

Designing Disability-Aware E-Learning Systems: Disabled Students' Recommendations

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Abstract

Disabled students in higher education are faced with a lot of difficulties accessing learning resources when e-learning systems are inaccessible. When instructional designers and developers of e-learning systems overlook the needs of disabled students, this leads to exclusion in what is termed disability divide. This paper reviews some disabilities encountered in higher education and assistive technologies used in accessing e-learning environments and presents disabled students' recommendations on designing inclusive e-learning systems, obtained during the user evaluation of a disability-aware e-learning software. It is hoped that these recommendations would be adopted by designers and developers of e-learning and web-based systems so that they can meet the needs of disabled students.

Keywords: *E-learning, disabled students, inclusive education, instructional design, disability-aware systems*

1. Introduction

The development and significant advances in e-learning over the last two decades has meant disabled students can now have access to learning resources at anytime from anywhere in a way that they could not do before. Paradoxically, the advances in e-learning have created a disability divide [1] as most e-learning systems are not designed to cater for the needs of disabled students. Most of such systems do not anticipate the needs of disabled students, hence are not disability-aware.

Disabled students have varying needs when accessing e-learning environments. As disability is an individual experience and two people with the same disability can have different experiences, it is necessary to consider and incorporate the common needs of disabled students into e-learning environments at the design, development and testing phases. We have previously identified the need for disability-aware engineering of software systems and proposed a methodology [2]. All efforts to build inclusive systems are further strengthened with the participation of disabled students through seeking their opinions as will be expressed in this paper.

This paper mainly deals with disabled students using ICTs to access learning environments and services in an educational context. Some of these interactions are very difficult because of specific impairments which are further compounded by inaccessibility of web-based systems to people with disabilities. This paper will examine issues related to disability and e-learning in a higher education context. These discussions start by examining some types of disabilities encountered in higher education, including various models of disability. The paper proceeds to present recommendations for designing disability-aware e-learning systems from the perspectives of disabled students.

2. Disability and Education

Disability refers to some physical or mental impairment to an individual which prevents them from carrying out their normal activities. Physical impairments may affect the senses such as sight, hearing and movement. Disability affects the way students study and in some cases, require special technology known as assistive or adaptive technologies to access information on the web. Depending on the disability, individuals will need personalized information in specific formats.

Disability discrimination is discrimination against a disabled person because of their disability; for instance refusal to hire a disabled person or to recruit a prospective student because of their disability. If a higher education institution does not have the equipment to meet the needs of a prospective disabled student at the time of application but is able to do so and does not recruit the student on the grounds of their disability, they would be discriminating against them. The same applies to teaching and assessment where an institution fails to provide “reasonable adjustments” such as providing examination support or assistive technology to meet the needs of a disabled student. Disability discrimination is greatly discouraged by most governments in the West, through legislations. These laws make it illegal to discriminate against disabled people because of their disability. Although disability discrimination has greatly reduced in many countries with disability legislations which have measures to enforce them, it still continues today and is manifested in the disability divide.

Just like the digital divide where there is a wide gap between those who have and can use information and communication technology (ICT) and those with very limited or no access, there is a disability divide. This is the divide caused by information and communication technology inaccessibility to people with disabilities compared to able-bodied people [1]. Although there are special technologies (assistive technologies) that enable disabled people to access learning content online, some of these systems are still inaccessible to some disabled people. This cuts them away from others, resulting in a divide which places disabled people at a disadvantaged position. In many developing countries, people with some common forms of disability such as blindness still lack appropriate assistive technologies (screen readers, magnifiers, etc.) to access online content.

3. Types and Characteristics of Disability

The number of disabilities is on the rise with an increasing number of disabled students progressing into higher education studies each year. Age-related disabilities are also on the rise. As there are numerous disabilities, this section will focus on some of the major disabilities encountered in higher education.

3.1. Autistic Spectrum Disorder

Autistic spectrum disorder is a term used to describe disorders such as autism and Asperger Syndrome [3]. This lifelong developmental disability tends to affect the way the individual relates and communicates with people and could also involve a range of repetitive behavior and interests. People with such disorders tend to have difficulties with understanding written and verbal speech. Social interaction difficulties manifest in difficulties in making friends and interacting with other people.

Very little research has been done on the semantic web regarding autism. An ontology of autism for phenotype-based querying of archived data has been developed by Young, et. al., [4] which could be useful for research into autism. A number of related researches utilising an

autism ontology [5] are amongst the recent research using ontologies for the benefit of those with autism.

3.2. Visual Impairment

Visual impairment affects an individual's ability to perceive information. Students with visual impairment particularly severe impairments usually require some form of assistive technology in order to read lecture notes. This group of people are often disadvantaged when websites or e-learning systems are not designed following accessibility standards.

3.3. Mental Health Difficulties

It is estimated that 1 in 4 people of the adult UK population will experience some form of mental health problem. Mental health difficulties range from mild depression to acute schizophrenia. Other common mental health difficulties include psychosis, anxiety (including panic attacks), attention deficit disorder, obsessive compulsive disorder, self-harm and eating disorders (such as anorexia nervosa, bulimia nervosa and binge eating disorder). Agoraphobics avoid crowds and hence public places and would thus benefit from personalization of services online. In designing websites for people with disabilities, accessibility and usability guidelines must be followed, to include such people; hence, Friedman and Bryen [6] recommend twenty web accessibility design guidelines for people with cognitive disabilities with the top recommendation being the use of pictures, graphics, icons and symbols along with text.

The semantic web also offers solutions to solve problems related to mental health difficulties. Coyle and Doherty [7] have described the potential of using ontologies in the development of interactive systems to support mental health interventions. Their system emphasizes psycho education, shared peer content and stories and adaptability. The ontology described there is specific for use by clinicians and care workers to diagnose and provide support to those with mental health problems but also allows for elements such as learning models and interaction preferences/requirements to be incorporated in the ontologies.

3.3. Mobility Difficulties

Mobility and dexterity difficulties which could also be referred to as physical impairments may be acquired or congenital in origin and affect individuals in a variety of ways. Such difficulties could be characterized by problems with sitting for long periods or slow movements which in some cases could be painful, resulting from injury or amputations, arthritis or spinal cord injury for example. Some students with mobility difficulties will need to use wheelchairs or electric scooters. Mobility difficulties are not only limited to the lower limbs, but also affect the upper limbs and this could make using the mouse and keyboard difficult for such people. Alternative input devices such as joysticks could be used. To make "reasonable adjustments", higher education institutions will need to provide tables that are accessible using wheelchairs as well as ramps, where this is needed.

Research into building systems for people with mobility difficulties is on-going in the European Union (EU). The EU funded project ASK-IT (Ambient Intelligence System of Agents for Knowledge-based and Integrated Services for Mobility Impaired users) uses semantic web enabled services to support and promote the mobility of mobility impaired people. This is done by enabling the provision of personalized, self-configurable, intuitive and context-related applications and services as well as facilitating knowledge, content organization and processing [8].

3.4. Hearing Impairment

Hearing impairment refers to the loss of hearing in one or both ears, which could be complete or partial. WHO [9] estimates the number of people with such impairments worldwide in 2005 to have been about 278 million. In using information and communication technology, people with hearing impairments will have specific requirements such as captioning for video and audio. System designers thus need to incorporate the needs of such people into their design.

The semantic web also has the potential to offer solutions to problems faced by people with auditory impairments through applications that could aid hearing. In a higher education context, services offered online for disabled students need to consider the need for non-audio alternatives. A personalized system which recommends services to such students will need to provide mainly visual information as audio resources might be irrelevant in this case.

3.5. Specific Learning Difficulties

Specific learning disabilities cover a wide range of difficulties including dysgraphia (difficulty with writing), dyspraxia (motor difficulties) and dyscalculia (difficulties with mathematical calculations).

Given the increasing occurrence of learning difficulties amongst students in higher education, an inherent trend giving the drive for wider participation, it is worth seeking various solutions that can enhance their learning and access to specific services. Current research has shown that the semantic web could offer solution to the problems faced by disabled people through personalization [10] and increased accessibility [11, 12]. In education, semantic technologies such as ontologies could be used to develop applications that will support dyslexics in their learning. Schmidt & Schneider [13] and Tzouveli, et. al., [14] have developed an adaptive reading assistance for dyslexic learners using semantic web technologies. This application has been developed for pupils, but in a higher education context, the requirements and application may be different.

4. Assistive Technologies for Disabled Students

Assistive technologies have provided one of the main means of including disabled students in education. When used with computers or the web, disabled students could have more access to online information. This section will examine some assistive technologies used to enhance access to information for disabled students.

4.1. Screen Magnifiers

Screen magnifiers are used by people with low vision to increase the size of content displayed by the screen and to focus on desirable areas of the screen. Students with visual impairments can use these to aid their reading of learning materials online or in print form. Much research has been done on screen magnifiers; for instance, Blenkhorn, et. al., [15] presented the architectures of some screen magnifiers and note two approaches to implement screen magnifiers on Windows systems thus: driver-and system-based magnification. Zhao, et. al., [16] used some principles in visual search theory to design and develop a screen magnifier and recommended the use of a yellow background for a magnifier when the text is black.

As screen magnifiers mainly magnify information to visually impaired people, they may not have a similar accessibility problem as those encountered by screen readers.

4.2. Screen Readers

Screen readers are used by blind people to read text-based content. This is some form of text-to-speech software. As Freitas and Kouroupetroglou [17] have already expounded on screen readers and other speech-enabled devices, we will not dwell so much on that. Students with very low vision or who are blind can use screen readers to read online content. In a phone survey amongst 80 visually impaired people in Turkey, Bengisu [18] found that screen readers were the most used assistive technology. Screen readers browse through websites and when they encounter an image, they read the description contained in the ALT or LONGDESC attributes of the IMG tag. However, when no description is provided or in the case where such description is incorrect, the visually impaired person using a screen reader may not be able to understand the description of the image. A setback of using ALT or LONGDESC is that the ALT attribute only provides a short description of images while LONGDESC which could provide a longer description is not supported by some browsers and assistive technologies [19]. This calls for the use of cutting edge technologies such as web ontologies to comprehensively describe images for assistive technology interoperability and interpretation to visually impaired people.

4.3. Screen Keyboards

Screen keyboards (Figure 1) enable people who cannot use standard keyboards to select keys usually by using a pointing method such as pointing devices or switches. Advances have been made in keyboard development with new developments such as the Touch Display Keyboard [20] which is an interactive touch display. This could be easier to use by people with upper limbs mobility difficulties. Kwon, et. al., [21] produced a prototype screen keyboard and used two females and ten male subjects without work-related musculo-skeletal disorders to compare the performance and subjective ratings of a conventional finger touch entry text method and a regional error correction method. Their results revealed that error correction was a better method for both performance measures and subjective ratings.

4.4. Screen Reading Software

Speech recognition is software which enables people with mobility difficulties to manipulate computers with their voices rather than using a mouse or keyboard. In an educational context, Demenko, et. al., [22] used speech recognition to train in foreign language pronunciation and prosody, a positive way of employing such technology in computer assisted learning [23] and has been shown to improve word recognition and reading comprehension [24]. Speech recognition software have been further developed to achieve a high degree of accuracy with McHenry and LaConte [25] achieving 12% errors for a synthesized speaker compared to 36% for a native Greek speaker. For people with mental health difficulties, Derman, et. al., [26] note that speech recognition may be useful in mental health documentation as six of twelve physician participants preferred using speech recognition for creating electronic progress notes.

5. The Difficulties of Inaccessible e-learning Systems

Higher education institutions face inaccessibility problems when delivering learning and its related services. Although much has been done in making the physical environments accessible to students with disabilities such as provision of lifts, ramps, wheelchair access and support workers, just to name a few, much of this accessibility is not being translated into the digital environment, resulting in a digital divide for students with disabilities [27].

For some students with some form of impairments such as dyslexia and dyscalculia, studying could be a great challenge, necessitating the use of assistive technologies to facilitate learning. The high cost of assistive technologies may not be affordable by some disabled students, thus excluding them [28].

Students with visual impairments appear to be more disadvantaged than students with other disabilities [29]. This is not surprising as has been found that such people face much difficulties accessing information online due to inaccessibility [30].

6. Recommendations for Inclusive e-learning

An ontology-driven e-learning system (ONTODAPS) was developed and evaluated both heuristically by experts (lecturers) and some students (disabled and non-disabled). After ethical approval, thirty disabled students participated in the evaluation and their recommendations for designing disability-aware or inclusive systems are herein presented. The disability type of the disabled students who participated in this study is represented in Figure 1.

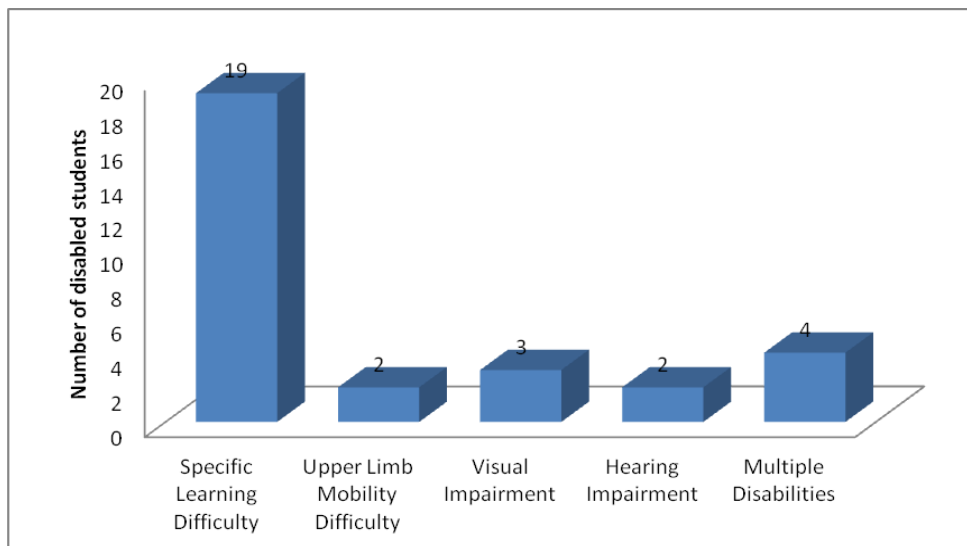


Figure 1. Distribution of Participants' Disability Type

By carrying out the evaluations with both disabled and non-disabled students and observing their interactions with the e-learning system as well as listening to their opinions on designing inclusive learning environments, the following recommendations were obtained.

6.1. Designing for Visually Impaired Students

Whilst interacting with ONTODAPS, some visually impaired students first sought to change the font type, face and size of the interface. This reveals an inherent need to be able to have flexibility and control over an e-learning system. Thus, disability-aware e-learning systems need to be flexible enough to allow users to change their look and feel to suit their disabilities. In this age of Web 2.0, such ability becomes even more relevant for e-learning systems, given that most web users are now able to drag and drop components from one place to the other to suit their needs. The need to control the look and feel was also observed amongst students with specific learning difficulties such as dyslexia.

The contrast between the font and the background could determine if such students will be able to quickly consume and assimilate the information.

Interfaces for students with severe visual impairment also need the inclusion of a screen reader which reads out information to the student. Where this is included, some students stated that they want to be able to control the speed, being able to also stop and pause it or to turn it off. The inclusion of a screen magnifier is also needed for students with low vision who may rely on a magnification of the text in order to view information.

6.2. Designing for Hearing Impaired Students

Some students with hearing impairments preferred text-based information. This could be understood as they cannot rely on the sense of sight to listen to audio-based learning resources. Prior to interacting with the ONTODAPS graphical user interface, the students were given a tutorial on the system. They had the choice of accessing the tutorial in either text, audio or video format. It is not surprising that the two students with hearing impairment who participated in the evaluation preferred a text-based tutorial format.

The ability for an e-learning system to convert audio and video into text would be a welcomed addition for the benefit of students with hearing impairments who may not benefit from text or audio resources without transcripts. In the case where audio and video need to be included, transcripts and/or subtitles should be included.

6.3. Designing for Students with Multiple Disabilities

Whilst most designers design for people with single disabilities, there are some students who present with two or more disabilities, making it difficult for designers to fully understand their needs. However, during the evaluation of ONTODAPS, some students with multiple disabilities gave their input on designing inclusive e-learning systems. One of these students had both hearing impairment and wore hearing aids and also had reading difficulties. To cater for her reading difficulty, this student had to highlight the text because the ONTODAPS system at the time did not provide any means to change the background color. Without highlighting the text to provide sufficient contrast, she could not read the information. To compensate for her hearing difficulties, she preferred text-based information to audio or video. Responding to how learning environments could be designed to include her needs, she had this to say:

“The way that learning environments could adapt to my learning disabilities and hearing difficulties would be if I can change the text and the background color so that the text is much clearer for me to read”

She thus ruled out the need for any audio or video, preferring text with the ability to control how the text is presented. This is very important if she would understand the information presented.

6.4. Designing for Students with Specific Learning Difficulties

Most of the participants with specific learning difficulty such as dyslexia preferred resources in audio and video formats. Nevertheless, when allowed to choose which format to access the tutorial, some chose text while others chose video, none of them preferring to listen to the audio tutorial. It is noteworthy that video formats could be very helpful for those with moderate to severe learning difficulties while those with mild learning difficulties readily chose text formats as shown in Figure 2.

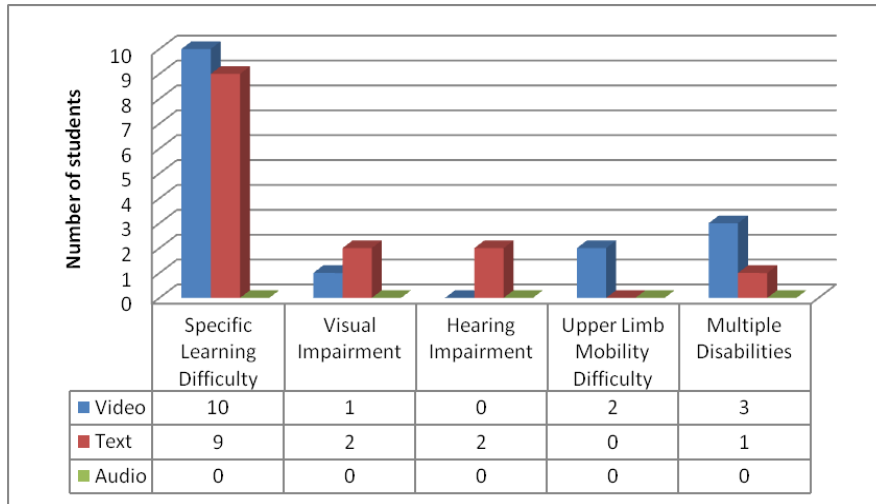


Figure 2. Disabled Students' Preferred Format of Accessing Learning Resources

It is important to include multiple formats of learning resources for learners to choose their preferred format. Some participants during this study found that such multiple formats allow them to check a different media format if they failed to understand a topic as it will help them double check information. Additionally, some students indicated that these multiple formats are still very good for those without disabilities because they may have different learning styles.

Some students with dyslexia suggested that learning environments should contain a good help menu so that they could always refer to it when they have any difficulties with the environment. This help menu will be very useful if it also contains such help information in multiple formats to meet the needs of various learners.

6.5. Granting User Control

To sum it all up, in this age of social media and Web 2.0, learners want the ability to control the learning environment by being able to personalize it. One way to do this could be for them to drag and drop things around, add or remove features they do not need.

Users interacting with the ONTODAPS system mainly liked the personalization it offers in terms of aggregating learning resources and presenting them in formats that are suitable for their specific needs. They thus recommended that online learning environments should provide this possibility of personalizing modules and their learning resources in addition to presenting such resources in multiple formats.

Some of the participants indicated the need for communication features such as chat facilities so that they could readily contact lecturers when doing an assignment. This need was expressed by some with dyslexia who needed guidance on their choice of reading materials.

7. Conclusion

This paper has examined some disabilities facing students in higher education and the assistive technologies utilized to compensate for their impairments. As most e-learning systems are not designed favorably to meet the needs of disabled students, the recommendations of disabled students on designing disability-aware systems were presented.

It is hoped that designers and developers of e-learning systems would turn to disabled students' recommendations in order to design more inclusive systems.

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