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Meeting the needs of disabled students in online distance education – an institutional case study from The Open University, UK

For the journal: Distance Education in China

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Abstract

This paper reviews the evolution of the access provision and support for disabled students studying at The Open University (OU) in the UK. It is intended as a case study from which other institutions offering distance learning can draw. The paper introduces the OU context and recounts the history of the development of provision for disabled students since 2000; that is, over the period that distance education has moved increasingly online. The educational, social justice and legal drivers for this are considered. A detailed description is given to a cross-university programme called “Securing Greater Accessibility (SeGA)” instigated in 2010 that has sought to co-ordinate the various activities and clarify responsibilities for accessibility across the institution. SeGA has sought to embed accessibility in business-as-usual practice and not consider provision for disabled students as a bolt-on extra. A summary is made of some of the guidance developed by SeGA on making online teaching and learning accessible to all, including students with disabilities. A brief note on current research activities at The Open University relating to accessibility is given.

Keywords: distance education, accessibility, disabled students, policy and practice

1 Introduction

This paper considers accessibility, in the sense of ensuing access for disabled people, to online teaching and learning. It draws extensively on the experience of The Open University where the author has been based since 1998.

1.1 Overview of Open University, UK

The Open University (OU) was one of the world’s first dedicated distance teaching universities founded in 1969 and is now one of Europe’s largest educational establishments, as judged by student numbers. The Open University is a “Mega-University” as defined by Sir John Daniel [1], a former vice-chancellor of the university. It currently has over 240,000 students, with more than

19,000 disabled undergraduate students (12%). It has approximately 1,000 PhD students (mostly conventional not distance learning) and delivers its teaching and learning through a network of about 7,000 tutors (known as Associate Lecturers). It has developed a model of open and supported distance education that has enabled many, otherwise denied a higher education to reach their educational goals. It is called 'Open' because there are no educational pre-requisites to begin studying with the OU. The Open University has always used current technologies and from its early days made extensive use of television and radio programmes; although much of its teaching and learning was print based. Since the late 1990s the Internet has been increasingly core to its educational offering and pedagogies have evolved with the arrival of the new tools the Internet brings. The move towards online education has brought increased opportunities for some disabled students but created accessibility challenges for others.

The OU is also a research university in the conventional sense but has a world-wide reputation for its research in distance education and the use of diverse media in teaching and learning¹. This includes being a world leader in research in various aspects of accessibility.

2 Models of Disability - What is Accessibility?

Disabilities have traditionally been described with reference to the medical conditions from which they were seen to arise. This is known as the medical model of disability, encapsulated in the influential international classification of impairments, disabilities, and handicaps produced by the World Health Organisation (WHO) in 1980 [2], which included the following definitions:

Impairment = a loss or abnormality of physical bodily structure or function, of logic-psychic origin, or physiological or anatomical origin

Disability = any limitation or function loss deriving from impairment that prevents the performance of an activity in the time-lapse considered normal for a human being

Handicap = the disadvantaged condition deriving from impairment or disability limiting a person performing a role considered normal in respect of their age, sex and social and cultural factors

The main alternative to the medical model of disability is the social model. This has been highly influential, over the last 30 years, in shaping policy, practice and attitudes. The social model stems from the publication in 1976 of 'Fundamental Principles of Disability' by the Union of Physically Impaired against Segregation [3]. This document revolutionised understanding of disability, arguing that its main causes are the ways in which society is organised and responds to disabled people, rather than physical or mental ability.

In the social model, disability is caused by the way society is organised and is therefore neither the 'fault' of individuals, nor an inevitable consequence of their limitations. Disability is the product of the physical, organisational and attitudinal barriers present within society. This model of disability views disabled people as part of an economic, environmental and cultural society.

¹ See: <http://www.open.ac.uk/research/main/> (accessed 18-05-14)

The WHO revised its definitions of disability, in part as a response to this social model, and in part due to the realisation that the medical model was of very limited use in defining effective responses to the needs of disabled people. In 2001 it published the 'International Classification of Functioning, Disability and Health' (ICF), describing disability as:

the outcome or result of a complex relationship between an individual's health condition and personal factors, and of the external factors that represent the circumstances in which the individual lives [4]

Building on the social model, the IMS Global Learning Consortium offered more education-specific definitions of both disability and accessibility when introducing its work on the development of technical standards for accessibility in e-learning:

[...] the term disability has been re-defined as a mismatch between the needs of the learner and the education offered. It is therefore not a personal trait but an artifact of the relationship between the learner and the learning environment or education delivery. Accessibility, given this re-definition, is the ability of the learning environment to adjust to the needs of all learners. Accessibility is determined by the flexibility of the education environment (with respect to presentation, control methods, access modality, and learner supports) and the availability of adequate alternative-but-equivalent content and activities. The needs and preferences of a user may arise from the context or environment the user is in, the tools available (e.g., mobile devices, assistive technologies such as Braille devices, voice recognition systems, or alternative keyboards, etc.), their background, or a disability in the traditional sense. Accessible systems adjust the user interface of the learning environment, locate needed resources and adjust the properties of the resources to match the needs and preferences of the user [5]

The term 'accessibility' is widely used in the context of web design. This is particularly pertinent to this paper because the World Wide Web is now pervasive in education. The W3C, the International Web standards body, describes accessibility thus:

Web accessibility means that people with disabilities can perceive, understand, navigate, and interact with the Web, and that they can contribute to the Web. [6]

This view of accessibility is, in essence, based on a functional model of disability. Generally, in Human Computer Interaction (HCI), a functional approach is most useful. This is because what is important in the design of Web-based applications or content is how the diversity of users access the computer. A design can be said to be accessible if it facilitates full interaction by all users, irrespective of the assistive technologies or access approaches that may be adopted by some.

3 Why Accessibility?

The Open University's mission is to be "Open to *people, places, methods and ideas*" and they acclaim that they "... promote educational opportunity and social justice by providing high-quality university education to all". Equality and diversity have been part of core OU values since its inception. This includes extending higher education opportunities to people with disabilities. To be successful in this the university needs to ensure that its teaching methods and learning content are accessible.

Most if not all higher education establishments will have a similar social justice mission and many will be actively engaged in widening participation in higher education. Thus access for disabled students should be an agenda important to all universities and colleges.

In most developed countries there are legal drivers for accessibility too. In the UK the Special Educational Needs Discrimination Act (2001) (SENDA) [7] extended the Disability Discrimination Act (DDA) (1995) [8] to include the education sector from primary education through to higher education. This was a major driver to the education sector considering the needs of disabled students. The law has evolved since then and the legal context is now the Equality Act (2010) [9] which replaced the Disability Discrimination Act (2005) [10] and brought all anti-discrimination legislation (gender, sexual orientation, disability, etc.) into a single piece of legislation. In essence all these pieces of legislation put the same obligations on educational institutions:

- They must not discriminate against a disabled student on the basis of their disability
- They must make “reasonable adjustments” to meet disabled students’ needs in all aspects of their education
- They need to anticipate the needs of disabled students and not just address them on a case by case basis as they arise.

4 The Story of Accessibility at the Open University

The Open University made particular efforts to meet the needs of disabled students from its early days. For example, Tom Vincent devised a computer for the blind to be used in the OU’s educational delivery in 1979 [11]. The University has long provided alternatives to printed material including: comb binding for those who find manipulating a conventional book difficult; large print; and Braille (discussed in detail later in this paper). When computers became increasingly used in educational delivery particular efforts were made to make both the systems used for this (e.g. the Virtual Learning Environment (VLE)) and the content it mediated accessible. However, when this provision was reviewed in 2006 notable deficits were revealed. There were organisational challenges with diverse efforts by different units within the university largely operating in silos². Responsibilities were not clear and there was poor integration across units. The move to greater online delivery was presenting challenges. There was a diversity of practice sometimes leading to false expectations by disabled students who might experience good access provision on one course³ but then find a subsequent one not accessible to them. There were only a small number of people, including the author, with specialist knowledge about accessibility, who were thus unable to support *all* Module Teams.

This was the context for the initialisation of a cross-university programme called “Securing Greater Accessibility (SeGA)”.

² An English megaphone for different parts of an organisation working in isolation by analogy with agricultural grain stores that stand as separate storage towers called silos.

³ Note – the terms course and module are used inter-changeably in this paper. Historically the OU used the term course but in the last 5 years has moved to referring to units of study as modules within a programme of study towards a qualification. Thus Course Teams have become Module Teams.

4.1 The history of SeGA

The SeGA programme had a long gestation. There was a cross unit workshop in 2006 (led by the author) that identified key issues. In 2008 the Director (Students)⁴ sponsored a management consultant to research the situation and write recommendations. A workshop discussing the conclusions of this management consultant was held in April 2009. SeGA Objectives were agreed in March 2010, and then revised in November 2010.

The SeGA Objectives:

The agreed SeGA objectives are listed here:

- Clarification of responsibility and accountably
- Improved access to the curriculum for disabled student
- Improved understanding of staff roles and responsibilities
- Improved documentation of reasonable adjustments
- Reduced overall cost of adjustments
- Improved organisational knowledge of enabling accessibility best practice
- Improved visibility of the levels of accessibility afforded to students

Some activity followed but significant progress was only achieved when a SeGA project officer was appointed in June 2011.

5 Technical Accessibility

UK law is understandably not specific about what “reasonable adjustments” means in terms of accessibility of online offerings. However it is widely accepted that the Web Content Accessibility Guidelines (WCAG 2.0) [12], a formal recommendation of the web standards body the W3C, is the benchmark. This has been referenced in accessibility court cases to date. WCAG 2.0 comprehensively covers making online offerings technically accessible but this is only part of the picture in making online learning accessible to disabled students. WCAG 2.0 is notoriously difficult for non-specialists to interpret and apply. To address this The Open University has developed its own Web Accessibility Guidelines that re-frame WCAG 2.0⁵. Accessibility also has to be addressed at the teaching and learning level as well as the technical level.

6 Accessibility in Teaching and Learning

Accessibility is not just a technical issue, it needs to be addressed in the learning design; indeed the author, with others, has long advocated that standard learning design tools should support accessible design [13]. Accessible learning design essentially means ensuring that all the learning objectives can be met irrespective of any access needs a student might have whether these are associated with physical, sensory or cognitive impairments. This could range from simple matters as

⁴ A senior manager and part of the Vice Chancellor’s Executive in the university’s management structure.

⁵ The Open University Web Accessibility Guidelines are publically available at: <http://www.open.ac.uk/about/web-standards/standards/accessibility-standards/accessibility> (accessed 26/05/14).

ensuing that all figures and graphics are described so accessible to the visually impaired to the provision of alternative learning activities so that where interactive software that might not be accessible for some is deployed, the learning objectives can still be achieved another way.

7 Accessibility Across an Organisation

Accessibility requires an institutional-wide response. There are accessibility roles across a module life-cycle (as shown in the diagram below Figure 1). [Note - this diagram shows the situation prior to 2013. The OU is currently changing the way support is organised during the module presentation phase. However, the roles remain essentially the same but who undertakes them and their role titles are changing.]

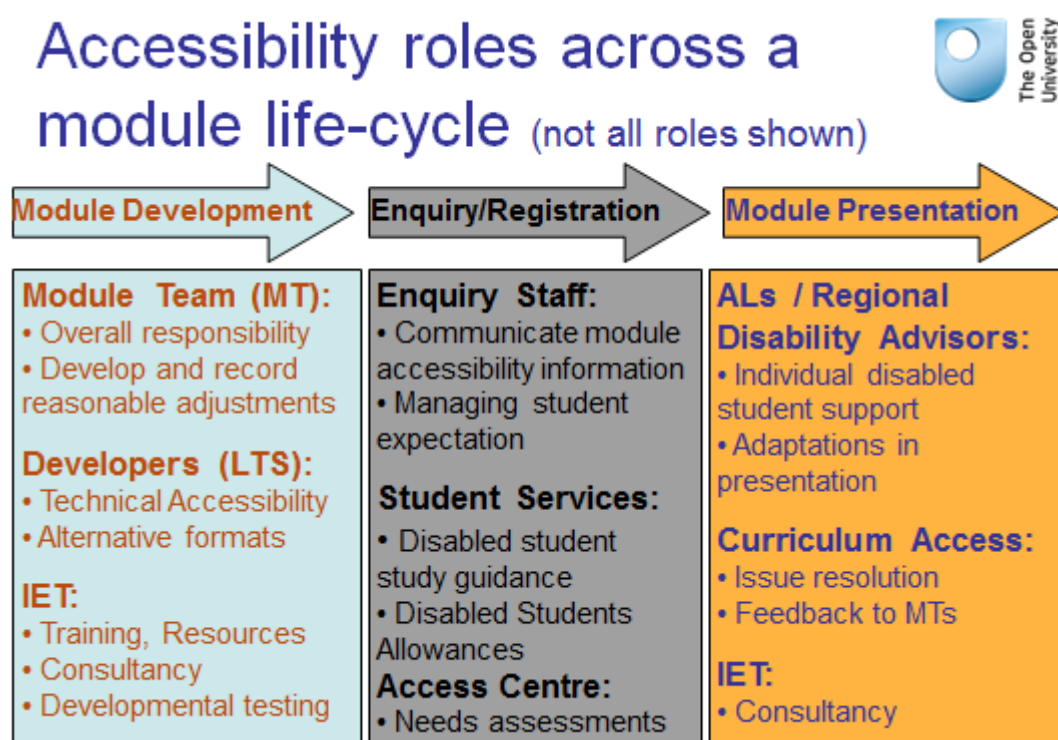


Figure 1: Accessibility Roles across the Module Life-Cycle

7.1 Accessibility in Module Development

It is essential that accessibility is addressed from the outset of the design of a course; it might even impinge on curriculum choices before any learning media are written. However, the key reason for this is that trying to address accessibility late in the development cycle or worse still in delivery inevitably leads to less effective and more costly solutions.

As expanded upon in Section 7.4, Module Teams are given the primary responsibility for accessibility. This is because the accessibility provision is directly linked to the teaching and learning. Module Teams at the OU are encouraged to appoint a member of the team to personally take on this responsibility. They need not have specialist expertise but have the role within the group to raise the question at any decision point: “Are there any accessibility implications here?”. The module team is also charged with recording the accessibility provision they make and known

challenges they become aware of as the course is developed. Module Teams at The Open University work with a central production and publishing unit called Learning and Teaching Solutions (LTS). It is LTS that is responsible for the technical accessibility in the media they develop or commission for the Module Team. There is often some negotiation here where LTS may advise the Module Team that a particular specification for a learning resource may create accessibility challenges and alternatives or modifications will then be reviewed. At this stage of the module life-cycle the Institute of Educational Technology (where the author is based) provides training, consultancy and undertakes developmental testing.

7.2 Addressing Students' Needs at Enquiry and Registration Stage

However a course is advertised to students, this needs to be accessible to ensure disabled students have equal access to information about it. So accessibility in marketing is an equality issue too but this is not discussed further in this paper. Beyond this additional information may need to be provided to disabled students to help them make good choices about individual courses and onward paths of study. Disabled students embarking on study at higher education level may need to be assessed and advised on access technologies and approaches that will enable them in their studies. The Open University has an Access Centre, which is part of a national network of such centres for undertaking this role.

7.3 Accessibility in Module Presentation

It is the Associate Lecturers (Tutors) that are the students' main point of contact with the University as they study their modules. It is thus they that are most likely to first recognise or have raised with them by the student any accessibility challenges. They are also in a position to put into place accessibility accommodations in many cases. They are supported in this role by a network of specialist disability advisors based in the OU's regions. For example there are advisors for mental health, visual impairment and dyslexia. When a problem arises that cannot be readily resolved it may be escalated to an Accessibility Referrals Panel (established by SeGA) which is made up of accessibility experts and those with expertise in anti-discrimination legislation. They advise on what would constitute a "reasonable adjustment" in each case and may direct the Module Team to make additional provision to meet the access needs of the student in question. In rare cases it may not be possible for the access needs of the student to be met on the module in question. Here the university will often advise on alternative routes of study but where this is not possible or acceptable to the student fees are reimbursed and compensation may be offered.

7.4 Rationale for Module Teams having overall responsibility for accessibility of modules

Fundamental to accessibility considerations in online education are the learning objectives. What one is seeking to make accessible is the learning, not just the technology used to deliver it. In some cases the appropriate response may be to offer an alternative activity to a particular online element in a course. In determining whether a particular accessibility approach is appropriate in a given case one must answer the question: does it enable the learning objectives to be achieved?

7.4.1 Module Accessibility Guides

We are now encouraging Module Teams to produce course specific Accessibility Guides. These document the accessibility accommodations the team design into the course and highlights activities that might be challenging to some disabled students and identifies what impact not undertaking

these might have on module assessment and what alternative activities may be undertaken instead. It is important to realise that accessibility may be best achieved for some students by alternative activities not through an accessibility response in the original activity – in other words there are fundamental limits to accessibility. An example to illustrate this: an Art History module may have an activity that involves a visual discrimination task to demonstrate the history of perspective in Western art. A blind person will never be able to perceive this and an alternative text based activity would be more appropriate covering either the same topic or more likely a different topic of equal merit in the context of the course. Note these Module Accessibility Guides supplement the general guides offered to disabled students⁶.

8 Accessibility in eLearning Infrastructure

Systems used to deliver teaching and learning need to be accessible as well as the content they mediate. The Open University maintains a Virtual Learning Environment (VLE) based on Moodle⁷. On initial adoption it invested a lot of effort in making this accessible and offered these developments back to the Open Source Moodle community. The university maintains a unit within the Institute of Educational Technology that tests for accessibility software under consideration for incorporation into teaching and learning. It uses heuristic task-based approaches and sometimes user-testing with disabled students for this [14]. The same approach is applied to systems developed in-house. The OU undertakes its own research and development of online learning tools as well as adopting these from third parties. Thus accessibility considerations are integrated into the processes of development or procurement impacting on the infrastructure tools that affect the offering of many courses. Where this is done well in it can reduce the load on those responsible for particular course elements in making those accessible. This is an area for continual improvement; there are known deficits. Where problematic for some disabled students every effort is made to address them in subsequent version updates. Where it is not possible to address the deficit, module teams and students are advised of work-arounds.

9 Alternative Formats

The OU has a long history of providing alternative formats to print e.g.: audio recordings for visually impaired and dyslexic students; comb-bound versions for students with some physical disabilities and more recently e-Books in DAISY⁸ or ePub⁹ formats. These may be used as means of achieving accessibility in online delivery however moving to online learning has reduced the requirement for some alternative formats. In recent years the move has been to mainstream the production of alternative formats. This has been achieved by the adoption of a standardised XML-based system for authoring (see Section 13.2). The XML thus generated can be readily transformed to specialised printed versions or electronic file versions such as DAISY or ePub.

⁶ The Open University produces guides called “Meeting Your Needs” covering different disabilities, available at: <http://www2.open.ac.uk/study/support/disability/publications>

⁷ See: <http://moodle.org/>

⁸ DAISY is an open eBook standard specifically designed with disabled users in mind, see: <http://www.daisy.org/>

⁹ ePub is an international open standard for eBooks, see: <http://idpf.org/epub>.

10 Assistive Technology used by Students

The OU operates an Access Centre (part of a national network) where disabled students can be assessed as to what computing approaches and assistive technology are best likely to equip them for their studies. Students that meet certain criteria qualify for government grants - Disabled Student Allowances to purchase this equipment; for others the university operates a limited loan scheme. A key unresolved issue is that there is no funding available for training in using this technology.

11 IET Roles Relating to Accessibility and Usability

The Institute of Educational Technology (IET), where the author is based, is a specialist unit of the Open University that as well as its own teaching and research roles, is particularly charged with supporting the other faculties of the university in the effective use of technology in teaching and learning. It has been core to the University's mission to make the best use of new technologies since the early days of the University's history. IET is a key repository of expertise in accessibility and continually updates this by internationally leading research in that field. It does this by unifying the themes of pedagogy, usability, accessibility and user centred design and evaluation. IET co-ordinates the SeGA programme for the University and thus acts as a nexus for all units with a role in meeting the needs of disabled students. It runs a staff training programme of Continued Professional Development for colleagues across the university. It undertakes internal and external consultancy advising other units and projects on how to best address accessibility challenges. It has a key role in developmental testing working closely with the developers on teaching and learning technologies by undertaking both expert evaluations, mostly using heuristic techniques and end-user evaluations [14]. IET runs a globally respected masters course on Online and Distance Education¹⁰ which includes a module on inclusive education¹¹.

12 Professionalism in Accessibility

The Open University was a partner in a major EU project called EU4ALL¹² than among many other things devised a framework for professionalism in accessibility as a way of classifying the efforts of universities in this regard. This framework has been discussed in detail in other publications [15] but is summarised here.

12.1 Introduction to EU4ALL

The EU4ALL (European Unified Approach for Accessible Life Long Learning) was a major European Commission funded project under the eInclusion Section. It ran from October 2006 to March 2011. The project developed a conceptual and technical framework principally to enable higher education institutions to make their teaching and learning more accessible to disabled students. This included an approach to Content Personalisation for accessibility and a range of eServices. The first year of

¹⁰ MA in Online and Distance Education (MAODE), see:
<http://www.open.ac.uk/postgraduate/qualifications/f10>

¹¹ H810 Accessible online learning: supporting disabled students, see:
<http://www.open.ac.uk/postgraduate/modules/h810>

¹² See EU4ALL web pages: <http://eu4all-project.atosresearch.eu/>

the project consisted of extensive background research part of which formed the basis of the model cited below.

12.2 EU4ALL 4-Stage Model

The project developed a 4-stage model of professionalism in accessibility against which universities could be classified as to what level they were achieving in meeting the needs of disabled students through good accessibility practice. This model was used in the research of the project on the state of European universities with respect to accessibility provision [16] and subsequently in consultancy both with the OU and with other universities. It has proved helpful for institutions to make an assessment of their current status and in setting goals for improvement. It is recommended that readers of this article use this in assessing provision at their own institutions.

| <div> <div>Intervention</div> <div>Institutionalisation</div> <div>Professionalisation</div> </div> | | | |
|--|---|---|---|
| Low level of accessibility practice (T1) | Medium level of accessibility practice (T2) | Substantial level of accessibility practice (T3) | Outstanding level of accessibility practice (T4) |
| <ul style="list-style-type: none"> - Responsibility and roles unclear, ambivalent - Low awareness of senior management - Low level of accessibility practice - Weak legal frameworks | <ul style="list-style-type: none"> - Low awareness and responsibility of management, accessibility no priority - Considerable activity for SWD by single persons - Existing practice not institutionalised - Ad hoc solutions to ad hoc problems - Weak legal frameworks | <ul style="list-style-type: none"> - Responsibility of senior management clear, accessibility a priority - CoP existing with high level of institutionalised processes - Strong legal requirements | <ul style="list-style-type: none"> - Responsibility clear - High priority of accessibility - Institutional processes (CoP) and stakeholder involvement - Development of policies - Evaluation of implementation - Legal framework strong driver |

Detailed surveys of how, and to what extent accessibility, is addressed in universities across Europe with some comparisons with Australia, Canada and the USA were undertaken in the first year of the EU4ALL project. From this a typology was drawn up summarised in the table above. This is referred to as the EU4ALL 4 Stage Model of Professionalism in Accessibility. This model was used in

discussion with a range of stakeholders at the Open University including senior managers, disability service providers and IT specialists in 2009. The consensus then of this self-rating process is that the Open University is currently at (T3) in this model but with strong aspirations to reach (T4). As stated above the UK has a strong legal framework and this is a driver in the OU. The key identified deficits were the need to more fully embed the addressing of accessibility in the core process of the university; a requirement for a clearer definition of responsibilities across the organisation; and currently only a partial and localised evaluation of accessibility implementation exists. This is the objective of the SeGA policy discussed earlier in this paper (see Section 4.1).

13 A Summary of Accessibility Guidance

The Open University has developed extensive guidance for its own staff to support them in addressing the needs of disabled student in the development and presentation of their teaching and learning and other Web based resources. This section summarises key guidance of different types.

13.1 Technical Accessibility

Recognising that the WCAG Recommendation of the W3C is difficult for developers to interpret and put into effect and wanting a common standard for all the university's Web presence OU Guidelines on Web Accessibility have been agreed [17]. These have re-evaluated the WCAG priorities for a teaching and learning context and rephrased its guidance and included illustrative examples.

13.2 Accessibility of Documents

The WWW and the university's VLE are often used to distribute documents to students that they then download and print off or interact with online. Here is a list of key guidance for creating accessible documents:

- **Images**
All images, except those that are used for decoration only should have meaningful "alt-texts"; these must be pedagogically appropriate and particular care must be made in images used in assessment. Assessment presents a particular challenge as there can be difficulties in creating alt-texts that do not simply give away the answer to the assessment away. All graphics must be scalable so that they remain readable when enlarged by people with a visual impairment. The use of Scalable Vector Graphics (SVG)¹³ is highly recommended here.
- **Tables**
Tables should be correctly marked up with Row/Column Title Tags (<th>, <tr>). Merged cells should be avoided as they impede screenreader navigation of tables. Care must be taken when placing text in cells remembering that a screenreader reads a table from left-to-right¹⁴ so text that should be read together is best located in a single cell.
- **Links**
Screenreader navigation tools give the user a list of links in a page. It is important to make

¹³ SVG is a formal recommendation of the W3C and available at: <http://www.w3.org/TR/SVG/>. Tools are readily available for creating SVG graphics e.g. Inkscape (<http://www.inkscape.org/en/>).

¹⁴ This is for English screenreaders how Chinese screenreaders reads a table is not known.

link labels meaningful (e.g. avoid “click here” but use a label that describes what the link jumps to).

- **Proper Use of Headings**

Sighted people navigate a document with the aid of the visual appearance of the documents structure. To extend this facility to screenreader and screen magnifier users correct mark-up must be used (<Title>/<H1>/<H2>/ ...). It is important to use these in the correct nested order.

- **Fonts**

The choice of fonts aids readability for all but is particularly important for those with a visual impairment and dyslexia. Size is important as is the style. In Latin languages sans serif fonts should be used. The author has no expertise in fonts for Chinese characters. Line spacing should be set to a minimum of 1.5 lines and text should be justified left or right not both as this can lead to “rivers of white” in the text which are particularly difficult for dyslexic people to read.

- **Technical Format**

What file format a document is created in impacts its accessibility. Word, although proprietary, is a very accessible format because of its ubiquity. PDF must be handled with care. PDF documents can be created accessibly but this needs expertise and PDF documents saved from Word are often not accessible. The Open University has developed a system of Structured Content based on XML and standardised DTDs. The OU uses an XML authoring tool called oXygen¹⁵ in creating XML documents that have accessibility features built in. This also facilitates the ready publication to other formats including HTML for the VLE, PDF, DAISY and ePub.

13.3 Access to Mathematics, Chemistry and Music Notation On-line

Symbolic languages such as Mathematics, Music and Chemistry notations present a challenge to represent in Web pages and making them accessible to blind people is a particular challenge. This is because these symbolic languages are 2-dimensional in nature whereas HTML was designed to present alphabetic languages in a linear fashion. There are different approaches blind people use to interact with maths. Some of these are based on Braille and there are particular maths versions of Braille: British Maths Braille; Nemeth Code (originating in the USA); and Marburg, a maths code used in the Germanic countries. Most blind professional mathematicians think in a highly abstract way. They usually exchanged mathematics in LaTeX, a publishing language that is designed for the typesetting of mathematics. There have been general efforts to present maths online and a dedicated mark-up language based on XML devised called MathML [18]. This is used by some blind mathematicians or students using maths in their studies but browser support for MathML is patchy. The author is working with others on innovative ways to present maths on-line in a way that can be useful to those with a substantive visual impairment; however, these have not all reached the point

¹⁵ oXygen is a proprietary XML editor see: <http://www.oxygenxml.com/>.

of practical application yet [19]. An approach that is currently being explored at The Open University that holds promise is based on MathJax¹⁶ a JavaScript based way of representing maths online.

Western music notation likewise has Braille and XML versions, the latter called MusicML¹⁷. In general music notation presents less of a problem for blind computer users. There are various software tools that can produce and read music notation where this is generated by electronic instruments such as synthesisers connected to the computer. There is a widely used electronic code MIDI¹⁸ that facilitates this communication between instrument and computer.

Various forms of chemistry notation are also 2-dimensional symbolic languages such as representations of molecular structures and chemical equations. Similar to maths professional blind chemists may elect to use XML based mark-up called ChemML¹⁹ or LaTeX based approaches. Studying Other subjects such as computer-science also involve the use of symbolic or graphic languages, e.g. UML²⁰.

Important to the teaching of any subject that deploys one or more symbolic languages is the teaching of those notations; when teaching students with a visual impairment, teaching the notation in an appropriate accessible form must be undertaken. At university level this can often build on the students' experience from high school and they may have preferred accessible approaches they are experienced with. However, because The Open University often takes students long after their school experience or with a low level educational background this often is not the case for their students. This presents a particular challenge and it is probably fair to say it is not one we meet well or systematically at present.

14 The Challenges and Opportunities of New Technologies in Education

Many disabled students are enabled by online education but it presents accessibility challenges for others. These challenges are not just for the students. New technologies require new pedagogies and different types of teaching activities from those established academics may have been used to. Further these may present particular challenges for academics that have a disability. Examples of new educational tools facilitated by the Internet include:

- Interactive software
- Group work in forums or wikis

¹⁶ MathJax is a JavaScript based means of representing maths online originating from the American Mathematical Society (AMS). It has been developed with accessibility in mind, see: <http://mathjax.com/resources/articles-and-presentations/accessible-pages-with-mathjax/>.

¹⁷ MusicML Project see: <http://www.musicmarkup.info/>

¹⁸ MIDI is an open standard for encoding music electronically, see: <http://www.midi.org/>

¹⁹ ChemML, see: <http://www.xml-cml.org/>

²⁰ UML – Universal Modelling Language is a set of graphical representations used in the specification and design of software, see: <http://www.uml.org/>.

- The use of Social Media in peer support
- The move to students as the content creators not the teachers
- Massive Open Online Courses (MOOCs)

The way these approaches and tools are implemented must include addressing accessibility. Sadly some of the proprietary and open-source tools for these features exhibit significant accessibility deficits. Accessibility must be a criterion in selecting these and in some cases modifications or scaffolding resources must be put in place before they are used in teaching and learning.

15 Recent and Current Research into Accessibility at the OU

This section summaries some of the recent and current research activities of The Open University relating to access to teaching and learning for disabled students. References are made to other papers reporting this work in more detail.

15.1 Accessibility Standards and Metrics

The author has been involved in the development of accessibility standards since 2000. He has also engaged with the world-wide web metrics community and has been a critic of much of the work in this area [20]. This has arisen because he maintains that accessibility is not a property of a web resource but a property of the relationship between the user and that resource. Much of the research in this area has been in defining metrics that assign some figure to the level of conformance to WCAG [21]. Not only is this approach flawed he maintains it is of little value in practice.

Most of the work undertaken by IET in accessibility standards has been in the development of metadata standards that facilitate personalisation for accessibility (see below). The author and colleagues have worked in various forums developing these including: IMS Global²¹; Dublin Core²² and ISO²³. This work culminated with the publication of a public draft of the AccessForAll Metadata Specification 3.0 [22] and is being further taken forward in the context of the GPII project²⁴ and the IEEE AdBook²⁵ initiative. The practical application of this work is outlined under Personalisation for Accessibility below.

15.2 Remote Controlled Teaching Laboratories

The author was the Project Director of an EU collaborative project PEARL (Practical Experiments for Accessible Remote Learning) [23]. This project developed pilots of remote controlled teaching laboratories partly driven by the motive of wanting to extend to disabled students access to experimental work in science and engineering subjects. The project developed remote controlled

²¹ IMS Global – Accessibility, see: <http://www.imsglobal.org/accessibility/>

²² Dublin Core – Accessibility, see: <http://dublincore.org/groups/access/>

²³ ISO SC36 – Information technology for learning, education and training, see: http://www.iso.org/iso/standards_development/technical_committees/other_bodies/iso_technical_committee.htm?commid=45392

²⁴ Global Public Inclusive Infrastructure (GPII), see: <http://gpil.net/>

²⁵ IEEE AdBook, see: <https://ieee-sa.centraldesktop.com/adbook/index>

optical spectroscopy; access to an electron microscope; visual inspection in manufacturing engineering and an electronics development and test bench for creating and debugging FPGA based microprocessor devices. The project demonstrated, by creating accessible interfaces to these facilities that disabled students could be enabled to undertake high level practical work in higher education science and engineering courses.

15.3 Three-Dimensional Audio Virtual Environments for Blind Students

There has been an increasing interest in the use of virtual environments in education. The benefits of these approaches are largely denied to blind students because the virtual environments are essentially visual. The author led a project team exploring the possibility of creating audio virtual worlds in 3-dimension based on a technical approach called Ambisonics [24]. The vision is that complex environments such as an audio orrery²⁶ could be created and learning by exploration thus facilitated. The fundamental practicalities of this approach have been verified. Further work is planned in this field to further establish the evidence base for the validity of this approach in education for blind students.

15.4 Personalisation for Accessibility

As discussed under Alternative Formats (Section 9) different disabled students benefit from the provision of educational media in different forms. The vision of personalisation for accessibility is that the most appropriate format is automatically served to each student when they request a resource. This is achieved by two linked sets of metadata: a user profile of each student's access needs and preferences and resource metadata that describes the properties of the resource [25]. A comprehensive system that achieved this was developed in the EU4ALL project based on the AccessForAll metadata specifications referred to in Accessibility Standards and Metrics above.

15.5 Learning Analytics for Accessibility and Disabled Student Support

Learning analytics is a "hot topic" in the field of technology enhanced learning. It seeks to exploit the "big data" generated by modern Virtual Learning Environments which record every "click" each student makes while accessing their courses online. This is combined with more traditional data such as completion and pass rates and the grades achieved in assessments. The author is leading a team at the OU seeking to exploit this approach to identify accessibility deficits in courses automatically and offer timely support to disabled students when they come to learning activities that might pose accessibility challenges for them. Further details of this work can be found on the author's blog²⁷ and in this paper [26].

16 Concluding Comments

Accessibility must be addressed if disabled students are to have parity of access to teaching and learning online. This paper has set forward the case that doing so needs an institutional wide response and given a case study of how that has been achieved at The Open University in the UK. This is held up as an exemplar but it will need to be adapted to the institutional context of any other university or other company or organisation. The EU4ALL 4-stage model of professionalism has been

²⁶ Model of the solar system, originally mechanical but here as multimedia software.

²⁷ <http://martyncooper.wordpress.com/> - search category 'Learner analytics' (accessed 26/05/14)

given as a tool for analysing the current status of an organisations position with respect to accessibility and to set goals for improvement.

Addressing the needs of disabled students often benefits all students. Where learning activities have been carefully designed with accessibility in mind they facilitate learning in a variety of ways and usually exhibit well-considered pedagogy. So, as well as ensuring wider participation in higher education, accessibility is a driver for quality in general.

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