
		Dexterity	6.5%
		Intellect	5.6%
		Language	0.9%
		Speech	0.4%
		Dyslexia	4.7%
		Mobility	8.9%
65 & over	13%	Over 65	14.8%
NB Individuals may appear in more than one figure quoted above			

Table 1: Disability and Demographic Statistics

The report “Enabling America: Assessing the Role of Rehabilitation Science and Engineering” (Institute of Medicine, 1997), comments that:

> “The emerging field of rehabilitation science and engineering could improve the lives of many of the 49 million Americans who have disabling conditions, and is ready to assume a prominent position in America's health research agenda.”

It points out that almost 10 million Americans (about 4 percent of the nation's population) have a disabling condition so severe that they are unable to carry out fundamental activities of life, such as attending school, working, or providing for their own care. An additional 6 percent are limited in their ability to engage in such activities, and another 4 percent are limited in social, recreational, or other pursuits. Medical expenditures for disabilities and the indirect costs from lost productivity exceed $300 billion each year, or more than 4 percent of the gross domestic product.

Thus older and disabled people are a significant minority, and represent a major market segment in the developed world.

3.2 Sensory Impairments

Perhaps the most easily understood and recognised group of people who may face accessibility barriers when attempting to use technology are those with sensory impairments. Technology relating to smell and taste as an interface enhancement is as yet in its infancy, and therefore an impaired ability to smell or taste is currently of no real significance when using technology.

Those senses that are most required in order to interact with computer technology are vision and hearing, and anyone with impaired hearing or vision may encounter significant accessibility barriers when using inappropriately designed technology.

3.2.1 Visual impairments

Visual impairment may cover a range of conditions, each affecting varying aspects of vision. Conditions include myopia, cataracts, age-related macular degeneration, or macular dystrophy, and in many cases will result in a combination of the symptoms described below. It is worth noting that these conditions can result in a range of visual impairments which are also associated with healthy ageing. The visual impairments lead to handicaps when using computers. For more details, a useful collection of information about various visual impairments is provided by the Royal National Institute of the Blind (RNIB)[1].

Reduced visual acuity affects the ability of the eye to define detail, the degree to which detail is sharp and clear at short or long distances. People with low visual acuity may particularly struggle to use computer interfaces where one or more of the following situations exist:

- information is presented in small text or small or very detailed graphics, and where magnification of this content is not possible, or not effective;
- low contrast text and background colour schemes are used, or font styles used that do not promote easy on screen reading;
- interaction styles that require fine and accurate positioning of a pointing device or finger in order to activate an operational control.

The main impact of a **reduced field of vision** is that only a small proportion of a computer interface can be seen at any one time, and therefore interaction is significantly extended as reading, exploration or searching for specific features of the interface will require a slow progression. In certain conditions, such as hemi-inattention, the person is not even aware that they are operating with a reduced field of vision, and thus will ignore, and not even search for data that is not in their reduced field of view.

People with reduced field of vision are likely to encounter problems using interfaces that position important content in significantly different areas of the screen, or interfaces that rely on the user in noticing changes to content located in a different part of the screen to which they are looking, for example the use of a ‘pop-up’ window or other alert appearing to signify an event that requires a response.

It should also be noted that anyone with low vision who requires any form of magnification to allow them to access on-screen content will also effectively reduce their field of vision, as magnification will effectively allow only a small portion of the interface to be viewed at a time.

People with **colour deficit** may encounter accessibility barriers when using computer interfaces. Impairments relating to colour perception generally manifest themselves as an inability to distinguish between specific colours, rather than an inability to perceive one specific hue. Colour deficit is widely regarded as affecting significantly more males than females (approximately 4-5% of males in the Western world), and can result from one of three main types of condition (Clark, 2002) – protanopia, deuteranopia and tritanopia, or insensitivity to red, green and blue respectively.

These conditions may manifest themselves as an inability to distinguish between red and green or red and black. Additionally, given that red or green colours may appear as beige, yellow or orange to someone with protanopia or deuteranopia, problems may arise in attempting to distinguish between any of beige/yellow/orange and either

[1] Royal National Institute of the Blind (2004) Common Eye Conditions. Available at http://www.rnib.org.uk/xpedio/groups/public/documents/PublicWebsite/public_eyelist.hcsp

of red or green. Accessibility barriers may therefore result if interfaces use these problem colour combinations as a text/background combination or use these combinations in displaying adjacent objects

Complete loss of colour perception amongst sighted people is extremely rare (though of course this situation will effectively exist for anyone who has no functional vision at all and is accessing text using Braille or a speech synthesiser). Age-related decline in visual processing may lead to a reduction in effective colour perception (Carmichael 1999), while the combination of blue and red can cause the temporary visual effect of chromostereopsis, a condition that can cause unpleasant effects for anyone who can perceive shades of blue and red.

Thus, any computer interface that relies on colour as the only way to present information may present accessibility barriers to people with colour deficit. Interfaces that use low-contrast colour combinations, or use those problematic colour combinations described above, may also cause accessibility barriers.

Additionally, conditions such as dyslexia or scotopic sensitivity, not traditionally classified as visual impairments, may manifest themselves in ways that effectively induce a visual impairment whereby specific text and background colour schemes, or text styles may render an interface unusable to someone with that condition.

Aspects such as glare, brightness and level of background lighting may, in combination with inappropriate use of colour in interface design, also exaggerate the effects of an existing visual impairment, or temporarily introduce a new visual impairment to a user.

People who are blind may be considered to have effectively no functional vision, and rely on alternative channels, normally auditory and/or tactile, to access computer based information. Statistically speaking, people with no vision at all are rare; it is far more likely that some degree of vision will exist, in terms of at least the ability to distinguish shades of light.

Blind people can use text-to-speech or tactile technology to accesses computer systems, but that information must be available in an appropriate text format. Computer interfaces where one or more of the following situations exists will be very difficult or impossible to use by people who are blind:

- Information presented in a way that does not allow text-to-speech or tactile devices to output the information in audio or tactile form. This includes graphically presented information without a text equivalent or information presented through the use of colour alone
- Information that is not available directly in audio or tactile format on public interfaces such as autotellers.
- Information that is available in textual format, but is not provided in a way that allows efficient delivery and comprehension of the information when it is output in audio or tactile form. For example, text alternatives provided for graphics may be excessively detailed, or may result in duplication of adjacent textual information, in either case significantly lengthening the time required for the screen to be output in audio format.
- Specific problems may occur due to the 'linearisation' of the content of a graphical user interface or web page, where the order of the page or screen content may become jumbled to such an extent that all logic and comprehension is lost. For example, instructions in using an interface may refer users to "the button on the right" – but relative descriptions such as 'right' and 'left' often lose meaning when heard in an audio-only interaction environment.

- Interfaces that require the use of a pointing device such as a mouse in order to allow user interaction or navigation.

A recent problem has been increasingly encountered by blind people when attempting to negotiate "Turing tests" – that is, a test to distinguish a human from a computer - as a means of a security check. A widely used solution[2] is to take a distorted graphic of a word or selection of alphanumeric characters, and request that users type in the word they see. In theory this should only be possible by a human, but, these security features result in an insurmountable barrier for people unable to see the graphic. This is potentially unlawfully and accessible alternatives are thus being explored (W3C 2003).

3.2.2 Hearing Impairments

It may be argued that the auditory channel is underused in computer interface design (Macaulay & Crerar, 1998), but there are many examples of computer technology that use sound to present information. This provides a major accessibility barriers, when this is the sole way of presenting the information. Audio alerts may be used to warn or notify a user of an event; but, without a means to make this alert occur in another way, people with hearing impairments may miss this alert, with potentially significant consequences.

Interfaces that rely on voice-control may also result in difficulties. Pre-lingually and post lingually deaf people often have speech intonation patterns that result in difficulty operating speech-activated interfaces. Other barriers may be encountered if there is no opportunity for a deaf or hard of hearing person to specify a text-phone or facsimile number as an alternative to the telephone.

Often overlooked by interface designers is the fact that some deaf people, particularly those who were born deaf or lost their hearing at a very early age, use a sign language as their primary means of communication, and may have low reading skills. Such people can also have poor literacy skills, and may struggle to understand information presented on-screen in text format – even if this information is a text alternative to audio content, for example captions for a video including spoken content.

3.3 Motoric Impairments

The 'wheelchair' icon has become a widely recognised symbol for disability in the physical environment, undoubtedly due to the challenges the built and natural environments may present wheelchair users. A physical disability that requires someone to use a wheelchair is, however, less likely to present significant problems in using computer technology, so long as the technology is ergonomically designed to allow easy access and operation[3].

In general, given that the vast majority of computer interfaces are operated using the hands, those motor-related impairments that most frequently impact on accessibility of computer technology relate to how the impairment affects a person's level of manual dexterity. The effect of this is exacerbated for people with severe mobility restrictions for whom the use of other limbs to control an interface may not be possible.

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[2] For example, the CAPTCHA project at Carnegie Mellon University; http://www.captcha.net/

[3] Of course, designers of public access terminals such as automatic telling machines (ATMs) will need to consider the needs of wheelchair users, but desktop and mobile computing technology should not in itself present a wheelchair user any operational difficulties.

Many people may experience temporary or long term restrictions on manual dexterity or the use of the hands, and this can co promise the ability to effectively control a computer system. Limited manual dexterity may be due to the effects of arthritis; the tremors caused by a condition such as Parkinson's disease may also seriously affect manual dexterity. Muscular related impairments such as carpal tunnel syndrome or repetitive strain injury (RSI) are increasingly common workplace-related injuries where use of a computer terminal is common.

An interface that is based on a menu or button and pointer style of interaction may present some challenges for people with limited manual dexterity, while people who cannot use their hands to operate a mouse will have to rely on a keyboard or some form of switching device, and as a result any interface that demands the use of a mouse for control will present significant challenges.

3.4 Cognitive Impairments

The umbrella term 'cognitive impairment' is a wide ranging yet hard to define term, but generally covering any impairment of the thought process. A cognitive impairment does not necessarily impact on innate intellectual ability, but may inhibit the ability to concentrate, to read, to process and organise information displayed on a computer screen Such impairments, which can be exaggerated by concomitant sensory impairments, can make it difficult to use interactive systems, although such difficulty can be attenuated to some extent by appropriate design (Carmichael 1999).

Dyslexia is a particularly common condition that is generally considered to be a cognitive impairment, with up to 10% of the population believed to be affected to some extent,. Effects include difficulty with sequencing, misreading of words and poor comprehension to varying extents, problems with number and letter recognition, letter reversals, spelling problems, fixation problems and in many cases, scotopic sensitivity. The effect of scotopic sensitivity is often described as resulting in individuals being unable to take data in because it is "jumping around" and seems to be exacerbated by a cluttered peripheral field of vision.

Other impairments that fall under this broad category include conditions that affect short term memory, attention deficit disorder and other conditions that affect the ability to concentrate. Limited reading skills may also affect a significant proportion of the intended audience, particularly when considering public access terminals or web sites that provide a public service. It has been estimated that approximately 40% of the unemployed population of the UK are functionally illiterate, although this is not always due to a cognitive impairment.

The nature of access barriers caused by cognitive impairments is wide ranging, and can include:

- Presentation of text in in such a way that on-screen reading and processing is very difficult – for example long unbroken paragraphs of justified text;
- Animated content that is not easy to turn off or freeze, causing potential distraction;
- Inconsistent screen layout and design, or inconsistencies in interface functionality and terminology, all of which can significantly increase cognitive load;
- Inappropriate writing style for the intended audience;
- Content that flickers or flashes at a frequency of between 2 and 59 Hz, potentially inducing seizures in people who have photosensitive epilepsy;

- General clutter on the screen caused by over-featured interfaces, misguided design or too many windows open at one time.

There is enormous potential for technology to significantly enhance the lives of people with severe learning disabilities, yet the specific challenges facing this group in using technology remain frustratingly under-researched and under-defined.

3.5 The Ageing process

Much of the functionality of able-bodied human beings, such as sight, hearing, dexterity, and cognitive processing begins to decline soon after 30 years of age. This decline is not usually apparent for the first few years after this age, but, for example, most people needing brighter lights for reading and then reading glasses becomes a factor not long after 40 years of age. By the age of 50 there will inevitably be some decline in many aspects of functionality, but again this depends on individuals.

The decline of functionality is yet another example of the “average person” myth. It is often assumed that everyone’s functionality declines at much the same rate, but this is not true. A few people will have very little decline, and a few will have substantial decline, but importantly the range of functionality shown by people increases with age and the rate of change of this also increases with age. It should be remembered that the functionality of “high functioning” older people is very similar to the functionality of “medium to low functioning” middle aged people. This underlines the suggestion made earlier in this chapter that designing for older people means that one designs for the whole population, whereas the range of functionality of older people is much greater than that of middle aged people.

In addition to this general decline, older people are much more likely than younger people to have a major disability, the probability of which increases with age. For example, over 50% of those over 65 in the USA are known to have a major impairment. The number of people who are elderly and/or disabled in Europe is estimated at between 60 and 80 million, and the changing age structure means that by the year 2020, one in four of the population will be aged over 60, and the largest increase is expected in the oldest (75+) age group where disability is most prevalent.

The overall functionality of an older disabled person is, however, significantly different even to that of the typical (young) disabled user of technology. Instead of having a single disability (sight/ hearing/ speech/ mobility, etc.), older people usually have a more general impairment of several of their functions, usually including minor impairments in sight, hearing, dexterity and memory.

Older people can, very crudely, be divided into three groups:

- Fit older people, who do not appear – nor would consider themselves - disabled, but whose functionality, needs and wants are different to those they had when they were younger
- Frail older people, who would be considered to have a “disability” - often a severe one, will, in addition, have a general reduction in their other functionalities
- Disabled people who grow older, whose long-term disabilities have affected the ageing process, and whose ability to function can be critically dependent on their other faculties, which will also be declining.

This taxonomy is important, because it serves to illustrate the fact that capability and disability are not opposites. The implications of this are often not apparent to software developers who have a tendency to develop things “for disability” or for “normal people”, failing to recognise the whole range of capability levels which, while declining, do not yet represent a disability as such. In addition a combination of reduced capabilities, which separately are not significant, can constitute a handicap when taken together and interacting with a computer.

The major characteristics of older people, when compared with their younger counterparts, include:

- The individual variability of physical, sensory, and cognitive functionality of people increases with increasing age
- The rate of decline in that functionality (that begins to occur at a surprising early age) can increase significantly as people move into the "older" category
- There are different, and more widely appearing problems with cognition, e.g. dementia, memory dysfunction, the ability to learn new techniques
- Many older users of computer systems can be affected by multiple disabilities, and such multiple minor (and sometimes major) impairments can interact, at a human computer interface level to produce a handicap that is greater than the effects of the individual impairments. Thus accessibility solutions focused on single impairments may not always be appropriate.
- Older people may have significantly different needs and wants due to the stage of their lives they have reached
- The environments in which older people live and work can significantly change their usable functionality – e.g. the need to use a walking frame, to avoid long periods of standing, or the need to wear warm gloves.

3.6 "Technophobes"

An important "impairment" is technophobia in all its manifestations. This is more common, but not exclusive to older people, although as we have said previously, to regard all or even most older people as technophobic is an inaccurate stereotype. It is not usually considered to be a "disability" but it is important for designers to consider accessibility for this group of people. There are significant numbers of people of all ages who essentially claim to be scared of computer technology. In practice, however, most are not scared of technology *per se*, but by the way it tends to be manifested. Thus a person may claim not to be able to "cope with computers" whilst owning a brand new car (which will contain a number of computers) and being a habitual user of autotellers. The authors once interviewed a retired lady who said that she had never ever used the internet, although it subsequently transpired that she was an avid user of an email system provided by her cable supplier.

Thus computer phobia can be based on a semantic misunderstanding, and this is exacerbated by the extensive use of jargon, and obscure metaphors within the industry. It is not impossible to design easy to use systems which do not rely on an understanding of particular jargon and metaphors, but it requires some thought and exposure to people who do not share a common educational and life experience with the designer. For example, in a recent experiment conducted in Dundee, novice older users were presented with an example of a popular instant messaging system and described it as variously as "… totally bemusing", "very complex and very difficult", "overpowering - too much information", "very, very confusing" and "irritating"

3.7 The Norm…

The foregoing discussion has essentially divided the population into

- young able bodied people,
- young disabled people,

- old people, and
- people who are old and disabled

These are, however, artificial divisions and have been made to illustrate various points in the discussion. In fact there are not separately defined groups, other than in legal and/or pure age categories. In terms which are most important to software developers the groups are overlapping and in a very real sense very dynamic. There is not a specific group who are completely “disabled” - there will be people with a wide range of sight impairments, a small percentage of whom will be “blind” and some of this group may have hearing impairments – there are some people who are deaf and blind, and will have a range of motoric and cognitive abilities. At the other end of the continuum, there will be very few people who exhibit the top ten percentile in all the functionality relevant to operating a complex computer system. Most will have some reduced functionality.

People start their lives as babies, become children, grow up, reach maturity, and then grow old. During their lives, their functionality will undergo massive changes due to maturing and growing old, but in some cases changes will occur within relatively short time scales. Accidents can produce step function changes with, in most cases, a long ramp back to normal functioning. In addition, the functional characteristics of people can change significantly over very short time scales. This is particularly noticeable in cognitive functioning. Short term changes in cognitive ability occur with all employees during their working day caused by fatigue, noise levels, blood sugar fluctuations, lapses in concentration, stress, or a combination of such factors. Alcohol and other drugs can also induce serious changes in cognitive and physical functioning.

People may also become suddenly temporarily or permanently disabled by accident, or by the use of equipment, within their employment, and permanent dysfunction caused by technology is leading to increasing litigation. A great deal has been known for some time, for example, about the effects of exposure to loud noise, and vibration white finger, but the use of keyboards and associated input devices is increasingly being blamed for long term or permanent dysfunctions such as Repetitive Strain Injury (RSI). Evidence is growing that the use of mice has a part to play in injuries of this kind and there is also the possibility that voice disorders can be caused by over-use of speech input devices.

Users are actually very unlikely to be static and “fully able-bodied” for the entire period they are using a particular piece of software. Thus all users are potential beneficiaries of more accessible systems.

3.8 The disabling environment

In addition to the user having characteristics which can be considered “disabled”, it is also possible for employees to be disabled by the environments within which they have to operate. Newell & Cairns (1993) made the point that the human machine interaction problems of an able bodied (ordinary) person operating in an high work load, high stress or environmentally extreme (i.e. extra-ordinary) environment had very close parallels with a disabled (“extra-ordinary”) person, operating in an “ordinary” situation such as an office.

For example, a noisy environment creates a similar situation to hearing or speech impairment, and communication systems which are designed for deaf or speech impaired people (Newell, 1995) may be appropriate for use in these environments. There are a very great range of jobs where the noise level is very high, and a greater understanding of the permanent effects of this on hearing has caused a wider use of hearing protectors. This protects the work force from long term damage, but also makes them less sensitive to acoustic signals. Sometimes the workforce creates their own solutions. For example, in the jute mills of 19th century Dundee, an informal sign language evolved to cope with the high level of noise; however, it might have been more effective if employers in the jute industry had realised that they were effectively creating a deaf community, and therefore taught their workforce a sign language system.

The effects of darkness or smoke are similar to visual impairment, and the possibility of using technology designed to provide access for people with visual impairments should be considered in such situations. Such techniques could be a valuable addition to a work place where darkness and/or smoke were a permanent feature. System designers need also to consider the effects of emergencies. How do plant room operators or pilots cope when their workplace is full of smoke? Should they be provided with alternative non-visual ways of obtaining essential information from their instruments, and, if so, what is the most effective and efficient way of providing this?

Many industrial situations require the wearing of protective clothing which reduces sensory input as well as manual dexterity. This obviously applies to firefighters and other emergency services, as well as people who have to operate underwater or in space. A Norwegian telecommunications company developed a large key telephone keyboard specifically for people with poor manual dexterity, but found that it was very useful in cold outdoor locations where users tended to wear gloves.

An extreme example is when people have to operate in space. Engineers who try to repair space stations may apparently be healthy individuals at the peak of their physical and mental fitness, yet, due to the environment in which they are operating, become effectively extremely disabled. Not only are they visually and auditorily disabled due to the space suits they wear, but manual dexterity is extremely curtailed, and the stress and fatigue caused by working within such environments means that their performance is similar to that which could be achieved by a severely disabled person operating in a more normal environment. It is not always clear that the equipment they have to operate has been designed with this view of the user.

Situations where people are using standard equipment, but not in standard locations can effectively disable the user. If a lap-top or palm-top computer has to be operated whilst the user is standing and cannot lean the system on a ledge, then effectively the user is one handed. Special keyboards have been designed for one handed use by people with disabilities, and some access software has “sticky keys” so that two keys do not have to be pressed at the same time, but mainstream users are seldom aware of these “accessibility” solutions. Similarly word prediction software developed for people with poor manual dexterity can be useful for single fingered typing, or for situations where long complex words have to be entered into systems (Alm et al 1992). Such software has also been found particularly beneficial for people who have poor spelling and dyslexia of the type which is too extreme for standard spelling checkers to be effective but again are rarely found within mainstream software (Newell et al 1992).

One of the most popular examples of technology developed initially for disabled people is the “predictive systems” offered in mobile (cell) phones. These were originally developed in the 1980s for people who, because of physical disabilities, could only use a small number of large keys, and were called “disambiguation” systems. (Arnott & Javed, 1992)

A major effect of environment is on the cognitive functioning of human beings. High work loads, and the stress levels to which this can lead, often reduce the cognitive performance of the human operator. A fairly extreme case is the dealing room of financial houses where the stress level is very high and is often accompanied by high noise levels. A significant advance could be made, if the software which was to be used in these houses was to be designed on the assumption that the users would be hearing impaired and have a relatively low cognitive performance. It is interesting to speculate as to whether such systems would produce higher productivity, better decision making and less stress on the operators.

4 The Technical Benefits of Inclusive Design

An inclusive design approach, if correctly applied, can have significant technical benefits. These benefits are not always obvious but can be substantial.

A key objective of accessible computer interface design is to promote interoperability and device independence in access and use. This is particularly so with web design, where inclusive design principles acknowledge the wide-varying nature of the devices and circumstances through which access is gained to on-line information and services.

Accessible web design thus requires developers to be aware of limited-functionality browsing technologies, such as text-only or legacy browsers, or limited-channel browsing environments, such as audio- or Braille-rendering of sites. At the same time it encourages the use of emerging web standards as appropriate to take advantage of the enhanced functionality of newer browsers – or to prepare for functionality that is not yet available in mainstream browsers.

The ideal objective of 'graceful degradation' – that is, ensuring that information and functionality, if not the desired presentational attributes, is available to less capable browsing technologies – has met with some objection by those designers and developers who interpret this as an exercise in coding to the lowest common denominator. Accessibility advocates argue that on the contrary, designs should, where possible, take advantage of enhanced functionality offered by newer, more standards-compliant browsers – so long as unjustifiable barriers to content and functionality do not remain when resources are accessed using less capable browsers.

A further benefit of accessible web design is that there is a significant overlap between accessible design techniques and web design techniques which promote a web page or site's visibility to the indexing or spidering agents used by many search engines.

Search-engine optimisation involves techniques to present content in a way that maximises the ability of search engine indexing agents to gather text that is representative of a web page's content. The objective of this is to maximise the chances of the page appearing prominently in the results produced by a search engine in response to a relevant search query. The techniques required to make sure that information on the page is presented in meaningful and structurally sound text format are very similar to the techniques required to optimise the accessibility of a web page for blind web users. The Google search engine indexing software has been referred to by some as the "richest visually impaired web user in the world"[4].

Following principles of inclusive design can also lead to a more thoughtful, considerate and efficient design of technology, with superfluous detail being rejected, which will lead to a reduction in storage and processor power required. Also a web site or software application that follows accessible design principles may well be easier to navigate and easier to use by a majority, and this can also have beneficial effect on the load of the host machine or server.

[4] It should, however, be noted that certain less ethical tricks for boosting search engine ratings can have catastrophic effects on usability and accessibility, particularly for blind and visually impaired people.

It is accepted that some aspects of accessible design, particularly where multi-modal access is concerned, will require additional effort in terms of time, expertise and resources. For example, enhancing the accessibility of the content of a video clip, through text captions and the addition of audio descriptions[5], will require extra effort. The payoff, however, is not only for archetypical “older and disabled people,” but frequently a resource is produced that is more accessible to more people in many more circumstances than might have originally been presumed .

[5] Audio descriptions enhance the accessibility of video content for blind and visually impaired people through additional spoken audio, providing necessary extra information to describe any non-spoken events important to the video clip.

5 Legislative Responsibilities

There are many benefits of accessible design for everyone, including older and disabled people, but there are also legislative responsibilities. The anti-discriminatory legislation promoting the rights of disabled citizens which have been introduced in many countries are widely regarded as applying to technology and accessibility as well as access to more traditional physical environments and services. Legislation, which makes unjustified discrimination against a person on account of their disability unlawful is increasingly considered to apply to 'digital discrimination', and several countries now have laws that attempt to directly define the legal responsibilities of technology providers with respect to accessibility and disabled people.

A landmark ruling took place in 2000 in Australia, where, for the first time, a disabled person was ruled to have encountered unjustified discrimination when he was unable to access web based information due to accessibility barriers present on the site. Bruce Maguire, a blind web user, filed a complaint against the Sydney Olympics Organising Committee (SOCOG), that, under the Disability Discrimination Act of 1992, he encountered unjustified discrimination when he was unable to access on-line the results of certain events of the Sydney Olympic Games, through the official Games web site. Supported by evidence from representatives from the World Wide Web Consortium (W3C), and despite arguments that to amend the site to remove the accessibility barriers would take an unreasonable amount of time and developer resources, Australia's Human Rights and Equal Opportunities Commission (HREOC) found in Maguire's favour[6]. This was the first case where a court ruled that a web site with accessibility barriers was unlawful. It is unlikely to be the last.

In the United States the rights of disabled people are protected under several acts (Department of Justice, 2002). These Acts include the Americans with Disabilities Act (ADA), setting out the rights of disabled American citizens not to encounter unjustified discrimination, and the Telecommunications Act, which requires manufacturers of telecommunications equipment and telecommunications service providers to make sure that equipment and services can be accessed and used by disabled people.

Cases relating accessibility of web sites have come to court under the ADA. In 1999, the National Federation for the Blind took America On Line (AOL) to court, claiming that the proprietary software AOL provided its customers to access the Web was inaccessible to blind users. An out-of-court settlement was reached, and no court ruling was made. In the case of Vincent Martin et al v MARTA (Metropolitan Atlanta Rapid Transit Authority), it was ruled that Title II of the ADA - relating to State, local government bodies and commuter authorities - did apply to web sites.

However, the situation regarding application of the ADA to the Web became less clear when Southwest Airlines successfully defended a claim by a blind man that discrimination had occurred as a result of his failure to be able to use Southwest's web site in order to obtain discounted air tickets. In his case, however, the ruling centred on the judge's decision that the ADA, which does not specifically refer to electronic data, applied only to 'physical accommodations'. The Judge held that Physical accommodations do not include cyberspace, and so the ADA cannot apply to the Web. This ruling has been widely criticised and contradicts the previously

[6] HREOC's ruling in the case of Bruce Lindsay Maguire v Sydney Organising Committee for the Olympic Games is available on-line at:
http://www.hreoc.gov.au/disability_rights/decisions/comdec/2000/DD000120.htm

noted interpretations of the ADA by courts in several other States.[7] (particularly since the ADA was introduced in US in 1990, around the same time as Tim Berners-Lee was taking the first steps towards developing his idea that became known as the World Wide Web.)

Perhaps the most widely known and most significant US legislation relating to technology and disability is known as "Section 508". In 1998, Section 508 of the Rehabilitation Act was amended to set in law the requirements of federal departments and agencies to ensure that the technology they procure and provide, for the use of employees and for provision of information and services to members of the public, is accessible to disabled people[8].

The Section 508 1998 amendment also provided for the establishment and development of the Section 508 Electronic and Information Technology Standards, defining technical requirements relating to the accessibility of technology to be incorporated by each federal agency. The legislation requires conformance with a standard that is not itself part of legislation, and this separation of technical criteria from legislation allows the standards to be updated to reflect technological advances and innovation without requiring legislation to be rewritten.

While Section 508 refers only to the legal obligations of federal departments and agencies, the effect of the legislation has been far-reaching, with two particular notable phenomena:

- Economic pressures have encouraged steps to be taken by *providers* of software and technologies used by federal agencies to address inherent accessibility issues, in order to ensure that federal agencies can still use their software. Recent years have also seen a marked increase in the accessibility of web authoring tools and the ability of such tools to facilitate accessible web content creation, and improvements in the accessibility of multimedia technologies such as Macromedia Flash and document formats such as Adobe Portable Document Format (PDF).
- Section 508 has also been a catalyst for an increase in the amount of resources and assessment and validation tools supporting accessible design, as well as being the driver behind software and web development agencies increasing advertising new services relating to "508-compliant" design.

Section 504 of the US Rehabilitation Act, sets out the rights of disabled people not to encounter discrimination when accessing any "program or activity receiving Federal financial assistance". "Program or activity" is defined as including departments and agencies of a State or local government, college, university or other postsecondary education institution, and any corporation or organisation "principally engaged in providing education, healthcare, housing, social services or parks and recreation"[9].

In the UK, the Disability Discrimination Act 1995 (DDA) has defined the legal responsibilities of employers and providers of goods facilities and services to avoid unjustified discrimination against a person on account of their disability. This was extended to providers of post-16 education in the 2001 amendment to the Act. The legislation does not make mention of any technology, or any technological criteria to

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[7] Although the decision in the Southwest Airlines case is under appeal at the time of writing, it is unlikely to be overturned due to other, technical, problems with the action.

[8] The 1998 amendment to Section 508 of the Rehabilitation Act is available on-line at http://www.section508.gov/index.cfm?FuseAction=Content&ID=14

[9] Section 504 of the Rehabilitation Act – available on-line at http://www.section508.gov/index.cfm?FuseAction=Content&ID=15

be met. The Codes of Practice that accompany the DDA, however, describe examples of where provision of technology would be covered by the DDA.

Thus, in the UK, there are legal imperatives for employers who require their employees to use technology, for goods, facilities and service providers who offer their services via a web site, and for education providers who use technology in teaching and learning, to ensure that the technology they use does not contain unjustified accessibility barriers. By the summer of 2004, no case law existed relating to the application of the DDA to software or web site accessibility, but the authors understand that there have been out-of-court settlements, the details of which have not been made public.

With regard to broadcast media and, in particular, interactive digital television, the UK's Communications Act 2003 gives power to OFCOM, the regulator for the UK communications industries, to take appropriate steps to encourage providers of domestic equipment capable of receiving broadcast media to ensure this equipment, including electronic programme guides for interactive digital television, is accessible to and usable by disabled people. The Act also sets quotas to ensure that an increasing proportion of broadcast output is provided with accessibility features such as captioning and audio description.

Other examples of anti-discriminatory legislation that directly addresses technology include:

- In Portugal, the 1999 Resolution of the Council of Ministers Concerning the Accessibility of Public Administration Web Sites for Citizens with Special Needs[10] sets out a legislative requirement for web sites to meet a defined accessibility standard.
- In Italy, in January 2004, legislation came into place – "Provisions to Support the Access to Information Technologies for the Disabled[11]" – that set out in Italian law requirements for accessibility of computer systems, with specific provision for web sites.

In a 2002 Resolution on Accessibility of Public Web Sites and their Content[12], the European Commission called for:

> "…all public websites of the EU institutions and the Member States to be fully accessible to disabled persons by 2003, which is the European Year of Disabled people; furthermore, calls on the EU institutions and the Member States to comply with the (World Wide Web Consortium's) authoring tools accessibility guidelines (ATAG) 1.0 by 2003 as well, in order to ensure that disabled people can read webpages and also to enable them to manage the content of the webpages (content management)"

As yet, EU policy on web site accessibility has taken the form of the above Resolution and a preceding Communication, limited to cover public web sites of member states, rather than commercial sites, and not legally binding. While it is anticipated that legislation will be produced relating to accessibility requirements, this process may take some time.

[10] An English translation is available at http://www.acessibilidade.net/petition/government_resolution.html

[11] An unofficial English translation is available at http://www.pubbliaccesso.it/normative/law_20040109_n4.htm

[12] Available online at: http://europa.eu.int/information_society/topics/citizens/accessibility/web/wai_2002/cec_com_web_wai_2001/index_en.htm

6 Accessible and Inclusive Design Practice

6.1 Introduction

Specialist designers and rehabilitation engineers have been developing software and hardware systems specifically for older and disable people for many years. As the use of computer systems became more and more ubiquitous in the late 1980s, however, a number of approaches were suggested for design processes which would ensure that older and disabled people could use and would benefit from standard software packages. These could be divided into:

a) Considerations of how standard software could be modified so that older and disabled people could "access" it, and

b) How to design systems which were designed *ab initio* to be accessible to a wide range of users including older and disabled people

This led to the overlapping themes of "accessibility" and "inclusive design" respectively.

6.2 Accessibility

As has been described above, improving the accessibility of software is usually implemented by providing specialised software options which can be used to personalise the software for particular individuals. There are two other ways in which the accessibility of a software application can be improved. These are:

1. Minor modifications to general design principles to take into account the needs of a wider group of people,
2. Providing communication links to externally provided software and hardware for people with severe disabilities.

6.2.1 Improving access by minor modifications to standard software.

Minor modifications to standard software can significantly increase the range of people who may need to use the without any reduction in usability of the software. In many cases such modifications can actually improve the usability of the software for all users.

For example many current software and web sites would benefit from:

- A small increase in font size and the size of buttons and other widgets such as menus and scroll bars.
- Greater contrast between background and text;
- Less cluttered screens
    - The above two requirements interact in that larger widgets would mean that fewer options could be simultaneously available on the screen which would reduce screen clutter. The designer thus needs to design a system with fewer controls which can still be operated efficiently and effectively. This exercise, however, will often result in a more usable interface overall
- Significantly reduced functionality
    - Reduced functionality will assist in providing less cluttered screens, but there is a great tendency for designers to increase functionality - because it can be done - and the market may encourage this, as customers directly relate the amount of functionality to quality. Both

these trends are counterproductive in terms of providing accessible and usable software and the authors speculate that a time will come when most customers ask for a small amount of accessible and usable functionality rather than extensive functionality which very few users ever need.

- Reduction in the need to remember complex operations which are articulated in such a way as to require knowledge of computers rather than the application domain.

The authors believe that substantial improvements could be made in much current software by minor changes which respond to a more realistic view of the sensory, motoric and cognitive capabilities of users, and to their knowledge of computer jargon and metaphors.

6.2.2 Assistive technologies and software to overcome specific barriers

The software options described above may not be appropriate for some of the most severely disabled people such as blind people, and those with severe motor dysfunction. Their needs can be met by specific equipment provided by specialist vendors. Examples of such equipment includes screen readers, screen magnification software, dynamic Braille displays, specialised keyboards, and alternative input devices, such as gesture and gaze recognition systems.

It is rarely appropriate for mainstream system manufactures to include such equipment as part of their range, but it is important for software and web designers to ensure that there are appropriate "hooks" within their software to which these specialist systems can be connected. Technologies such as Microsoft's Active Accessibility (discussed more in Section 1.7.3) can enhance accessibility, but must be supported and used by both the software in question and the assistive technology used by the disabled user.

At a more basic level, information needs to be provided in a format – normally text - that can be accessed and output by an assistive technology, and interfaces need to be designed to allow interaction through alternative input devices, rather than assuming that everyone will be using a mouse.

6.3 Inclusive Design

A number of initiatives have been launched to promote a consideration of people with disabilities within the user group in product development teams. These initiatives have had a number of titles including: "Ordinary and Extra Ordinary HCI", "Universal Design", "Design for All", "Accessible Design", and "Inclusive Design". Examples of "universal design" initiatives are the i-design project in the UK involving Cambridge University and the Royal College of Art, the INCLUDE project within the European Union (http://www.stakes.fi/include), and in the USA, the Centre for Universal Design at North Carolina State University (http://www.design.ncsu.edu/cud/ud/ud.html), and work at the Trace Centre in Wisconsin-Madison (http://www.trace.wisc.edu), and the extensive accessibility programme within the World Wide Web Consortium

Keates and Clarkson (2004) give an excellent introduction to inclusive design and Clarkson et al, (2003) provide a extensive and detailed review of inclusive design mainly from a product design perspective. They suggest that a user's sensory, motion and cognitive capabilities can be represented on an "inclusive design cube". For any particular product, a cube representing the whole population can be subdivided into those who can use the product and those who cannot – in other words, where the demands of the product exceed the capabilities of the user. This cube can be further sub-divided into:

- the “ideal population” – the maximum number of people who could possibly use an idealised product;
- the “negotiable maximum” - the people who are included by the product requirement specification, and
- the “included population” - those who can actually user the finished product.

Keates and Clarkson suggest that the ratio between the various segments of this cube provide measures of the “merit” of design exclusion for that product. They have applied this approach to a number of domestic products, and suggest, for example, that toasters and hair dryers exclude 1% of the population digital cameras and mobile phones exclude 6%.

Newell (1995, referred to above) proposed the concept of “Ordinary and Extra-ordinary human-machine interaction”. This drew the parallel between “ordinary” people operating in an “extraordinary” environment (e.g. high work load, adverse noise or lighting conditions), and an “extra-ordinary” (disabled) person operating in a ordinary environment. He suggested that researchers should focus on the relationship between the functionality of users and the environment in which they may operate. He introduced the concept of considering a “user” as being defined by a point in the multi-dimensional space which specified their functionality, and the relationship of that functionality to the environment in which the user operated. He underlined the fact that both the position in the functionality space, and the characteristics of the environment, change substantially throughout a user’s life from minute to minute as well as from day to day, together with very long term changes due to ageing and physical changes in the physical environment and social situation (Newell & Gregor, 1997). As people age, the range of each ability within each individual tends to increase, while the differences between the abilities of different people tend to diverge. Designing to try to accommodate such ranges of, and changes in abilities has been referred to as Design for Dynamic Diversity (Gregor et al., 2001, 2002).

If extreme portability as well as high functionality is required, such as in the mobile telephone with an alphanumeric input requirement, then all human beings are effectively handicapped. This is one example of the bandwidth of the information channels between the machine and the user (i.e. the connection between the user and the equipment) being the dominating factor in constraining the performance of the human machine system. The technology which is providing internet access using a mobile phone provides a much narrower human interface bandwidth for the user to access information than access via a PC and this will also have the effect of greatly handicapping the user of such systems.

The INCLUDE project produced a methodology for “Inclusive Design” for telecommunication terminals (Hypponen, 1999), which was based on standard textbooks for user centred design and usability engineering (such as Nielsen, 1993), Ulrich & Eppinger’s (1995) methodology, and on an extension of the International Standard for human centred design (ISO 13407, 1999). They suggested that one approach was “to compromise slightly on the product design so that, while the design retains the functionality required by people with disabilities, it still appeals to a wider audience.” They also commented that “there were many different methods of choosing how to collect user needs and integrate them into product development, and that the suitability of this approach to accommodating a range of disabilities into the design process (in an effective and efficient manner) is unclear”. They recommend “guidelines as a good cheap basis for integrating needs of people with varying abilities into design at an early phase”. Examples of such guidelines can be found at their web site and within Hyponnen (1999), together with other literature on “Design for all”.

The Centre for Universal Design at North Carolina State University has also produced guidelines for Universal design which can be found at http://www.design.ncsu.edu/cud/ud/ud.html. Like the Hypponen (1999) guidelines, these are very similar to general user centred design principles, including: flexibility in use, simple and intuitive use, perceptible information, tolerance for error, low physical effort, and size and space provision. They also remind the reader to be aware of the needs of people with disabilities when following these guidelines. Their philosophy, is based on the underlying premise of "Equitable Use", that is: "the design should be useful and marketable to *any* group of users" (our emphasis). If taken literally, however, this imposes very substantial requirements on the designer, which may not always be appropriate.

Designers should be explicitly aware of these concepts and understand how they can be used to the greatest benefit of everyone, including people who are either temporarily or permanently disabled, and that designing inclusively has more advantages than simply increasing market share (Newell, 1998).

The "Design for All" / "Universal Design" movement has been very valuable in raising the profile of disabled users of products, and has laid down some important principles and guidelines. In addition the World Wide Web Consortium (W3C) has produced a number of sets of guidelines, together aimed at raising the accessibility to disabled people of web content. These are discussed in more detail in Section 7.2.2

6.4 Know your potential users

Essentially the message of all these approaches is the need to know the user and to have users more closely involved in the design process. The more different the users are from the designers - in age, experience, or functionality, the more important this becomes. Otherwise there is a tendency to follow the guidelines without any real empathy with the user group – which is likely to lead to applications which closely adhere to a subset of the accessibility guidelines, but have very poor usability for those groups for whom these guidelines were designed.

This message is, of course, identical to the underlying principles of User Centre Design. Unfortunately the needs of older and disabled people do not have a high a profile within the User Centred Design community which tend to focus mainly on able-bodied user. In the vast majority of papers in the proceedings of human computer interface journals and conferences, what the authors means by "people" or "users" is not clearly defined, the very large actual diversity of the human race being more or less ignored. If there is any description of what the authors mean by "people" it is usually given in terms of occupation, users being described in terms such as "school teacher", "doctor" and "nurse". Very few studies describe or appear to take into account the physical and cognitive functionality of the user.

As has been pointed out above, this focus on so-called able bodied people essentially excludes a substantial and growing population of older and disabled people, and the occasions or situations in which otherwise able-bodied people exhibit functional characteristics which are significantly outside the normal range.

Thus questions which designers need to consider include:

- Does the equipment which I provide comply with legislation concerning disabled people?
- To what extent does my design take into account the needs of users who are not considered "disabled", but have significant temporary or permanent dysfunction?

- Does my design make specific accommodation for the known reductions in abilities which occur as people get older (e.g. larger or clearer displays, louder sound output, pointing devices which cope with slight tremor, less requirement for short term memory, and a reduction in the need to learn new operating procedures)?
- Will my equipment be used always by someone in full possession of their faculties and if not, how should this be taken into account in the design (e.g. should it be possible to vary the level of awareness of speed of response required to cope with periods of fatigue)?

It would also be unusual for anyone to go through their working life without at some stage, or many stages, being significantly disabled. If equipment designers took this into account, it is probable that the effectiveness and efficiency of the work force could be maintained at a higher level than would be the case if the design of the equipment was based on an idealistic model of the characteristics of the user.

Designers should also consider:

- Should features be available in equipment design to allow employees to return to work as soon as possible after an accident (e.g. design for effective and efficient one handed operation of equipment would enable a hand or arm-injured employee to return to effective working more quickly than if they had to use standard equipment)?
- What are the specific obligations designers and employers have to provide systems which can be operated by employees who have been disabled by the technology they have had to use (e.g. the effects of RSI)?

6.5 The boundaries for inclusive design

In its full sense, except for a very limited range of products, “design for all” is a very difficult, if not often impossible task, and the use of term has some inherent dangers. Providing access to people with certain types of disability can make the product significantly more difficult to use by people without disabilities, and often impossible to use by people with a different type of disability. It is also clear that the need for accessibility for certain groups of disabled people might not be required by the very nature of a product. We need to be careful not to set seemingly impossible goals as this has the danger of inhibiting people from attacking the problem at all. Sir Robert Watson-Watt, the inventor of radar, once said that “the excellent is an enemy of the good”. In our context “accessibility by all” may provide a barrier to greatly improved “accessibility by most”.

When considering increasing the accessibility of software products the following considerations need to be taken into account.

- A much greater variety of user characteristics and functionality;
- The need to specify exactly the characteristics and functionality of the user group;
- Difficulties in finding and recruiting “representative users”;
- Possible conflicts of interest between accessibility for people with different types of disability, e.g. floor texture can assist blind people but may cause problems for wheel chair users;
- Conflicts between accessibility and ease of use for less disabled people;
- Situations where “design for all” is certainly not appropriate (e.g. blind drivers of motor cars, or e-learning applications the pedagogic aim of which is inextricably linked with a specific ability).

Newell & Gregor (2000) thus suggested the term “User Sensitive Inclusive Design” . The use of the term “inclusive” rather than “universal” reflects the view that “inclusivity” is a more achievable, and in many situations, appropriate goal than “universal design” or “design for all”. “Sensitive” replaces “centred” to underline the extra levels of difficulty involved when the range of functionality and characteristics of the user groups can be so great that it is impossible in any meaningful way to produce a small representative sample of the user group, nor often to design a product which truly is accessible by all potential users.

6.6 Technology as a means of supporting disabled people

In addition to providing access to standard software for disabled people, specialised computer technology can substantially enhance the lives of disabled people. In some cases, technology can provide a far greater impact on the lives of older and disable people, than on those who are young fit and mobile. For example, smart house technology can be used to provide a safe environment for motorically disabled people – enabling them to control domestic equipment, and monitoring them in case of accidental falls or other emergencies. Remote communication can provide the main source of social interaction for house bound people.

It is thus particularly ironic that there are many examples of how the introduction of new technology has increased the barriers for disabled people, the most well known example being the introduction of GUI environments. With the help of speech synthesis technology and/or Braille displays, many blind people had been able to use command line interfaces very effectively, and were using these systems both personally and in industrial environments. The early manifestations of GUI systems, however, had not taken any cognisance of the needs of blind people. They were completely inaccessible to these groups and there were instances of blind people loosing their jobs when a new computer system was installed. It was many years before GUI systems which could be used by blind people were made available.

A particularly exciting area of research is supporting people with cognitive dysfunction by technology, or so-called “cognitive prostheses”. Mobile phone technology, particularly when including personal organisers and location sensitive technology, such as GPS, has great potential in providing memory aids for people with a wide range of memory impairment (Inglis et al., 2004), and at the extreme end, research is showing that computer technology has a place in providing support and entertainment for people with dementia (Alm et al., 2004).

7 Support for Inclusive Design

7.1 Inclusive design principles

A number of standards and guidelines exist to support designers of technology and digital media in ensuring that their information, products and services are accessible to the widest range of people. While specific, and more detailed, requirements vary from platform to platform, and are dependent on the environment in which end users access the technology in question, there is general consensus on the key principles for optimal accessible interface design.

The important principles of inclusive design of computer interfaces can be summarised as:

- Interface functionality should support keyboard operation, and should not rely solely on the use of a pointing device such as a mouse;

- Interface functionality should not interfere with or override any accessibility features provided by the host system, nor prevent assistive technology from effectively rendering the interface;
- Display customisation should be possible – in particular it should be possible to adjust text size, text and background colours, and font style;
- Information available in graphical format should also be provided in an equivalent textual format; visual equivalents should be provided for audio alerts;
- Text should be written with a clarity appropriate for the target audience, and the unnecessary use of jargon or technical terminology should be avoided;
- Features such as titles and headings should be used appropriately to identify information; user interface controls should have appropriate labels;
- Graphics, audio, video and animated content should be used where appropriate to illustrate or enhance textual content, particularly complex data or concepts;
- It should be possible for users to stop or otherwise control animated content; information should also be made available about the presence of automatically refreshing content or any timed response required by the user
- Information should be distinguishable without requiring colour perception;
- Information should be made available about accessibility features of the interface, plus advice on alternative methods for overcoming existing barriers.

It must be stressed that inclusive design should not be an exercise in ticking boxes – in addressing accessibility issues, it is crucial to bear in mind the intended target audience, the environment in which the interface will be used and the function the interface in question is intended to offer.

Designers are thus at liberty to ignore a specific guideline if meeting it would compromise other objectives. Any such decision, however, must be taken with a knowledge of the relevant legislative or economic implications arising from any exclusion that results from this decision.

7.2 Standards, Guidelines and Initiatives

The acknowledgment of the importance of accessibility in the development of technology and electronic information and service provision has been marked by the development of standards, guidelines and other initiatives supporting inclusive design. Initiatives have emerged from a number of sectors, including government, academic, commercial software as well as the open-source community.

7.2.1 Industry Guidelines and Resources

Most of the major developers of operating systems and software applications provide accessibility-related resources and information for developers and users of their products, primarily through web resources.

IBM[13] provides perhaps the most comprehensive set of accessibility guidelines in the form of checklists for developers, covering accessibility of:

- Software

[13] IBM accessibility guidelines – index of online guidelines available at http://www-306.ibm.com/able/guidelines/index.html

- Web Content
- Java applications
- Lotus Notes applications
- Hardware and hardware peripherals

Sun Microsystems and Microsoft both provide extensive online information relating to accessibility and software development; Microsoft additionally publishes information relating to the accessibility of Windows products. However, at the time of writing, Microsoft's widely quoted "Windows Guidelines for Accessible Software Design" appear no longer to be available on-line.

Open source software (OSS) accessibility initiatives include the KDE Accessibility Project (http://accessibility.kde.org/) and the GNOME Accessibility Project (http://developer.gnome.org/projects/gap/), while the Free Standards Group (http://accessibility.freestandards.org/) was established in 2004 with the aim of developing and promoting accessibility standards for Linux and Linux-based applications.

7.2.2 Web Accessibility

The World Wide Web Consortium (W3C) has been at the forefront of promoting the need to consider accessibility of web resources: Tim Berners-Lee, founder of the Web and the W3C, famously said:

> "The power of the Web is in its universality, Access by everyone regardless of disability is an essential aspect,"

To advance the issue of web accessibility, the W3C established the Web Accessibility Initiative (WAI), charged with the task of promoting web accessibility through technological development, provision of guidelines, education and research.

Crucially, the WAI has addressed the need for guidance on a variety of levels, developing guidelines and supporting information for web site developers, authoring too developers and developers of "user agents" - browsers and assistive technologies that support web browsing.

For web content providers, the Web Content Accessibility Guidelines (WCAG). Version 1.0 was released in 1999[14]; version 2 is due for release in late 2004. Version 1.0 of the WCAG is presented as a set of 14 guidelines, each consisting of a number of prioritised checkpoints. There are three priority levels:

1. Priority One – a failure to follow a Priority One checkpoint means that some groups may be unable to access the content
2. Priority Two – a failure to follow a Priority Two checkpoint means that some groups may have significant difficulty in accessing the content
3. Priority Three – a failure to follow a Priority Three checkpoint means that some groups may have some difficulty in accessing the content

Web sites can be evaluated to one of three WCAG conformance levels, based on these priority levels:

1. Single A conformance is the basic level, meaning that at least all Priority One checkpoints have been met;

[14] W3C Web Content Accessibility Guidelines (WCAG) 1.0. Available at http://www.w3.org/TR/WCAG10/

2. Double A (AA) conformance is the intermediate level, meaning that at least all Priority One and Priority Two checkpoints have been met;
3. Triple A (AAA) conformance is the optimum level, meaning that all Priority One, Two and Three checkpoints have been met.

For web authoring tool developers and users, the Authoring Tool Accessibility Guidelines (ATAG)[15] support the creation and usage of web content authoring tools that promote accessible web content creation.

For developers of web browsing technology, the User Agent Accessibility Guidelines (UAAG)[16] have been produced to acknowledge the need for web browsing software to support and enhance accessibility of the web content they give access to.

With the advent of XML as a key technology in the future of the Web, the XML Accessibility Guidelines (XAG) are in development[17], while the WAI also influence the development and specification of other W3C-approved web technologies. Successive HTML and XHTML standards have been enhanced with new elements and attributes that specifically support accessibility, and accessibility considerations have also been taken into account in specifications of technologies such as Cascading Style Sheets (CSS), Synchronised Multimedia Integration Language (SMIL) and Scalable Vector Graphics (SVG).

7.2.3 Other Standards and Guidelines

Various sets of standards and guidelines exist, relating directly or indirectly to accessibility of technology, covering software, hardware and access to electronic information and services. These have been produced by nationally and internationally recognised standards organisations, by research centres and by, or on behalf of, public and governmental agencies.

Some standards concentrate on design methodologies for user-centred or inclusive design, while others specify technical requirements; yet others concentrate on supporting developers of standards in ensuring accessibility is considered as part of the standard. **Table 2** shows a selection of relevant standards and guidelines, all of which are published unless otherwise stated.

In many cases, the various accessibility-focused standards and guidelines show significant overlap in terms of content, and many refer to other sets of guidelines, most notably the W3C Web Content Accessibility Guidelines (WCAG), rather than set out specific technical requirements.

[15] W3C Authoring Tool Accessibility Guidelines (ATAG) 1.0 Available at http://www.w3.org/TR/ATAG10/

[16] User Agent Accessibility Guidelines (UAAG) 1.0 Available at http://www.w3.org/TR/UAAG10/

[17] W3C XML Accessibility Guidelines. Draft available at http://www.w3.org/TR/xag.html

Publishing Organisation	Reference	Name
European Telecommunications Standards Institute (ETSI)	ETSI EG 201 472	Human Factors: Usability evaluation for the design of telecommunication systems, services and terminals;
International Standards Organisation (ISO)	ISO 13407	Human-Centred Design Processes for Interactive Systems
International Standards Organisation (ISO)	ISO/AWI 16071	Ergonomics of human-system interaction -- Guidance on software accessibility (target date for publication - 2006)
Standards Australia	AS 3769-1990	Automatic teller machines – User Access
Trace Center (University of Wisconsin, Madison, Wisconsin, USA)		Information/Transaction Machine Accessibility Guidelines[18]:
European Committee for Standardisation (CEN)/ European Committee for Electrotechnical Standardisation (CENELEC)	CEN/CENELEC Guide 6	Guidelines for standards developers to address the needs of older persons and persons with disabilities

Table 2: Standards and Guidelines supporting Inclusive Design

The amended Section 508 of the USA's Rehabilitation Act requires conformance with the Section 508 Standards. Section 508 standards provide technical criteria for the accessibility of:

- software applications and operating systems
- web based intranets and information
- telecommunications products
- video and multimedia content
- self-contained and closed products
- desktop and portable computing technology

The Section 508 standards exist as an independent set of requirements, and though there is a close relationship between most of the criteria to be met by web based intranets and information and the WCAG, the two remain independent of each other. Section 508 Standards also set out criteria relating to the functional performance of technology, and in terms of the supply of supporting documentation to end users.

The Treasury Board for Canada produced the Common Look and Feel for the Internet standard[19], a standard required to be followed by the web sites of all Canadian federal government departments and agencies. It covers requirements for accessibility of web sites, and refers directly to the W3C Web Content Accessibility Guidelines.

[18] Trace Center Information/Transaction Machine Accessibility Guidelines: Available online at http://trace.wisc.edu/world/kiosks/itms/itmguide.htm

[19] Treasury Board for Canada Common Look and Feel for the Internet standard. Available at http://www.cio-dpi.gc.ca/clf-nsi/index_e.asp

As part of the UK's Implementing Electronic Government/Joined-Up Government initiative, guidance on effective design of e-government sites in England and Wales[20] requires conformance to a specified level of the Web Content Accessibility Guidelines. In the Republic of Ireland, the Irish National Disability Authority IT Accessibility Guidelines[21] cover specific guidelines for developers of web content, public access terminals, telecommunications and application software. As with the Canadian Common Look and Feel standard, these guidelines refer heavily to the WCAG Web Content Accessibility Guidelines.

In the e-learning field, the Boston, MA- based National Centre for Accessible Media (NCAM) has published extensive and detailed guidelines on Making Educational Software and Web Sites Accessible[22]. Additionally, a significant amount of work has taken place in order to support accessibility of reusable e-learning objects (Brewer and Treviranus 2003). The IMS Global Learning Consortium have developed guidelines for the creation of accessible e-learning resources (IMS 2002) while proposed extensions to the IEEE Standard for Learning Object Metadata (LOM) and IMS Learner Information Package specification are respectively exploring the use of metadata to describe the accessibility of a resource and the accessibility requirements of a specific learner.

7.3 Development Tools and Environments

In supporting accessible software development, a number of tools and technologies exist to help developers enhance the accessibility of their applications.

Microsoft Active Accessibility (MSAA) is a technology that supports development of accessible Windows applications by giving supporting assistive technologies access to information about user interface elements, relationships, status and events. This information is particularly important to ensure that existing screen reading technology can output software interfaces in a comprehensible audio format.

One example of the usage of MSAA to enhance accessibility has been through advances in the accessibility of Macromedia Flash, which utilises MSAA to pass additional information to screen reading technologies. (Macromedia, 2004)

For Java applications, the Java Accessibility API and Java Accessibility Utilities are available to developers to enhance the accessibility of the user interface. Additionally, the Java Accessibility Bridge provides a means by which assistive technologies provided by a host operating system can interface with a Java application.[23]

For web content authors, as previously mentioned, an increasing number of elements and attributes specifically aimed at enhancing accessibility have been added to successive specifications of HTML. In addition to these, there has been a marked improvement in the ability of the latest versions of popular web authoring tools and content management systems to facilitate the creation of accessible web resources. As outlined by the W3C Authoring Tool Accessibility Guidelines (ATAG), accessible

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[20] http://www.local-egov.gov.uk/Nimoi/sites/ODMP/resources/IEG3%20final%20guidance.pdf

[21] Irish National Disability Authority IT Accessibility Guidelines. Available at http://accessit.nda.ie/

[22] NCAM: Guidelines for Making Educational Software and Web Sites Accessible: Available at http://ncam.wgbh.org/cdrom/guideline/

[23] More on Java and accessibility is available at http://java.sun.com/products/jfc/jaccess-1.2/doc/guide.html

content creation can be made easier particularly for non-technical experts, through a number of techniques, including:

- Automatic generation of code that conforms to accessibility guidelines and HTML standards;
- Prompting for the manual addition of information to enhance accessibility, for example alternative text for images;
- Checking mechanisms alerting authors to potential accessibility barriers and support on how to remove these;

While these improvements have been made to varying extents in widely used authoring tools, as yet though, it is not clear whether any commercially significant authoring tool has full support for the ATAG.

Steps have also been taken to enhance the accessibility of rich media. For example, Macromedia has taken significant steps to reduce potential accessibility barriers inherent in their Flash technology, while the organisations behind popular rich media players have also addressed, to varying extents, accessibility issues relating to the accessibility of media players and the rich media content itself.

A key feature of the W3C technology Synchronised Multimedia Integration Language (SMIL) is to support the addition of synchronised captions and audio descriptions to time-based presentations, while NCAM have developed the Media Access Generator (MAGpie) software to support authoring of caption and audio description files for combining with rich media content.

8 Testing and Evaluation of Inclusive Design

As the importance of accessibility has increased, methodologies for evaluation of software and web interfaces for accessibility have evolved. The most efficient way of developing an optimally accessible interface is, of course, to consider accessibility throughout the design lifecycle and perform evaluation and testing, preferably with users, at various stages in the iterative design cycle. Through regular user-involvement with disabled people, potential accessibility barriers can be identified and addressed as quickly as possible, before they become embedded in the system, architecture and functionality to such an extent that their elimination at a later date may be difficult or impossible.

In reality, though, many developers and technology providers are faced with the pressing need to evaluate an existing resource or application for potential accessibility barriers. Thus accessibility evaluation methodologies tend to concentrate on identification and prioritisation of existing problems, in order that a staged redevelopment can take place.

Sloan et al (2000) developed an early methodology for evaluating web sites for accessibility, and this methodology is largely that recommended by the W3C's Web Accessibility Initiative (WCAG 2002). The methodology, which may be applied with slight modification to software and other interfaces, covers the following key activities:

- Evaluation with automated checking tools. Many automated checking tools for assessing web site accessibility now exist, including Watchfire's Bobby, the WAVE from WebAim, A-Prompt from the University of Toronto, Lift from UsableNet, TAW (Test de Accessibilidad Web) and Torquemada from WebxTutti, the last two being developed in Spanish and Italian respectively. These automated tools have some very useful features to support developers, but they can check for only a subset of accessibility barriers, and, when used, must be supplemented by manual checks.

- Manual assessment of the accessibility of interface when used with a variety of assistive technologies, ideally including screen magnification software, screen readers, Braille displays, and alternative input devices.
- Manual assessment of the interface – or at least a subset of screens or pages – using a checklist of recognised accessibility checkpoints, such as the W3C WCAG.
- Manual assessment under different access conditions, including:
  - in monochrome – black and white printed screenshots can be useful here;
  - with graphics turned off;
  - with speakers unplugged or sound turned down to a minimum;
  - with the mouse unplugged;
  - for web pages, with style sheets, scripting and frames disabled
- Web-based simulations can also help identify potential problems – for example a colour blindness simulator is available at http://vischeck.com . Bookmarklets, or favelets are small scripts that, when run by a web browser, temporarily change screen display or disable a specific feature. These are widely available as additional browser tools for testing a web page for a specific accessibility issues.
- Even when the above checks have been carried out, some accessibility issues may still go uncovered. Carrying out usability evaluations with disabled users can be a very effective way of identifying barriers that may not have been otherwise apparent, or cause a significantly greater problem than might have been expected. While making contact with people with a variety of impairments may seem like a daunting challenge to some, the authors suggest that this is becoming less of a challenge, as more people with specific disabilities become active online, and more information becomes available regarding local disability groups, as accessibility evaluation becomes more commonplace and high profile.

In some cases, where time or expertise may be limited, it may be prudent to commission an accessibility audit, and this is being offered by an increasing number of academic, public sector and commercial organisations, such as the Digital Media Access Group (www.dmag.org.uk).

9 Developments and Challenges

9.1 Developments

Recent years have seen a number of positive developments in progress towards computer applications, services and digital media that are accessible to the widest possible range of users, regardless of disability.

9.1.1 The embracing of standards and accessibility– by developers, by authors and by consumers

Given the work carried out by the W3C and others in ensuring accessibility is a key consideration in the development of specifications and standards for the web and other technologies, it follows that standards-compliant technology design is highly compatible with inclusive technology design.

In terms of software accessibility, major development companies like Microsoft, Sun and IBM for many years have invested in research and development into how the accessibility of their products to disabled people can be enhanced. Increasing numbers of accessibility features have been incorporated into successive versions of the Windows operating system, to such an extent that it effectively became the only viable platform for assistive technology developers to create their products.

Apple initially led the way in accessibility innovation and solutions in early versions of the Macintosh operating system, but perhaps mirroring the decline and re-emergence of the company in the late 1980s and early 1990s, investment in accessibility aspects dropped, severely affecting the accessibility of later versions of Mac OS, and only recently has there been evidence that accessibility is once again an important consideration (Clark 2001a; 2001b)

In the web design and development field in recent years, there has been a remarkable increase in evidence of developer enthusiasm for the adoption of web standards as a basis for web design. With that has come an increased interest in, and support of, the need to develop resources in line with accessibility guidelines. Where it might have been argued, in the past, that accessibility was not a high priority consideration, and not compatible with cutting-edge graphic design or complex functionality, standards-adherence and accessibility are now increasingly being seen by many web professionals as baseline professional requirements that are non-negotiable prerequisites to the work they do.

Through largely grassroots organisations of web developers, advocacy groups such as the Web Standards Projects (WASP, http://www.webstandards.org) and MACCAWS (Making a Commercial Case for Adopting Web Standards, http://www.maccaws.com/) have been influential in providing coherent and cogent arguments supporting the uptake of standards in the development and procurement of web applications, browsers and authoring tools.

The EuroAccessibility (http://www.euroaccessibility.org) movement is a consortium of academic, public and commercial organisations, with the aim of promoting use of use of the W3C Web Content Accessibility Guidelines as a way of standardising web accessibility evaluation and certification across Europe.

Another European initiative is the European Design for All e-Accessibility Network (eDEAN, http://www.e-accessibility.org/). This European Union initiative was founded in 2002, with the aim of promoting awareness of uptake in inclusive design methodologies in the public and private sectors, through establishing, in EU member states, national centres of excellence in inclusive design.

9.1.2 Accessibility-focused resources

In the past, it has been argued that advice and support on accessible design topics has been scarce, hindering awareness-raising and education in accessible design, but this picture is changing rapidly. In terms of published literature, the fields of human-computer interaction (HCI/CHI) and more specifically software and web usability have, to some extent, acknowledged the importance of the need for technology design to take into account variations in cognitive and physical abilities of end users. Accessibility, however, was by and large seen as a specialist issue rather than a core aspect of effective user-centred design.

Several books on web accessibility now exist, notably Paciello (2000), Clark (2002), Thatcher et al (2002) and Slatin and Rush (2002), and, a further milestone was reached with the publication of Designing with Web Standards by Jeffrey Zeldman (2003).

Zeldman's work extended topics of standards compliance and accessibility to the field of creative web design, and attempts to show that goals of creativity, aesthetics and accessibility need not be mutually exclusive. This has been an important step in engaging a community previously seen at least as having different beliefs and objectives to accessibility and usability advocates - if not hostile to accessibility and usability – a cultural difference summed up as "Usability experts are from Mars, graphic designers are from Venus" (Cloninger, 2000)

On-line publications such as A List Apart (http://www.alistapart.com/), Digital Web Magazine (http://digital-web.com/) and Boxes and Arrows (http://www.boxesandarrows.com/) have also helped to promote standards compliance and accessible web design through discussion of new design techniques and methodologies using standards yet that also push boundaries of creativity and functionality in web design.

At the same time, the quantity of online accessibility-focused web resources is also increasing, and again, concentration is largely on web content development. Sites from organisations such as Utah State University's Web Accessibility in Mind (WebAIM, http://www.webaim.org) and the National Centre for Accessible Media (NCAM, http://ncam.wgbh.org/) are valuable resources to developers. The Techdis service (http://www.techdis.ac.uk) offers an advisory service on issues relating to technology, disability and learning to the tertiary education sector in the UK.

Two UK-based initiatives of particular mention have resulted in a strong on-line presence, and show evidence of a global social movement in the area of web accessibility:

- Accessify.com (http://www.accessify.com) is a web site providing resources on accessible web design. Perhaps the most successful of these resources has been the Accessify Forum, an on-line community visited by people across the globe, and used to share accessibility-oriented news, knowledge and design techniques.
- The Guild of Accessible Web Designers (GAWDS, http://www.gawds.org) was set up in 2003, in light of increasing awareness of accessibility by commissioners of web sites, to acknowledge the need for some form of professional accreditation of skill and commitment to accessible design.

9.1.3 The effect of legislation on ICT developers and commissioners of ICT

The increasing interest amongst the web development community is, of course, not solely altruistic, but market-driven, as increasingly well-informed organisations acknowledge legal responsibilities and business arguments for accessible technology when contracting or purchasing technology solutions such as software and web sites.

Anecdotal evidence suggests that contracts and invitations to tender are increasingly specifying accessibility as an essential requirement of the product to be developed, and as a result, interested technology developers may increasingly be required to demonstrate evidence of skills and awareness in accessible design. Increased awareness of legislative and other requirements may also pass added responsibility onto developers to commit to fulfilling contractual accessibility objectives in the work they carry out.

9.1.4 Research and Development

As awareness in technology accessibility grows, and commercial demand for product that are optimally accessible, so too does commercial and academic research and development into ways of:

- using technology to enhance accessibility of information, communication and services to disabled people, and
- ensuring that technology and digital media is optimally accessible to a specific user group

As mentioned, there are widely accepted accessibility guidelines for developing software and web content, but research is investigating ways in which accessibility barriers can be overcome.

A small selection of the many innovative research projects in the area includes:

- IBM have been exploring ways in which server-side transformations of web content can help to enhance the accessibility of web sites independent of existing access barriers being addressed by the site authors. The Web Accessibility Technology (WAT) provides enhanced functionality to web browsers by allowing easy adjustment of appearance characteristics such as text size and hyperlink appearance (Richards et al., 2003)
- In an effort to support people who are deaf and who consequently have reading difficulties, investigations have taken place into automating the translation of digital textual content – such as captions accompanying video - into sign language represented by an avatar. The ViSiCAST[24] and eSign[25] projects are examples of recent work on 'virtual signing'.
- Specific difficulties exist for people with communication difficulties in accessing and reading textual web content. These groups may use symbol-based augmentative and alternative communication (AAC) systems, yet translation of content in plain text into a specific AAC system, or translation of content from one system into another can be very difficult. The Concept Coding Framework project[26] is investigating how RDF (Resource Description Framework) can be used to provide a common framework to allow the easy translation of content such as messages between AAC systems.

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[24] More details on the ViSiCAST project are available online at http://www.rnid.org.uk/html/information/technology/visicast.htm

[25] More details on the eSIGN project are available online at http://www.sign-lang.uni-hamburg.de/esign/

[26] More details on the Concept Coding Framework project are available at http://dewey.computing.dundee.ac.uk/ccf/

9.2 Challenges

9.2.1 Continuing lack of awareness and knowledge

Despite the positive picture painted in the previous section on developments, there remains clear evidence of a lack of awareness of the need to develop accessible technology, and levels of knowledge in effective inclusive design techniques are disappointingly low.

This was emphasised in 2004 in research into the accessibility of UK web sites by the Disability Rights Commission (DRC), which found that:

> "81% of web sites evaluated failed to satisfy even the most basic Web Accessibility Initiative Category": (DRC 2004, p37)

The responsibilities of commissioners and purchasers of information and communication technology are clear. Given that where legal responsibility exists with respect to disability discrimination, it is most likely to lie with the provider of the technology - the employer or the service provider, rather than the manufacturer or developer. Therefore there is a continuing need to raise awareness amongst large and small organisations alike, of commercial, public, educational and not-for-profit organisations of their responsibilities to ensure that they use technology to reduce, rather than increase accessibility barriers to disabled employers and customers.

It is expected that as awareness grows, both from a client perspective and a developer perspective, and pressure grows from heightened user expectations in terms of accessibility, this issue will become more specifically one of knowledge and skill in accessible design.

Aside from a general lack of awareness, one specific stumbling block to increased knowledge in accessible design in the software and web development community appears to have been a difficulty in translating information on accessible design into effective practice. The DRC research found that, amongst web site commissioners interviewed in the study, over two-thirds of large (over 250 employees) companies had taken accessibility into account during web design. Yet the evidence of the web site evaluation did not back this up:

> "if 68% of web site commissioners from large organisations do indeed take accessibility into account, their concern to meet the needs of disabled people is, sadly, not being turned into good enough practice on the ground." (DRC 2004, p37)

Some have expressed the view that web accessibility guidelines provided by the W3C, in particular the WCAG, have been less than optimal in the presentation of information, and there have been suggestions that both the content and presentation of the guidelines inhibit end users from fully engaging with and understanding them (Colwell and Petrie, 1999). It has also been suggested that the WCAG is an uncomfortable mixture of prescriptive and vague requirements, and as a result can be difficult to effectively apply to a specific circumstance, regardless of the experience of the web designer (Clark, 2002).

The W3C's Web Accessibility Initiative (WAI) has acknowledged these difficulties, and in developing version 2.0 of the WCAG, is working towards representing the guidelines in a new navigational model, with the aim of making it easier for user groups to extract and understand the information they need. Presentation issues are also being addressed, in an effort to engage designers who may have difficulty engaging with text-based guidelines the presentation of which do not appear to empathise with goals of creative visual design.

At the same time, though, accessible design cannot be boiled down to a single prescriptive set of guidelines, and therefore there is a pressing need for every organisation that uses technology to provide effective training in accessible technology provision, software and web design. Training is necessary not just in accessible design techniques, but in awareness of the diversity of end users and their goals, their access technology and their specific needs, and how that might impact on the solutions adopted.

There is a particular need for increased awareness of accessibility issues amongst small organisations – the Disability Rights Commission's study into web accessibility found that only 29% of small organisations (i.e. with less than 250 employees) took accessibility into account when developing a web site, and indeed only 69% appeared to be aware of accessibility as an issue. (DRC 2004, p36)

Crucially, accessibility awareness must become integral to good design practice – and it must form a core part of any training programme, as opposed to an add-on.

9.2.2 More "accessible" accessibility features

There is an unarguable need for technology providers to take steps to make that technology as accessible and usable as possible to as many people. But at the same time, there is a need for increased awareness of such technology by those people who could benefit from accessible technology.

Many disabled technology users are extremely skilled, and the problems they encounter are likely to be exclusively due to shortcomings in the design of the resource, application or access technology they are using. However, the DRC report also, importantly, identified the need for improved education amongst disabled users of technology. The report found that many disabled people were unaware of accessibility features provided by operating systems and software such as browsers.

Several initiatives exist to raise awareness of technology amongst disabled people. For example, the UK charity AbilityNet supports disabled technology users by providing technology assessments for disabled people, assessing their access needs and matching those needs through showing how operating system or software accessibility options can be adjusted, or prescribing an appropriate assistive technology.

At the same time, there is a pressing need for interface designers to provide accessibility options in a way that makes them more conspicuous to the full range of users who may benefit from them. Recalling that many people who may benefit from accessibility options would not necessarily identify themselves as being disabled, these people may not think to use accessibility options that are labelled as being provided for 'disabled users', or identified by icons relating to disability. Instead, more success may be had by presenting accessibility options as ways of making the interface easier or more comfortable to use, rather than explicitly labelling them as 'features for disabled people'.

9.2.3 The need for a coherent and collaborative accessibility strategy

Closely related to effective training is the need for software and web development organisations, and indeed any organisation implementing in-house or third-party technological solutions, or having a web presence, to develop and maintain an effective accessibility strategy. Anecdotal evidence abounds of instances where accessibility, disability and technology have been addressed by an organisation through awareness raising and training programmes, or the appointment of a single employee to oversee alone all matters accessibility-related. Yet, once this initial burst of activity has passed, and the in-house accessibility expert has moved jobs, the system in place has no structure to replace the expert, momentum is lost, resources developed no longer maintain standards of accessibility, and the issue may shrink into the background in terms of priority.

The importance of an accessibility strategy is discussed in some detail by Urban (2002), who, in setting out an ideal organisational policy, stresses the need for a structured rather than *ad hoc* approach to accessibility.

Dependent on the function of the organisation in question, key stakeholders in formulating and overseeing the implementation of an institutional accessibility policy may include the following:

- Representative(s) from senior management;
- Legal representative;
- A dedicated 'accessibility champion';
- Representatives from sales and marketing, and corporate image or external relations;
- Representatives from IT provision – or development teams if a software or web development organisation.
- External representative from one or more disability groups.

In discussing an effective accessibility strategy, Bohman (2003) defines the following as essential elements:

- Definition of who is responsible for creating accessible content;
- How those responsible will receive training and support in achieving their objectives;
- What is meant by "accessible", and how to tell when content is "acceptably accessible" – this may involve defining a conformance level with an in-house or external set of guidelines;
- When, or how soon, content must be made accessible;
- Who verifies content reaches the specified standard;
- How, and by whom the standard will be enforced;
- What consequences will befall those who violate the standard, and the sub-standard content in question.

Implementing and maintaining an effective accessibility strategy is therefore a long-term task, requiring leadership and influence, plus support from and for all levels of the organisation, rather than vague and empty expressions of ideals.

9.2.4 Accessibility through segregation

The most accessible interface for someone with a specific set of access requirements is one that is uniquely tailored to their needs, and while this situation may be impractical, good accessible design should at least as far as possible allow customisation of display and interaction methods to suit a user's preferences. Provision of alternative versions of content – for example textual equivalents of graphical information - may be necessary to ensure accessibility for some users, while in certain situations, redundancy in features such as navigation mechanisms can also enhance accessibility.

A worrying trend in accessible design has, however, seen the emergence of completely separate versions of interfaces and web sites, intended as 'accessible versions' for disabled people. Segregation in this way does nothing to address the social exclusion faced by many disabled people, but, perhaps more significantly, a version marked as being 'for disabled people' will be ignored by the many people who do not identify themselves as being disabled, but might benefit from the accessibility features provided. At the same time, many text-only versions have suffered from neglect by developers, and text-only web sites have been found to be poorly updated, or missing much of the content or functionality of the 'graphical' version of the site. As a result, many disabled people treat text-only alternatives with distrust, even though with database-driven web sites, where all content is output from a central database, there is no longer a need for physically updating two separate versions of a site.

The irony of text-only versions of web sites is that, for a majority of users, there is minimal difference in accessibility of a **well-designed** web site with judicious use of graphics, colour and even multimedia, and a text-only version of the same site. Conversely, an automatically generated version of a text-only version of a poorly designed site will maintain most of the inherent accessibility and usability problems.

Yet, text-only web site generation is still encouraged and pursued by many, and software is available to facilitate automatic generation of such alternatives. There is a real worry that without a true understanding of accessibility needs, many organisations will choose to invest in significant amounts of money in this approach, leading to continued segregation and at the same time paying less attention to the need for developers and content providers in inclusive design.

Instead, as mentioned previously, developers should focus as far as possible on creating user-tailorable interfaces that support diverse accessibility needs, while being aware that there are occasional situations where a one-size-fits-all approach may not be the most effective. For web developers, technologies such as cascading style sheets have significant potential in allowing users to select or define alternative presentations of the same web page, based on their own access requirements; thus avoiding the need to provide and maintain parallel version of the site.

9.2.5 Unproven or undefined legislative responsibilities

As discussed in Section 5, legislation exists in several countries outlawing discrimination against citizens on account of their disability, and there seems to be little doubt that this legislation can be applied to case of discrimination resulting form software and web content containing accessibility barriers. Where there is often doubt is in a clear and unambiguous technical definition of accessibility, and whether it can be proved in a court that a resource has failed to meet this standard. Legislation such as Section 508 of the Rehabilitation Act does directly refer to the requirement of conformance with a technical standard; and the ruling of the Maguire v SOCOG case indicated that had the most basic conformance level of the Web Content Accessibility Guidelines been followed, there would have been no case to answer under the Australian DDA. Even so, there is an uncomfortable lack of clarity in the situation of what is legally acceptable and what is not.

In many countries, no law outlining discrimination against disabled people exists. Where such legislation does exist, it may not include a definitive requirement in terms of technical standards to be met to ensure lawful compliance, or it may be restricted to cover a specific sector, as, for example Section 508 does. There is also an issue of unclear consequences for unlawful activity - since most anti-discriminatory laws are civil rather than criminal law, courts have the power to award damages to the plaintiff and/or make orders requiring the defendant to take steps to amend their discriminatory practice, but any such order is assessed on the specific circumstances of an individual case.

In the absence of any case law defining exact responsibilities, there will be uncertainty over responsibilities. Where there is uncertainty, there may be opportunity for organisations to argue that they have no legal responsibility to design accessible technology, or downplay their responsibilities, or to work to a level of accessibility that is far below an acceptable experience for many groups of disabled people. Organisations may also justify continued discriminatory practice, if they consider the risk of financial penalties resulting from a court ruling against them acceptable.

Another stumbling block is the subjective nature of many of the existing guidelines on accessible design, and different interpretations of guidelines. Any debate over whether supposedly universally recognised accessibility guidelines have or have not been satisfied will weaken the authority of such guidelines in a court of law, and will undermine the argument that a resource failing to conform to the guideline is unlawfully discriminatory.

These challenges to effective application of disability discrimination law to any instance of digital discrimination underline the need to maintain campaigns for clarity in terms of technical requirements to meet existing legislation, and, where there is none, to press for introduction of disability discrimination legislation that clearly sets out accessibility responsibilities of developers and providers of technology.

There is also the continuing need for more empirical data supporting the business case for accessible technology. The ultimate objective is a culture that finds technology with unjustifiable accessibility barriers unacceptable, in the same way as fire-escapes are now seen as a core requirement in the built environment.

9.2.6 Bridging the gap between accessibility and usability

The success in the adoption of accessibility as a fundamental professional and technical skill in the independent web design community has been remarked upon earlier. Nevertheless, a guideline-focused, technical approach to accessibility can result in a design which presents a disabled person significant usability problems.

Thatcher (2003) describes an example of a US federal agency's web site that apparently met a specific set of accessibility standards but failed spectacularly to provide an acceptable browsing experience for a visually impaired user. Alternative text was provided for all images on the page, but the text provided was so unnecessary detailed and in many cases irrelevant that the site became virtually unusable.

The findings of the UK Disability Rights Commission Formal Investigation also stated that:

> "Compliance with the Guidelines published by the (W3C) Web Accessibility Initiative is a necessary but not sufficient condition for ensuring that sites are practically accessible and usable by disabled people. As many as 45% of the problems experienced by the user group (in the Formal Investigation) were not a violation of any checkpoint, and would not have been detected without user testing." (DRC, 2004a)

It is unfortunate that the two communities who are interested in usability and accessibility respectively are relatively separate. The usability community is primarily interested in how "typical" users operate systems and designing systems which can be operated with the minimum of difficulty. The accessibility community is seen to be primarily concerned with ensuring that people with varying disabilities can access the functionality of systems. Some from the usability community will claim that accessibility is simply a sub-set of usability, and that one first produces a usable system and then investigates its accessibility as an add-on extra. This approach almost inevitably leads to significant extra expense and compromised accessibility.

It is more useful to think of usability as a sub-set of accessibility, that is, firstly the designer ensures that their target user group - including those with disabilities - can access the functionality of the system, and then considers how to make it usable for all of the intended audience.

The relationship between accessibility and usability has been described as:

> “Usability problems impact all users equally, regardless of ability. That is, a person regardless of disability is not disadvantaged to a greater extent by usability issues than a person without a disability.
>
> “Accessibility problems hinder access…by people with disabilities. When a person with a disability is at a disadvantage relative to a person without a disability, that is an accessibility issue.” (Henry, 2002)

The same reference also acknowledges:

> “…it is rarely useful to differentiate between accessibility and usability…the distinction between accessibility and usability is especially hard to define when considering cognitive and language abilities.” (Henry, 2002)

This is particularly so as the impact of most usability problems is also dependent on a cognitive ability, namely the ability to detect and identify the problem and find a solution. For individuals with specific cognitive impairments, what may be seen as a minor challenge for a majority may again become a significant barrier to access.

Existing guidelines for accessible design thus may overlook, or fail to emphasise, the need to minimise or avoid apparently minor problems that, as a result of a specific impairment or combination or impairments, may be magnified to such an extent as to make the interface virtually unusable

Thus although an interface may seem to meet recognised accessibility guidelines, it may yet still be unlawfully discriminatory to particular disabled people:

> “Published Guidelines and automatic testing software are useful diagnostic tools but **are only part of what is needed** to fulfil the (UK) DDA duty on service providers to make “reasonable adjustments” to their website practices, policies and procedures.” (emphasis added) (DRC, 2004 p12)

Ultimately, this illustrates the importance of involving disabled users throughout the design and development of an interface to ensure both technical accessibility and to raise the user experience to a satisfactory level.

Microsoft’s research into accessible technology found that people with impairments who used accessibility options and assistive technologies often did not consider that they used these technologies because of their impairment – rather, they used them in order to make it easier to use their computer. In other words, accessibility options and assistive technologies were considered as **enhancements to usability**, rather than accessibility:

> “From trackballs to screen magnifiers, participants frequently reported that these products make computers “easier to use”, “more comfortable” and “more convenient”. (Microsoft, 2004)

9.2.7 Neglect of specific user groups

It is widely acknowledged that requirements for and provision of accessibility options for some groups of disabled people, are more widely known than for other groups. For example, guidelines for enhancing the accessibility of software and web interfaces for blind and visually impaired people are relatively well advanced. For other groups, however, there is less awareness of what can be done to design optimally accessible and usable technology. This can partly be explained by the relative homogeneity of the accessibility needs of blind people, in comparison to that of elderly people, or people with ‘cognitive disabilities’. It is much easier to ensure people are not excluded if there is a straightforward unambiguous set of guidelines.

For example, a key step to make information accessible to someone who is blind is to make it available in text, whereas a graphical, animated or audio format would be more suitable for someone with a severe learning disability or who has very low reading skills, but the resources and skills required to do this effectively may be beyond many content providers.

The situation was summarised by Clark (2002a):

> “There is no plan of action available … in order to accommodate learning-disabled visitors in the way that plans of action are available for other disability groups, however contingent and fractured those latter plans might be. There are no simple coding or programming practices – or even complex practices, for that matter – in which you can engage to accommodate this group.”

There is undoubted potential for technology to reduce exclusion and enhance the lives of specific groups, in particular for the significant group of people who have reading and learning disabilities, but their requirements are often diametrically opposed to that of other groups. The work of the Concept Coding framework project may be an important step towards this goal, but much work remains to be done to reduce exclusion amongst people with severe learning disabilities.

10 The digital divide still exists

In this chapter, we have seen how technology can be used to enable and facilitate inclusion, and we have noted how easy it is for designers and developers to inadvertently exclude large groups of users just by not taking proper account of the widely available knowledge on accessibility and inclusion. Given all the technical knowledge and guidance available, the trends in legislative activity and the emergence of frameworks for carrying out accessible design, it would be easy to be lulled into a sense that all was well and that inclusion and the digital divide had been removed. This would be wrong; there are still some major concerns.

The socio-economic divide still exists, and, although technology prices continue to fall, their purchase remains very low on the agenda for disabled and older people who are struggling to keep a roof over their heads. While the technology may be getting better, and cheaper, there are still significant economic barriers to its uptake by those who might benefit most from it.

Next, there is a battle for hearts and minds – while the technology exists to either assist or enhance quality of life and access, many older people in particular don't and won't make use of technology even when they clearly can afford it. A frequent reaction to the direct question is, "Oh, no, that's not for me". To some extent this problem will solve itself as the older population becomes one which was brought up with computing in their lives, but there is still a job to be done in convincing non-technology users that there can be significant benefits for them.

While many major players and niche companies are clearly working hard to avoid excluding people, there are still many systems appearing – software, hardware and web services, - which have clearly not been designed with any thought for the whole range of users. There is still far too much technology push in emerging areas. Whilst this is likely to reduce as developers see the success of well designed products and the legislative effects as case lore develops, the need for usable systems still needs to be positively promoted. The challenge is how to provide designers with the right sort of information, and in a way which doesn't get in the way of the design process itself. There is no shortage of information, but it is not always clear how to interpret and use it effectively. The solution most surely lies in the promotion of a *culture* of inclusion, where it is seen as an integral part of the design process, and is taught explicitly to the emerging generation of designers and developers.

There are many positive signs that computers are beginning to realise their potential as liberators and facilitators for older and disabled people, but there is still a long way to go

- in developing methods to ensure inclusion;
- in developing and implementing legislation concerning inclusion in the digital world
- in convincing sectors of the population of the potential benefit to them of technology uptake, and
- in evolving a culture of inclusion in the design and development communities.

Everyone in the computing and information technology communities has a role to play in this important task.

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