One for All and All for One: Making Engineering Learning Technology Accessible for All

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Abstract — As a result of the UK Special Educational Needs and Disability Act (SENDA) of 2001, UK education is no longer exempt from the Disability and Discrimination Act of 1995. SENDA came into operation in September 2002 making it unlawful for a university, or department to discriminate against a disabled person. With the increased use of learning technology within Engineering learning and teaching, it is essential to address the implications of SENDA with regards to the accessibility of a diverse range of learning technologies.

Across the engineering departments at Loughborough University a diverse range of learning technology materials are used to enhance student learning. These materials are delivered over the web, on CD/DVD, and via the university intranet and include electronic documents and presentations, HTML pages, commercial programming and simulation software. To ensure that the needs of students with disabilities were anticipated and responded to a review was carried out of the accessibility of learning technology materials used within engineering at Loughborough by the Engineering Education Centre. This paper details how the review was conducted including an audit of learning technologies and structured student interviews. Important outcomes from the review are also described.

The information collected from the review was used to develop an online guide for academics and content developers of engineering learning technology resources. The guide covers issues such as accessible media design, web repair, validation and filter/transform tools and assistive technologies.

The review into learning technologies and the production of the guide highlighted a number of important facets of developing accessible multimedia learning resources. One size does not fit all, different disabilities and different students with a similar disability do not have the same needs or the same preferences. Commercial software providers are increasingly providing new tools and features to make multimedia resources more accessible and it is important that academics and content developers are aware, and take advantage of these features. To ensure that a strategic and anticipatory approach is adopted towards accessibility, it is important to address it at the curriculum design stage and embed accessibility review within quality assurance approval procedures for programmes and modules.

Index Terms — accessibility, learning technology, SENDA.

BACKGROUND

The UK Special Educational Needs and Disability Act
As a result of the UK Special Educational Needs and Disability Act (SENDA) of 2001, UK education is no longer exempt from the Disability and Discrimination Act (DDA) of 1995. SENDA came into operation in September 2002 making it unlawful for a university, or department to discriminate against a disabled person. "The principle behind this legislation is that disabled people should have the same opportunities as non-disabled people to benefit wherever possible from whatever education or other related provision is available" [1].

The UK Learning and Teaching Support Network for Engineering have produced a guide to working with students with disabilities which outlines the implications of the act [2]. SENDA applies to any student or prospective student who is classified as disabled according to the definition in the DDA. There is a broad definition of the word disabled in UK Higher Education covering specific learning difficulties such as dyslexia and dyspraxia, blindness or deafness, mobility difficulties, invisible difficulties, diabetes, epilepsy, asthma and long-term conditions (for example, multiple sclerosis back difficulties, mental health issues). In this paper the term 'disability' can cover any of these and is used in the widest sense.
The Act makes it unlawful for a university, or department within the university, to discriminate against a disabled person in admissions and in the provision of services provided wholly, or mainly, for students. This includes all aspects of teaching and learning (including field trips, site visits and laboratories) and assessment.

Institutions are required to take positive steps to make their education and other related services accessible to disabled students. In particular there is a requirement to be ‘anticipatory’ with regard to the needs of disabled students. This means that a department or institution should be continually reviewing its policies, procedures and practices to ensure that the needs of a disabled person can be met, if and when they apply. Examples of this would be to ensure that course materials are in electronic form so that they can be easily transcribed should this be required, and to ensure that web based materials are made accessible to students who use screen readers. Failure to anticipate the needs of a disabled student may damage a defence against any allegations of discrimination. A department will need to ensure that it has both anticipated the needs of a disabled student and that it has made ‘reasonable adjustments’ to ensure that a disabled student does not encounter discrimination. In seeking to secure equity and inclusivity in the treatment of all students with disabilities, departments must ensure that changes in practice and provision are applied consistently to all students, including those already registered.

With the increased use of learning technology within Engineering learning and teaching, the need to address the implications of SENDA with regards to the accessibility of a diverse range of learning technologies is essential.

**Institutional implications of the act**

A number of initiatives already exist at Loughborough University to improve access and support for students with disabilities. These include a Disabilities and Additional Needs Service who provide guidance, support and information for students throughout their studies. A number of assistive tools are also available at the library.

Within the University, the range of student disabilities is diverse. Each department is actively seeking to achieve a more inclusive approach to help all students with disabilities reach their full potential and to remove the risk of complex appeals processes that would almost certainly arise out of any failure to meet the requirements of SENDA. To this end, a Co-ordinator has been appointed who is responsible for facilitating cohesion within the engineering departments. In addition, each department has appointed a Disability Co-ordinator.

Loughborough has one of the largest engineering Schools in the UK, consisting of six engineering departments. Across these departments a wide range of Information and Communication Technology (ICT) is currently being used, and new learning and teaching software is continually being developed or purchased and integrated into the curriculum. To ensure that these resources do not disadvantage students with disabilities an audit of current ICT provision to engineering students at Loughborough was undertaken followed by an investigation into methods of improving accessibility.

The Engineering Education Centre at Loughborough University has a remit to support academics with learning and teaching issues in all engineering departments, as well as develop innovative learning technologies to enhance engineering education. The accessibility of a range of ICT teaching resources within engineering modules and programmes at Loughborough have therefore been reviewed by the Engineering Education Centre. The following sections describe the Centre's experiences.

**METHODOLOGY**

A review of the accessibility of Information and Communication Technology (ICT) within engineering education at Loughborough University was conducted to identify and audit ICT learning resources that are incorporated into the curriculum. In addition, it was intended that the outcomes from the audit should form an online resource for staff within the engineering departments and Engineering Education Centre that includes a guide to best practice in developing ICT learning resources. It was also intended that the review would raise general staff awareness of SENDA and it's implications to the accessibility of computer-based learning resources.

Within the review additional contact with the Disabilities and Additional Needs Service and liaising with colleagues at other Universities and institutions was extremely valuable. A large range of staff development activities were available such as the attendance of internal workshops, on SENDA legislation and assistive technologies.

For ICT teaching materials there is a wide range of useful online resource which were investigated and includes guides and resources on SENDA legislation, implementation of commercial software, web validation, repair and filter/transform tools and assistive technologies.

Particular emphasis within the review was placed upon the student experience and an audit of current ICT use:

**Student interviews**

The interviewing of engineering degree students with disabilities was essential to the accessibility review. These interviews involved obtaining their opinions on the different types of technology that had encountered to date within their course. The interview took a structured form so that we could contrast issues for different students, for example what types of software
they had used within their course, what difficulties they had in accessing the materials, whether they had their own personal computer or laptop etc. Each interview concluded with a general question on recommendations that they had for increasing the accessibility of ICT in the engineering departments, which could be fed back to the relevant staff and used to improve new and existing resources.

**Software audit**

A list of external software used within each course was provided by the departmental IT co-ordinator. A record of Intranet based Computer Aided Learning (CAL) usage was also obtained from central services staff. These records were used to identify current Loughborough University learning and teaching software in engineering. The audit identified a wide range of ICT teaching materials which included extensive web-based resources, external software, intranet delivered Computer Aided Learning (CAL), Portable Document Format (PDF), Computer Aided Assessments, CD-ROM, Microsoft PowerPoint presentations and the university Virtual Learning Environment (VLE). As the responsibility of accessibility lies with the individual accountable for implementing that type of resource and within the VLE it is the responsibility of each academic to develop and maintain their own individual module pages, the need to develop best practice guidelines for each type of resource was essential.

**OUTCOMES**

The review of accessible learning technology for engineering at Loughborough University identified a wealth of issues and resources. The key points that arose are:

**Student feedback**

The SENDA disabilities act is very inclusive covering a wide range of disabilities. Students with a range of disabilities were interviewed and a range of issues and solutions identified. It was clearly evident that the solutions were very individual to the disability and the student, e.g. adapting materials to meet the additional needs of a blind student does not automatically meet the needs of a partially sighted student. Similarly, every student with dyslexia has a different pattern of difficulties, e.g. some students with dyslexia find the glare of a white computer screen uncomfortable, this can be improved by changing the monitor background settings to filter the screen, however different coloured backgrounds are necessary for different users. Preferred colour settings can also change over time for the individual.

Our experiences highlighted a number of important issues that need addressing in order to improve the accessibility of ICT within engineering education at Loughborough. It is important that students with disabilities should be able to change the administrative settings on any machine they may have to use as part of their studies. Traditionally, administrative settings in shared computer laboratories are locked down to maintain a standard desktop and for ease of set-up and maintenance. This poses difficulties for students with disabilities, for example dyslexic students or partially sighted students who require the size of menu fonts to be enlarged. Two approaches can be adopted to resolve this issue: a 'roaming profile' which restores preferred settings on log-in, or reserving an appropriate number of computers in each laboratory for students with disabilities that have permission to modify settings.

Further details of specific software and media issues are described below. The outcome from interviewing the students will be a set of recommendations that will feedback to the relevant engineering department or centre.

**Existing SENDA resources for ICT and implications**

There is a wealth of online resources that give legal and practical advice on the UK SENDA disabilities act. For example, within the UK, the JISC service TechDis [3] supports the further and higher education community in all aspects of technology in relation to disabilities and/or learning difficulties. TechDis have developed a range of online guides and resources for supporting students with disabilities, such as "Accessible Curricula, Good Practice for All" [4]. In conjunction with the Association for Learning Technology (ALT), TechDis have produced "Access All Areas: disability, technology and learning" [5] a valuable text that contains advice and case studies relating to many aspects of the learning process in relation to students with disabilities.

The Learning Teaching Support Network (LTSN) Engineering Guide: Working with Students with Disabilities [2] breaks down the terminology used within the Act and discusses how the legislation will affect the provision of learning and teaching. The LTSN guide provides an overview of the Quality Assurance Agency precepts and covers all aspects of accessibility from the student application process through teaching and learning to evaluation and assessment. It places emphasis on planning ahead, making facilities accessible and developing suitable teaching and learning resources that could be of benefit to all students.

Numerous other resources exist, and are included in the online guide that we have developed for staff, discussed in more detail below.
Software accessibility recommendations

The purpose of a software audit was to determine the types of technology being used in engineering education and provide resources and guidelines to support staff developing and using similar types of technology as part of their teaching. The accessibility of the software was variable and dependant upon many factors including whether it had accessibility features incorporated by the manufacturers (this is increasingly common in the case of external software companies) and also the age and version of the software.

- The range of web based learning resources was wide, and varied from resources provided by central support service such as the library and computing services to resources provided by academic staff located on the University's own Virtual Learning Environment (VLE) known as 'Learn'. Computing Services have ensured that Learn can be accessible by checking that all of the standard pages conform to W3C html standards [5]. However as academic staff are responsible for their own module content, it was essential that accessibility of existing resources was reviewed and that guidelines were produced on developing web-based learning materials. The guidelines are described below in 'Web accessibility recommendations'.

- A large proportion of learning resources in the engineering departments exist in web-based format (HTML, XML). It is also common practice for academic staff to put learning resources online as PDF and/or Microsoft Word documents. It was suggested in the student interviews that PDF documents should also provided in either HTML or plain text versions, and that consideration was given to accessibility of any charts or graphs in the PDF file. Students also highlighted the preference for documents to be downloadable in Microsoft Word format so that they can change background settings, font sized etc as appropriate. Alternatively, there are resources that aid content creators in producing accessible content with Adobe software. For example, PDF documents are readable by blind people using access technology with the help of 'Access Adobe' [6]. Access Adobe translates PDF into HTML or into a text email, making it readable by someone unable to access PDF in the usual way.

- Microsoft PowerPoint was found to be a popular tool for giving lectures and providing electronically for students to download from the Internet after the lecture. One student stressed in the interviews that a good relationship between students and staff is essential in order to make resources more accessible. The student had attended a lecture delivered with the aid of PowerPoint where the font size had been too small and the background colour was inappropriate for their disability. The student promptly alerted the staff member, who immediately amended the presentation and made it available online. This example highlights the importance of effective communication between staff and students enabling the efficient remedying of any inaccessible material as quickly as possible. 'Accessible PowerPoint slides' is a tool that adds a new menu to Microsoft PowerPoint that allows existing presentations to be saved as accessible html presentations. This means that not only do students no longer need PowerPoint, but two versions of the presentation - text and graphical - are generated, with an opening page allowing the user to choose which to browse.

- For the case of external software, where manufacturers had ‘built-in’ accessibility i.e. had developed software to include accessibility features, the feedback from students was positive. It is interesting to note however that there are significant differences between student and staff versions of some types of software. For example, there are two versions of a technical computing language for handling matrices, a student version and a full version. The student version has the accessibility features, the feedback from students was positive. It is interesting to note however that there are significant differences between student and staff versions of some types of software. For example, there are two versions of a technical computing language for handling matrices, a student version and a full version. The student version has the administrative settings locked down, which prevents students from changing the settings to make it more accessible.

- The accessibility of CD-ROMS was completely dependent upon the authoring. As the purpose of the audit was to present best practice for future developments of similar media, guidelines were identified that supported appropriate applications for authoring CD-ROMS such as Macromedia Authorware. This software has built-in facilities to make text audible, run movies with captions and to create accessible user interfaces, menus, and quizzes. It can also automatically detect the text-to-speech facilities already installed in the end-user's computer, including JAWS screen reader [7]. Furthermore, built-in scaling allows developers to set up multiple image sizes for individuals with visual disabilities. An additional important aspect includes keyboard shortcuts that allow end users to move forward or return to the previous page by pressing a key instead of clicking navigational buttons. Individuals with various disabilities including visual disabilities can use this feature to replay content as needed through the keyboard. Many other features are available from the product accessibility web site [8]. It is of utmost importance that local software authors are aware of the accessibility issues and features of this type of software and incorporate them into new software and version updates.

Web accessibility recommendations

Tim Berners-Lee, W3C Director and inventor of the World Wide Web (WWW) stated, 'The power of the Web is in its universality. Access by everyone regardless of disability is an essential aspect'. With the wealth of resources online giving practical advice and guidance on achieving universal accessibility, our review of the WWW suggests that this can be achieved. The following are examples of some of the key resources on web accessibility.
• Useful web sites that provide guidance on designing accessible web sites include the W3C Web Accessibility Initiative (WAI) [5]. The W3C WAI addresses the accessibility of the Web through a number of activities including ensuring that the technology of the Web supports accessibility, developing accessibility guidelines and co-ordinating tool development to facilitate evaluation and repair of Web sites. Macromedia have a 5-page Accessibility Test [9] for web sites, that includes sites with dynamically-driven content. The AWARE Center [10] is part of the HTML Writers Guild and another excellent source of information and resources, focussed on web accessibility. Other superb sources of information and resources on disability-related Internet issues sites include WebAim (Web Accessibility in Mind) [11] and WebABLE [12].

• Web validation, sometimes known as evaluation tools, perform a static analysis of web pages or web sites regarding their accessibility, and return a report or a rating. In the UK, it is thought that the most suitable accessibility standard to meet the requirements of SENDA is the AA standard, i.e. meeting all of the W3C WAI Priority 1 and Priority 2 guidelines. A number of validation or evaluation tools are available including the W3C HTML Validator [13] that is a free service that checks documents like HTML and XHTML for conformance to W3C Recommendations. For a full comprehensive list of validation tools the W3C Web Accessibility Initiative guide is recommended [14].

• Once the accessibility issues with a web page or site have been identified, web repair tools can assist web authors in making the pages more accessible. A-Prompt is a Windows-based tool that, when installed on your PC, will check web pages against specified criteria, and repair pages that do not meet accessibility standards. For automated repairs, LIFT for Macromedia Dreamweaver [15] will check for compliance with accessibility guidelines and identify problems on web sites, as well as helping to fix any problems found while creating new pages or retrofitting existing sites. For a fully comprehensive list of repair tools refer to the W3C Web Accessibility Initiative guide to repair tools [16].

• Web filter and transform tools assist web users rather than authors to either modify a page or supplement an assistive technology or browser. Some of these tools integrate into the browser although most of them work by proxy using a piece of software that sits between the user and the target server to transform a page to make it more accessible. In some cases the tools are designed for users to enhance their personal setup, in other cases they are for content providers to provide content that is particularly optimised. For a fully comprehensive list of filter and transform tools, the W3C Web Accessibility Initiative guide to filter and transform tools [17] is an excellent source.

**Assistive technologies**

According to the European Commission's Technological Initiative for Disabled and Elderly Persons [18], "assistive technologies are the total of technologies provided directly to elderly and/or disabled people to enable them to live more independent lives and become integrated in all the activities of their communities". In the context of ICT for learning and teaching there is a range of assistive technology such as screen readers, screen magnifiers, voice recognition software and voice aids, single switches, adaptive keyboards and alternative input devices. Our interviews identified use of the following by our students:

• Screen readers are designed for people who are blind or visually impaired to assist communicating information on a computer screen back to the user. One way of doing this is with text-to-speech software such as JAWS [7]. An alternative way would be to use hardware such as a refreshable Braille display, in other words a display that uses pins that move up and down to spell out words in Braille. The latter is the primary means of access to computers for users who are deaf-blind.

• Screen Magnifiers are designed for people with vision impairments. This type of software enlarges the screen image many times and permits the user to change the default colours of the display, for example, by using reverse video to provide better contrast where necessary. For definitions of the remaining types of assistive technology Macromedia.com [19] is a valuable source that also includes a section on design issues relating to their use.

• TextHelp Read and Write is assistive technology software designed to provide additional assistance to computer users with dyslexia. Loughborough University has made TextHelp Read and Write software available in a number of laboratories on campus and offers it to students to install on their own PC’s and laptops. A dyslexic student noted that there are limitations to the software as it can only read plain text Portable Document Format files and not images, however they also felt that it was the best software of its type as alternatives require the cutting and pasting of text.

**PUTTING IT INTO PRACTICE**

The purpose of the SENDA legislation is to enable disabled people to gain access to learning opportunities. In achieving this, it is not expected that academic standards should in any way be compromised. Course leaders and course developers need to be precise on what is, and what is not, a core element or aspect of a programme, so that they can assess where adjustments to teaching practices may be introduced. Wherever possible courses and teaching practices should be accessible by design, so that only minimal adaptations need to be made for individuals. This also will help in complying with the "anticipatory" aspect
of the Act. It is important to review whether course validation procedures consider the accessibility of new programmes. Programme specifications need to be reviewed to ensure they include no unnecessary barriers to access by disabled people, and staff must determine the core elements of a course and where adjustments may, or may not, be made.

With increasing time pressures on staff it is important that they can address these issues in an efficient and logical manner. Access to all learning resources is essential to students, including online materials and so wherever possible these need to be accessible by design. Where possible check lists can be used to provide guidance, for example the following is provided for staff developing additional resources to support lectures:

- Have booklists been provided sufficiently in advance for a student to obtain texts on tape or in Braille?
- Are paper-based materials available in Braille, large print or online?
- Do online learning resources comply with World Wide Web Consortium (WC3) guidelines?
- Are workstations with enabling technologies available?
- Are electronic materials (such as Java applets) accessible?
- Can appropriate alternative materials be provided (e.g. a plain text document as well as PDF)?
- Do learning technology materials allow students to go at their own speed or take rest breaks?
- Can users of assistive technology (such as screen reading software) access the resources?
- Have video materials been provided with subtitles, interpretation or transcripts?
- Is the layout and structure of your online materials suitable for students with dyslexia or with partial sight?
- Do sound clips and other audio materials have text alternatives or sub-titles?

This paper has described the approach adopted within engineering at Loughborough University to audit and improve the accessibility of online computer based learning materials. These outcomes are being used to facilitate good practice within our engineering departments.

A good practice guide on developing computer-based learning resources for engineering education was produced in light of the UK SENDA disabilities act and incorporated into the Engineering Education Centre’s web site [20]. The aim of the guide is to assist engineering staff at Loughborough in the integration and development of computer based learning materials that are accessible for all, with a section devoted to the key accessibility areas identified:

- What is SENDA?
- Learning technologies
- Accessible web design
- Web validation, repairs and filter/transform tools
- Accessible media design
- Assistive technologies
- Embedding within learning and teaching strategies
- Glossary of acronyms and terms

Conclusions

In light of new SENDA legislation, all UK institutions are required to take positive steps to make their education and other related services accessible to disabled students. There is a requirement to be ‘anticipatory’ with regard to the needs of disabled students. This means that a department or institution should be continually reviewing its policies, procedures and practices to ensure that the needs of a disabled person can be met, if and when they apply. With the increased use of learning technology within Engineering learning and teaching, the need to address the implications of SENDA with regards to the accessibility of a diverse range of learning technologies is essential.

In carrying out an audit or review of accessible provision of ICT within engineering education, the views of the students are of paramount importance. A wealth of existing guidance and resources already exists both online and in publications and should be utilised to avoid unnecessarily repeating work. Software providers are increasingly supplying additional information on accessibility of their products and providing new tools and features to make multimedia resources more accessible and it is important that academics and content developers are aware, and take advantage of these features.

The review into learning technologies and the production of the guide highlighted a number of important facets of developing accessible multimedia learning resources. One size does not fit all, different disabilities and different students with a similar disability do not have the same needs or the same preferences. To ensure that a strategic and anticipatory approach is adopted towards accessibility, it is important to address it at the curriculum design stage and embed accessibility review within quality assurance approval procedures for programmes and modules.
REFERENCES

[1] Disability Rights Commission, Draft Code of Practice (Post 16), Section 1.2