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E-LEARNING AND BLINDNESS: EVALUATING THE QUALITY OF THE LEARNING EXPERIENCE TO INFORM POLICY AND PRACTICE

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ABSTRACT

The thesis focuses upon the use of e-learning by learners who are blind. Specifically, the research examined whether they could access and engage in e-learning and, if so, was this on the same basis and of the same quality as sighted learners?

The thesis describes the development of a conceptual framework which distinguished between the activities of ‘accessing’, ‘using’ and ‘doing’ when engaging in e-learning. The framework was combined with cognitive load theory as the underpinning theoretical framework and used as a method of describing and understanding the quality of the learning experience. In the main study it was found that the two groups of learners did have a similar learning experience although it took the learners who were blind approximately twice as long to complete the task as the sighted learners.

It is argued that while learners who are blind can 'access' e-learning material, even if it is designed carefully there may be a danger of excluding them from the learning experience.

The thesis concludes by linking the findings to legislation in terms of specialist skills for supporting learners who are blind, accessibility and usability of e-learning materials, and funding and availability of specialist education and technology.

Key Words: blindness, e-learning, accessibility, cognitive load theory

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PREFACE AND ACKNOWLEDGEMENTS

The following description outlines the general structure of this thesis.

Chapter 1 is the Introduction and sets out the aims of the research, key terminology and an overall outline of the thesis but in more detail than is set out here.

The literature review is considered in Chapter 2 and commences with an examination of the difficulties people who are blind experience in accessing education, training and employment which is set in the context of adult learning in general. This then moves on to the difficulties that they may encounter in engaging in ICT, the internet and e-learning. The literature examines the definitions of accessibility and usability which are of particular importance in this study.

Chapter 3 explains the rationale behind the methodology. A range of methods was used because the research question was developed over a number of years through the process of several small but related studies. This development moved from a focus on qualitative methods to a mix of both qualitative and quantitative methods (blended method).

Prior to the main study there were two exploratory studies and one pilot study and these are described and analysed in Chapters 4 and 5. These chapters trace the development of a conceptual framework which makes a distinction between ‘accessing’, ‘using’ and ‘doing’. Alongside this was the journey to the theoretical framework of cognitive load theory which underpins the main study which was more formally introduced in Chapter 7.

In Chapter 6 the methodology and the literature review are revisited. The framework of cognitive load theory was introduced at this stage to analyse and measure the quality of the learning experience. In terms of the methodology a blend of approaches is described which also takes into account methods of measuring cognitive load.

The main study is set out in Chapters 7 and 8. Chapter 7 is concerned with the design and method, and Chapter 8 sets out the results and analyses and discusses their implications.

The final chapter, Chapter 9, is concerned with revisiting the aims of the thesis, summarising the findings from all the studies and considering the implications of these for policy and practice. The thesis ends with some suggestions for future research pathways.

I would like to thank a number of people and organisations who have helped and supported me along this journey.

Thank you to The Open University which provided me with my academic skills in the first place and subsequently provided me with a great deal of experience in tutoring on an e-learning course, including tutoring learners who were blind or visually impaired. I would like to thank teaching staff and learners at the Royal National College for the Blind. I would like to acknowledge the Joint Information System Committee (JISC) and the Association of Learning Technology (ALT). Membership of various technology-focused committees, working and advisory groups and working with experts in the field has given me a great deal of knowledge and experience in the area of e-learning.

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Shirley Evans, 15th October 2009

This thesis is dedicated to my patient and understanding husband, Garfield and our children, Nick and Clare.

CHAPTER 1

INTRODUCTION

> E-learning has the potential to progress people with disabilities from the outer edges of educational opportunities to the leading edge of educational innovation (O'Connor, 2000, p.11).

This research focuses on issues relating to e-learning and blindness. It is recognised that there may be issues and difficulties for a range of people with or without other disabilities, but there are specific problems for those who cannot access e-learning visually. It may be more difficult for learners who are blind to engage in many activities including those connected with education. One difficulty may be that it may take longer for a blind person to carry out a task than a sighted person.

The introduction sets out the research problem, the aims of the research, key terminology and an outline of the thesis. The research is based on an initial belief that it is more difficult for adult learners who are blind than sighted learners to engage in e-learning and therefore they are at a disadvantage in terms of education and training. This belief came about when the researcher was engaged in teaching learners who were blind or visually impaired to use the internet using a screen reader. At the time the researcher had a remit to research the viability of a virtual learning environment (VLE) to be used at a specialist college for people who are blind or visually impaired. At this time in 2000 it was becoming clear that VLEs were increasingly being used in universities, and to a lesser extent in Further Education Colleges, and learners at the college needed to be prepared for the transition to these institutions and the methods of delivering learning.

Information and communication technologies (ICTs) offer opportunities to learners who are blind to engage in interaction with others and with learning materials. This enables active communication opening both social and learning opportunities that were previously not available. Seale (2006) and Sloan, Stratford and Gregor (2006) posit that e-learning can personalise learning and significantly improve accessibility to learning opportunities. The question that is explored here is whether, and to what extent, there is a level playing field between learners who are sighted and those who are blind.

Many studies outside the field of visual impairment have shown that the multimedia presentation of learning content can lead to an enhanced learning experience and better performance (Mayer, 2001; Mayer and Moreno, 2003; Moreno and Mayer, 1999; Najjar, 1998). McAteer and Shaw (1995) found that e-learning is more effective when a range of senses are engaged; that is, when both the auditory and visual senses are engaged, deeper and more meaningful learning can take place. This finding may not be specific to e-learning, but it is significant in that regard because it implies that people who are blind are already at a disadvantage in that they have less experience of multi-modal presentation. A learner who is blind does not have access to multimedia presentation of learning information (that is auditory and graphical) unless tactile resources are incorporated. In essence they are limited to unimedia (auditory) presentation. Moreover, if people who are blind are using materials that are designed to enhance and maximise learning using text and images, they may be even more at a disadvantage if they are accessing only the textual element; that is, they have access to less information than sighted people.

Aims of the Research

The primary aim of this research is to examine the experiences of people who are blind in an e-learning environment and to:

- gain greater understanding of, and insight into, the issues that an e-learner who is blind might face;

The secondary aims of the research are to:

- indicate general solutions for designers of e-learning materials;
- help teachers to identify training needs and choose materials;
- help education and training organisations address the Disability Discrimination Act (DDA, 2005) and related equality and diversity policies;
- inform development of legislation and policy.

Related Research

This thesis cross-references papers that have been published during the course of the research. Exploratory Study 2, relating to a group of 16 to 19 year old learners who were blind working in a virtual learning environment (VLE), was published in the British Journal of Visual Impairment (Evans, 2002). The study was also presented as a short paper (unpublished) at the Association of Learning Technology Conference (ALT-C) in 2002. This study and the pilot study involving a group of six people, two of whom were sighted and four of whom were blind or visually impaired, working in two VLEs, were published as an article by TechDis (Evans and Sutherland, 2003). TechDis is a Joint Information Systems Committee (JISC) funded educational advisory service. This article has formed the basis of a number of presentations by the TechDis organisation relating to accessibility and VLEs and was cited frequently within Dunn's (2003) report on implementing accessibility for students with a disability in virtual learning environments in United Kingdom (UK) Further and Higher Education. The main study, which was a comparative study between ten sighted learners and ten learners who were blind working through a twenty minute learning object, was published in the Journal of Visual Impairment and Blindness (Evans and Douglas, 2008). In addition the knowledge and experience gained from this work has underpinned a number of papers presented by the author at international conferences such as the 2006 International E-learning Conference in Winchester, the 3rd and 4th China Accessibility Fora, held in Beijing in 2006 and Chongchinq in 2007, and the

California State University Northridge (CSUN) 24th Annual International Technology and Persons with Disabilities Conference in Los Angeles 2008.

In addition the research has enabled the author to enhance her own teaching practice, for example by supporting students who are blind on Open University ICT-related distance e-learning courses; developing a range of ICT and e-learning projects and contributing to a range of national e-learning initiatives. The author reflects on this at the end of the Conclusion prior to examining future work.

Definition of Terms

Key definitions are set out below since these are central to the thesis and clear understanding of this terminology is required. There is further explanation of these terms in the literature review. The following terms are defined:

- accessibility and usability
- assistive technology
- blindness and visual impairment
- cognitive load theory
- e-learning
- learning
- information and communication technology (ICT)
- magnification
- online learning object
- screen reader
- virtual learning environment (VLE).

Accessibility and usability

Perhaps the most interesting definition as far as this study is concerned is that of Howell (2008) who states in relation to web design that accessibility ensures that users can reach content, but that there is no guarantee that they will find what they require or that this will be in a reasonable time. For Howell, usability ensures that users can complete tasks successfully.

Howell asserts (2008, p.68):

> Usability by disabled people is therefore the designer's goal: where a disabled person can complete a task at the same time, in the same time, at the same cost and at the same convenience as users who don't have disabilities.

For the purposes of this study usability/using is taken to mean the ease of navigation within an e-learning experience.

In this study accessibility/accessing relates to the use of assistive technology, that is the screen reader or magnification (see below for elaboration of these terms).

Assistive technology

The RNIB (2003b) describe assistive technology as 'a specialised piece of equipment or software which is used by someone with a disability to improve their ability to use a computer. Types of assistive technology include screen readers, refreshable braille displays, screen magnifiers, voice recognition, closed captioning, alternative keyboards and mice.'

In this study the assistive technologies that were used were a screen reader and a screen magnifier. Extensive information regarding assistive technologies can be found on the TechDis website (TechDis, 2008).

Blindness and visual impairment

In the UK the legal terms used to classify visual impairment are 'blind' and 'partially sighted,' (Douglas and McLinden, 2005).

The official definition of blindness is: ‘a person is eligible to be registered blind if he or she is so blind as to be unable to perform any work for which eyesight is essential’ (National Assistance Act, 1948). Blindness, visual impairment, partially sighted and low vision are discussed in more depth in Chapter 2, the Literature Review.

For the purposes of the research carried out in this thesis a person who is blind is taken to be a person who needs to use a screen reader to access e-learning. (Note that all the participants using a screen reader were registered as being blind). A person with a visual impairment is taken to be a person who needs to use magnification software to access e-learning. (Note that all the participants with a visual impairment were registered as being partially sighted).

Cognitive load theory

According to Cooper (1990) cognitive load may be viewed as the level of mental energy required to process a given amount of information. As the amount of information to be processed increases, so too does the associated cognitive load. Cognitive load theory (CLT), which has a focus on instructional design, emerged as the key theoretical framework for the thesis (in Chapter 7). The hypothesis being that a blind learner has to expend additional mental energy when using assistive technology to access the e-learning. This may have an impact on the quality of the e-learning experience and CLT may offer a means of measuring or evaluating this.

E-learning

The Department for Education and Skills (DfES, 2003) in the Government's E-learning Strategy define e-learning as 'If someone is learning in a way that uses information and communication technologies (ICTs), they are e-learning.' For the purposes of this thesis e-learning involves the use of a virtual learning environment (VLE – see below for a definition) and an online learning object. A VLE is a system that enables teachers to deliver course content online.

Information and communications technology

According to Becta (Becta 2007b), information and communications technologies (ICT) are the computing and communication facilities and features that variously support teaching, learning and a range of activities in education. Information technology (IT) comprises the knowledge, skills and understanding needed to employ information and communications technologies appropriately, securely and fruitfully in learning, employment and everyday life. IT is to ICT as literacy is to books, journals or screen displays.

Learning

It is important for the reader to understand what learning is considered to be in the context of this thesis as it is primarily concerned with evaluating the quality of the e-learning experience for learners who are blind. Chapter 2 contains a further consideration of e-learning and learning theories alongside learning styles.

Fontana (1995, p.142) states, 'unless we are changed in some way learning cannot be said to have taken place'. This may include a relatively straight forward process such as acquiring skill and an example of this would be how to navigate in a VLE with a screen reader. Once the skill is learned then navigating the VLE would be using the skill to access learning.

As stated above under e–learning, participants in the studies were engaged in using VLEs and an online learning object. A major part of the conceptual framework used in the pilot and main studies involves identifying how much time is being spent by participants 'doing,' and this is concerned with task performing and part of this may include learning.

In Exploratory Study 1 the participants/learners were observed and fully supported in accessing and navigating around a VLE, that is they were learning to use the VLE.

In Exploratory Study 2 the participants were required, with initial training and some on-going support, to interact with a VLE. Creating a home page and accessing content are considered to be performing tasks. Engaging with the content and in the discussion board, that is discussing transitional skills and related topics, were considered to be learning.

In the Pilot Study the participants were required, after training to engage in five different types of tasks. The participants needed to access content, read and post messages on a discussion board; create a simple home page; answer a multiple-choice test and upload and send an assignment. Again, engaging with the content and in the discussion board, that is discussing transitional skills and related topics, were considered to be learning.

In the Main Study the participants were required to engage completely independently, with no training, in an online learning object. They were required to engage in the content and apply their knowledge to similar situations. This was tested with two different types of performance test. In essence they were performing tasks such as reading, listening, answering, checking and reinforcing. Engagement in this activity was considered to be learning and the extent of this learning was measured using the performance tests.

In summary for the purposes of this study learning is concerned with the acquisition and transfer of new knowledge to problem solve. Learning in a VLE may come about as a result of task performance. This aspect is developed further when the conceptual framework of accessing, using and doing is introduced fully (Chapter 4).

Magnification

A screen magnifier is hardware (lenses) or software that increases the size of the text or images displayed on a computer screen:

> Screen magnification programs are used to enlarge text and graphics and can also provide focus within a small area with an enlarged

> cursor or pointer. The more powerful programs have many other attributes which are very helpful including font smoothing at high levels of magnification so that a letter can appear without jagged edges even when it fills the entire screen (TechDis, 2003, p.4).

Magnification of greater than x4 may be difficult to use in a web-based environment and screen reader support may be needed. The screen magnifier used in the exploratory and main studies was Supernova.

Online learning object

An online learning object is a short contained piece of learning content delivered online. For the purposes of the main study (Chapter 8 and 9) this was a chunk of multimedia (text, audio and graphics) content designed to last 20 minutes.

Screen reader

A screen reader is a software program that allows a blind person to read text on the screen and identify some graphics like buttons on a toolbar or icons on ‘the desktop’. The user hears the information from a speech synthesiser or the computer's sound card. A screen reader also allows the user to control the computer using the keyboard rather than the mouse.

Screen readers are generally very verbose and a new user may only be able to cope with speeds of around 150 words per minute but an accomplished user has the speed set at around 250–300 words per minute, this is similar to average print reading speeds by normally sighted adults. In terms of navigation users may have to listen to elements of a page several times to find out where they are in a document or on a website. The screen readers used in these studies were Supernova and JAWs.

Virtual learning environment

A virtual learning environment (VLE), according to Becta (2007a), may contain the following features:

- communication tools such as email, bulletin boards and chat rooms;
- collaboration tools such as online forums, intranets, electronic diaries and calendars;
- tools to create online content and courses;
- online assessment and marking;
- integration with school management information systems;
- controlled access to curriculum resources;
- student access to content and communications beyond the institution.

The features used in the pilot studies were online forums, online assessment and access to curriculum resources. Two proprietary VLEs were used, Blackboard and WebCT.

Ethical Issues

Ethical considerations are important in all research but perhaps of even greater significance when working with potentially vulnerable participants. The framework used to influence this aspect of the methodology is taken from relevant sections of the British Educational Research Association Guidelines (2004). Other related ethical issues are considered further under the Methodology in Chapter 3 and the Literature and Methodology Revisited in Chapter 6.

Outline of the Thesis

The thesis has two distinct phases. Firstly a literature review and methodology chapter lead to two exploratory studies and a pilot study. In this first phase the emphasis of the research shifts from an exploratory and qualitative approach to a more quantitative approach. In the second phase of the thesis the literature and methodology are re-visited which leads to the 'main study' of the thesis. This involves a comparison of experiences using a VLE by 10 blind and 10 sighted participants.

The following section provides an outline of the thesis chapter-by-chapter. In the Literature Review (Chapter 2) the argument commences with an examination of the difficulties people who are blind experience in accessing education, training and employment which is set in the context of adult learning in general. This then moves on to the difficulties that they may encounter in engaging in ICT, the internet and e-learning. The literature examines the definitions of accessibility and usability which are of particular importance in this study.

The argument is followed through in the Methodology (Chapter 3). A range of methods was used because the research question was developed over a number of years through the process of several small but related studies. This development moved from a focus on qualitative methods to a mix of both qualitative and quantitative methods (blended method). The qualitative approach arose due to the author’s engagement in feminist research methodologies as part of a Master of Education module relating to gender and education. It was believed at this stage that this approach could help address the research question. Qualitative research in the form of in-depth investigation into the background of a learner’s experience of life, learning and work, and their use of ICT could provide a valuable insight into issues relating to learners who are blind and the disparity between the experiences of this group and learners who are sighted. The focus was very much on unstructured interviews and observation. However, as the research developed and comparisons were made between learners who were blind and sighted it became clear that a key difference was the extra time it took the former to access the content. It was necessary to implement quantitative methods to measure and identify what was happening. At the same time it was equally important to find out how the learners felt about the experience.

Chapter 4 describes the two exploratory studies. The term ‘study’ is used here for ease of reference. The studies and particularly the first, involved informal observation of two users who were blind engaged in accessing a VLE. The second study was action research in nature but largely based on informal observation. In this study learners were observed informally using two different VLEs to access a discussion board. Both studies were part of the author's normal teaching practice and employment remit. It was found that learners who are blind could access a VLE, that learning could take place and that they enjoyed this method of learning even though it could be frustrating in terms of navigation and accessibility.

It was at this stage that a conceptual framework of what was taking place in the VLE was developed. This conceptual framework is used as a method of explaining the way people who are blind carry out tasks in a virtual learning environment (VLE). It separates the time spent on 'accessing' with the assistive technology (in this case a screen reader) from that spent on 'using' (navigating) and from that spent on 'doing' which may include learning. The framework is used to analyse time spent on these three activities and to compare time used by a blind person to time used by a sighted person. In order to analyse these activities the learners were videoed working in the VLE and the videotapes were reviewed at a later date. A point sampling observation technique was used: a 10 second intermittent bleep was used at which point a judgment was made as to what the learner was doing at that moment. The intervals were then added up to give an overall picture of the number of observations taken during the whole task and this also indicated the total amount of time spent on each activity.

A pilot study involving five participants who were blind and two sighted participants, described in Chapter 5, was set up in which the amount of time taken on these activities was measured. Hence it can be seen that there was a shift towards a quantitative methodology at this stage. In terms of participant perception of the task, it was found that learners who are blind enjoyed the learning experiencing even though the technology could be frustrating. It was also found that learners who are blind were taking up to three times as long as the sighted learners to access the VLE. This indicated that the quality of the learning experience for the learners who are blind may be reduced not only because it took them longer to access the learning but because the use of the assistive technology in the VLE may have been impinging on their working memory. The success of the method and methodology in the pilot study led to a re-assessment of the conceptual and theoretical frameworks as well as indicating the way forward for the methodology.

The theoretical framework of cognitive load theory was introduced at this stage (and is discussed in Chapter 7) to analyse and measure the quality of the learning experience. The framework is examined in terms of its application in this research and specifically how the measurement of cognitive load links to the conceptual framework of accessing, using and doing as described above. This is followed by the methodology revisited (also in Chapter 7) which describes a blend of approaches:

- questionnaires
- satisfaction survey
- two performance tests
- perception of mental energy expended
- observation of time taken in completing tasks.

The approaches also took into account methods of measuring cognitive load. This chapter leads directly into the main study set out in Chapters 7 and 8. Chapter 7 is concerned with design and method. This is a comparative study which involved two groups of ten learners each. The learners involved were all male aged between 16 and 27. Ten of the males were fully sighted and ten were blind (all using the screen reader JAWs to access information on a computer).

The analysis and discussion is set out in Chapter 8 and indicates that the learners who are blind took twice as long as the sighted learners on the task and performed less well in the learning performance task. In terms of the additional time taken, some of this (though not all) could be explained by the additional time taken using access technology. In spite of these apparent barriers to learning, participants who are blind did not differ from sighted participants in how difficult or enjoyable they perceived the task to be. There was also little difference in the perception of the blind learners compared to the sighted learners of how difficult they found the task to complete, although observation of the task indicated that it was considerably more difficult for them.

This final chapter, Chapter 9, is concerned with revisiting the aims of the thesis and summarising the outcomes and implications. There is then an evaluation of the conceptual and theoretical frameworks in terms of their effectiveness in addressing the aims and to this extent how the research has contributed to the methodological understanding. This is followed by an overview of the considerations to be taken into account when designing e-learning/ICT for learners who are blind or visually impaired and the implications for teaching. Implications for equality and diversity and development of legislation and policy including accessibility of content and accessibility to equipment as well as staff development issues are then considered. The thesis ends with some suggestions for future research pathways.

Conclusion

The Introduction has set the scene in terms of the aims and objectives of the research. The primary question being concerned with whether there is a ‘level playing field’ in e-learning for sighted learners and learners who are blind. Another way of looking at this question is whether e-learning is sufficiently accessible and usable for learners who are blind so that they can experience the same quality of learning as sighted learners. In order to answer this, questions can usefully be set out as four stepping stones:

1. Can a learner who is blind access e-learning?
2. Can a learner who is blind engage successfully with e-learning?
3. Can a learner who is blind engage on the same basis as a sighted learner? For example do they differ in terms of time taken and ease of use/usability?

4. Will the quality of the e-learning experience be the same for a learner who is blind as for a sighted learner?

The aspect of levels of accessibility runs throughout the thesis and a key concept that emerged is the notion that ‘accessibility’ is not a black and white concept; that is, that e-learning resources are either 'accessible' or 'not accessible'. Rather it is argued that accessibility might be better conceptualised as 'levels of accessibility'. In the main study the learners who are blind had a positive learning experience even though they took on average at least twice as long as the sighted learners and performed less well in the learning performance task. However, if learning materials take impractical amounts of time for the blind learner to access (even if they pass various guidelines on accessibility) it may be found that blind students simply will not want to access the materials and will be effectively excluded from the learning experience. This may in turn exclude them further from education, training and employment opportunities given that e-learning is increasingly being used as a learning and teaching delivery method.

CHAPTER 2

REVIEW OF THE LITERATURE

Introduction

This chapter is concerned with literature in five key areas relating to this study. These key areas are:

- the context of education and training for adult learners in the United Kingdom;
- education and training opportunities for people who are blind;
- e-learning;
- e-learning and accessibility;
- ICT and blindness.

These areas were identified as being useful at the outset of the research and in relation to the key questions:

1. Can a learner who is blind access e-learning?
2. Can a learner who is blind engage successfully with e-learning?
3. Can a learner who is blind engage on the same basis as a sighted learner? For example do they differ in terms of time taken and ease of use/usability?
4. Will the quality of the e-learning experience be the same for a learner who is blind as for a sighted learner?

There has been limited research in relation to e-learning and blindness. This was particularly true at the outset. There were two very relevant studies, Nielsen (2001) and Craven and Brophy (2003) but these were in respect of using the internet and an online library catalogue. The researcher needed to look outside the field of visual impairment and blindness at what was happening in terms of education and training, ICT and the increasing use of e-learning.

Although the author was a specialist practitioner she had much involvement in mainstream ICT and e-learning developments on a regional, national and international basis. This afforded the acquisition of a broad overview of technology and related issues at technical, pedagogical and strategic levels and alongside her everyday specialist teaching role this enabled an almost unique opportunity to explore the research questions.

The first area to be addressed is the context of education and training for adult learners in the United Kingdom. The area is important because consideration of this enables an understanding of the education landscape in which learners who are blind have to operate. This should then enable a greater understanding of the opportunities and barriers that a learner who is blind may experience; this is particularly important in terms of accessibility to education in its wider sense. The second area to be addressed will be an overview of issues relating to people who are blind, including relevant statistics and the implications for learning. This will involve looking at the Government agenda in respect of education, training and skills, sometimes referred to as lifelong learning. Leading on from this will be an examination of related definitions, a short history of people who are blind, access to education and training, selected relevant statistics and related literature concerning people who are blind in employment and education.

The next area to be reviewed is in respect of e-learning. This will cover a range of aspects including human-computer interaction, hypermedia, usability and navigational issues. Of relevance here is the development of standards and guidelines. This should enable content to be delivered in the 'right'/preferred format to people with disabilities and will enable individual learning styles to be addressed. There will then follow a review of the literature on ICT and blindness including web-based navigational issues for people who are blind covering access technology and web accessibility.

The literature review does not cover types of eye condition, causes of blindness and other related medical conditions. The research is primarily concerned with adults who are blind in that they need a screen reader to access online information/e-learning. The terms 'learners who are blind' and 'people who are blind' will be used rather than ‘people who are blind and visually impaired’, for example. Otherwise the terms in the relevant literature will be used.

Cognitive load theory (CLT) is the key theoretical framework which emerged from the exploratory and pilot studies and this is considered separately in Chapter 6. This is because it was not examined in the development of the thesis until after the pilot study.

The Context of Education and Training for Adult Learners in the United Kingdom

In the following section the context in which the research is set is examined and the driving force behind it established. The section looks at government policy since 1998 in respect of education, training and employment.

Vocationalisation of education

There is much literature in the area of vocationalisation of education and the need for a flexible workforce. According to Brown and Lauder (1999), the aim of successive governments is the ability to participate in a global market if economic success is to be achieved. Workers need to be flexible and have transferable skills as there are no more jobs for life. As early as 1984 it was recognised that transferability and flexibility were necessary rather than the archaic ‘skill.’ The discourses of globalisation are based on a set of assumptions which both help to exonerate the state from responsibility for unemployment while putting the onus on the individual to become educated and trained to a level at which he or she is able to become employable, (OUa, 1997). Keep and Mayhew (1996, p.96) set out these assumptions, which they argue are, in the main, misplaced:

- that training and development are key determinants of economic success;

- that the UK will increasingly require highly educated and trained and autonomous workers;
- that UK employers will require a highly educated and trained workforce at all levels;
- that a market-based approach is best;
- control of the new training system should be vested with employers;
- employment opportunities require formal qualifications and skills.

Both Sargant (1996) and McGiveney (1990) argue that older adults, those with limited initial educational experience and adults from poor socio-economic backgrounds are all under-represented in the provision and take up of learning opportunities. McGiveney posits that several groups have been identified as being persistently under-represented in post-school education: ethnic minorities, women, physically and mentally handicapped adults, manual workers and the elderly.

Tough's (1976) evidence shows that the most common motive for adult learning is for new knowledge or a skill and that less than 1% of all learning efforts are for credit, with most adults regularly engaging in learning projects. This contrasts with many national surveys; for example, there has been a 3% decrease in learner numbers in further education between 1996 and 2007 (Aldridge and Tuckett, 2007). It is, though, difficult to measure participation and may depend on whether you focus on formalised education as McGiveney or informal learning as Sargant.

It should be noted that 'leisure', or 'leisure time' is a grey area. Some work-based learning takes place in employees' leisure time but it is to all intents and purposes compulsory. Sargant (1996) argues that for some people the boundary between learning for leisure and for education is invisible, for example gardening. Strain (1998) agrees that distinctions between learning, leisure, working and playing have become merged. It is not clear what is meant by learning, whether it is being meaningfully engaged in a task, which could include leisure. Tight argues that emphasis is given to vocational forms of study and participation (1998), this is based on analysis of text from 'The Learning Age' (Department for Education and Skills, 1998), the Labour Government's consultative paper. He also finds that individual responsibility is stressed not just in respect of participating but also in meeting part of the costs. He concluded that lifelong learning is becoming compulsory; that it has become embedded in work and that it has become re-labelled 'work'.

UK Government policy on adult learning

Vocationalisation can be seen as a discourse in Government documents, as evidenced below:

> In the Green Paper, the Learning Age we set out our vision of how lifelong learning could enable everyone to fulfil their potential and cope with the challenge of rapid economic and social change.

This is David Blunkett's (the then Minister for Education and Employment) introduction to the follow-up Government White Paper, 'Learning to Succeed – a new framework for post-16 Learning' (Department of Education and Skills, 2002, p.1). Its focus is on the 16 to 19 age group and contains proposals for reforming further education (FE). Much emphasis is put on employers and the University for Industry (UfI), now Learn Direct, under the auspices of the (then) new Learning and Skills Council (LSC) to provide adult learning. Moreover, in the document the Government states that the proposals will give employers unprecedented influence over the education system and promote a better match between supply and demand for skills.

In 'Learning to Succeed' (Department of Education and Skills, sect 4.15, 2002) the Government states that in respect of provision for the disabled:

> The LSC will have a particular duty to address the needs of learners with disabilities or learning difficulties… It will have the power to fund

specialist provision where it is satisfied that mainstream provision is not adequate or it is in the best interest of the students.

The LSC was to set up systems which evaluate, amongst other things, how well they help tackle social exclusion and promote equal opportunity. This will include ‘helping people to improve their employability…. and enabling students with special needs to achieve their full potential’.

'Learning to Succeed' focused very much on the concept of lifelong learning. The concept of lifelong learning first came into prominence in the 1960s, in a culture of international organisations such as the United Nations Educational, Scientific and Cultural Organisation (UNESCO) and more recently by the European Community and the provision of continuing education. Matheson and Matheson (1996, p.219) assert that it is suddenly fashionable in the United Kingdom (and elsewhere) to talk about lifelong learning and lifelong education. However, they come to the conclusion that these notions have all the trappings of what might be termed as a good idea, but that there is a lack of ‘conceptual solidity’, and ‘that adult education is unable to define its nature as education or leisure or as a fusion of the two’. Matheson and Matheson (1996) argue that, ‘a concept of education which includes learning from the home, the neighbourhood, from the mass media and from recreational activities (etc) is loose and lacking in “cutting edge”’. This seems to acknowledge only formal education and implies that education must have some form of qualification or accreditation at the end otherwise it is recreational.

There are different opinions as to when lifelong learning starts and whether it really is life long. Adult learning from a lifelong perspective in Sweden was at one time promoted by alternating periods of education, work and leisure (Abrahamsson, 1993). This has changed due to economic factors. In the United Kingdom lifelong learning tends to follow a pattern of education (school and university), work (vocational training) and leisure (retirement) for some, for example white middle-class males (McGiveney, 1990). Tight (1998, p.253) comments that, ‘Lifelong learning was articulated in distinction to front-end education, where education was seen as essentially confined to childhood.’

Knowles (1983) proposes a separate form of adult learning (andragogy) to childhood learning (pedagogy), arguing that the main distinctions are that adult learning is self-directed, based on experience, social roles and has immediacy of application. Hanson (1996, p.99) counters this by arguing that there may be no difference between adult and childhood learning and that the boundary masks differences of context, power and culture.

‘Learning to Succeed’ (Department for Education and Skills, 2002) was the Government White Paper that followed ‘The Learning Age’ (Department for Education and Skills, 1998) and it continues to reinforce vocationalism. According to Tight (1998) it implies that funding will be for vocational subjects and that the Government is placing so much emphasis on this that it is giving more power to the employers. People are to become employable and to move between jobs with their transferable skills. There is no longer the security of employment for life with one firm and this has implications for people who are blind in that it is difficult for them to learn skills. For example, information technology (IT) is not intuitive. If you cannot see the screen and the graphical user interface, you have to learn by rote and this is extremely difficult and time consuming. Many jobs are not suitable for people who are blind so there is less chance of obtaining work or of being part of a learning society. This is discussed further below.

'Leaning to Succeed' was replaced by 'Success for All' (Department for Education and Skills, 2003a, Introduction) which is 'the change programme designed to transform quality and responsiveness across the learning and skills sector'. This, when read in conjunction with the Government's E-learning Strategy (Department for Education and Skills, 2003b) which is addressed below, indicates that there will be increased amounts of public money allocated to e-learning.

In October 2006 the Learning and Skills Council (LSC) published *Learning for Living and Work: Improving Education and Training Opportunities for People with Learning Difficulties and/or Disabilities*, the first national strategy for LSC-funded provision for learners with learning difficulties and/or disabilities across the FE system: 2006/07 to 2009/10. Whilst there is a vision for improving the life chances of disabled people there is very much a vocational focus and this interlinks with the Leitch Review of 2007. In the review the focus is about upskilling the work force to enable the UK to become a world leader in skills by 2020.

At the time of writing, under the Machinery of Government (Cabinet Office, 2007), a new *Department for Innovation, Universities and Skills*, and a new *Department for Children, Schools and Families*, for the first time bring together all key aspects of policy affecting children and young people. These changes are undergoing consultation and, with the demise of the LSC (due to dissolve in 2010), there will be significant changes in the funding of education and training for, amongst others, people who are blind or visually impaired. Funding will move to local authorities and there will be less centralised funding for people with disabilities. Most provision of education and training will be expected to be met locally and this may result in a watering down of expertise.

In April 2008 there was a consultation by the Government in respect of informal adult learning. One of the reasons for this is that the number of adults engaging in formal education and training is decreasing (see above) and the Government is seeking to recognise informal adult learning and use it as a means to encourage adults to engage in informal education and training. Of relevance to this thesis is the statement by the Department of Innovation, Universities and Skills (DIUS, 2008): ‘Far more adult learning is being designed and developed by learners themselves. More people want to choose what, where, when and how they want to learn. New technologies make new ways of learning accessible, but the most radical possibilities are only just beginning to be understood.’ It is possible that this statement currently does not apply to many adults who are blind but it is one of the aims of the research that it should do.

European policy for adult learning

It is important to look at European policy as funding is available from international sources and government policy is subject to European directives.

Learning and enhancement of abilities and opportunities to learn have long been embedded and driven in European Union objectives. For example, the White Paper on Education and Training (European Commission,1995; the Commission of the European Communities, Brussels and most effectively in the Contribution of the European Commission to the Special European Council in Lisbon (European Commission, 2000) where learning is seen as part of the European social model: ‘Given the continuous pace of change, adapting our basic educational structure to new needs and extra investment in life long learning and training are now essential for long term economic and social success,’(2000, p.7). In addition, the Barcelona European Council Conclusions (European Commission, 2002) indicate that ‘The European social model is based on good economic performance, a high level of social protection and education and social dialogue.’ Among the responses to the challenges set in these documents is an e-space of social inclusion which seeks to promote and create world-wide accessible knowledge. However, the statistics of active and good use of e-opportunities are very diverse. In the European Community (EC) paper (Gass, 1996, p.3) ‘The Goals, Architecture and means of Lifelong Learning’, recognises the ‘logic of education’ but takes the ‘logic of industry’ as the approach to the paper. Brief mention is made of equal opportunities in respect of women and ethnic minorities but there is nothing about disabled people. It concludes that, amongst other things, everybody needs a portfolio of competences, education and training needs to be demand dominated rather than supply dominated.

EC policy can be seen to be vocationally orientated and educational policy clearly linked to economic factors. The above papers place emphasis on the need to address the demand side; that is, training should be focused upon what employers want, not what people are able or want to do. This will exclude many, especially the disabled, who may not be able to work as quickly or as economically as others. It seems that you can only succeed by being employed. This is particularly discriminatory for disabled people as evidence shows that employers are unwilling to employ people who are visually impaired (Honey et al, 1993) and that there are a limited number of jobs that they may be able to do.

UK legislation for disability

The Disability Discrimination Act (HMSO, 1995) was passed to address many of the issues faced by people with disabilities in a number of areas:

- Employment – employers need to make reasonable adjustment in respect of employees who are disabled.
- Access to goods and services – providers need to make reasonable adjustment to ensure goods are accessible.
- Transport – there should be minimum standards to assist people who are disabled to use public transport.

The Special Educational Needs Disability Act (SENDA, 2001) was passed by Parliament to address some of the inequalities faced by learners and supplements the Disability Discrimination Act (1995). The latter made it unlawful to discriminate against disabled people in the area of education. The Act covers aspects of the learner experience including use and provision of electronic materials, and, with relevance to this study, e-learning. There is therefore a responsibility for all learning materials including e-learning materials to be accessible. However the onus for this is on the institution and the teacher, not on the developer. The Act makes it an offence for educational institutions to discriminate against a disabled person by treating him or her less favourably than others for a reason relating to their disability. According to Seale (2003, p.2):

> Discrimination will be considered to have occurred if a disabled person is treated less favourably for a reason relating to their disability than a non-disabled person to whom that reason does not apply or if there is a failure to make "reasonable adjustments without which the disabled person is placed at a substantial disadvantage".

A reasonable adjustment may relate to the amount of time a learner is allowed to take for an exam or the amount of computer time available. It is this aspect which is specifically relevant to this study in that the amount of time spent by a blind learner accessing, using and doing has been measured and this has been compared to the amount of time taken by a sighted learner using no assistive technology. From a learning technology perspective, a reasonable adjustment might involve changing or adapting electronic teaching materials.

The Disability Discrimination Act (2005) act, passed in April 2005, places a duty on all public bodies to promote disability equality. Under this new legislation all public bodies, such as higher education institutions, are required to:

- eliminate unlawful discrimination against disabled people;
- promote equal opportunities for disabled people;
- eliminate disability-related harassment;
- promote positive attitudes towards disabled people.

There is an emphasis on organisational change rather than simply making adjustments. Examples of these changes are:

- Publish a Disability and Equality Strategy (DES) and an associated three-year action plan and provide an annual report on progress.
- Consider the impact of all current and proposed institutional activities (e.g. plans, policies, procedures) on disabled people and provide an explanation of how impact will be assessed.
- Describe how disabled people have been involved in the development of the DES and action plans – this involvement must be ‘influential’.
- Show how progress on disability equality will be measured and how they will monitor and evaluate their action plans.

The legislation does not refer explicitly to e-learning. However, the Disability Rights Commission (2002) published a code of practice in which they address two areas relating to e-learning and web accessibility. They mention e-learning in their list of services which also includes library services and distance learning. They also refer to two examples of good practice which include producing all teaching materials in text format so that they can be easily converted into other formats, and that all notes that are put on the internet/intranet should be accessible by assistive technologies.

It is worth noting that in the United States the Americans with Disabilities Act (ADA), (1995) covers the rights of disabled people not to be discriminated against in a similar way to the DDA in the UK. More specifically Section 508 requires federal agencies to procure and provide accessible technology; however, it does not ensure that manufacturers produce such goods.

Government strategy

In the Government's E-learning Strategy (Department for Education and Skills, 2003b) it is stated that:

> E-learning has the potential to revolutionise the way we teach and how we learn. There is e-learning already around us in schools, colleges, universities, community centres, in the workplace, and in the home. It's important because people are finding that e-learning can make a significant difference: to how quickly they master a skill; how easy it is to study; and, of course, how much they enjoy learning. It is important because it can contribute to all the Government's objectives for education – to raising standards; improving quality; removing barriers to learning and participation in learning; preparing for employment; upskilling in the workplace; and ultimately, ensuring that every learner achieves their full potential.

On 15 March 2005, the Department for Education and Skills published the e-Strategy 'Harnessing Technology: Transforming learning and children's services.’ This strategy describes the use of digital and interactive technologies to achieve a more personalised approach within all areas of education and children's services. It is an ambitious strategy covering all sectors for the next five years and beyond. The aim in five years time, by using a more strategic approach, is ‘to build the common ground that brings all our education and children's services to the critical baseline of being able to use the technology effectively. In ten years, building on the newfound capabilities of our workforces, our newly skilled graduates, and our new appetite for innovation, we could be anywhere – if we have the ambition and the imagination to go there.’

The Higher Education Funding Council for England (HEFCE, 2005) set out their e-learning strategy, 2005-2012 and state:

> We are committed to working with partners on plans to embed e-learning in higher education in a full and sustainable way within the next 10 years, as announced in the Government’s White Paper “The future of higher education” (HEFCE, 2005).

Further Education Colleges and Universities are required to produce e-learning strategies to release funds from the HEFCE and from the LSC, and the Office for Standards in Education (OFSTED) will expect to see embedding of e-learning within schools and colleges (including specialist colleges for people with a visual impairment) as part of the inspection process.

Summary

Adult learners, and learners with disabilities in particular, are amongst those who appear to be disadvantaged in education. There is a move towards technology, and in particular e-learning as a delivery medium to facilitate education and training for the work force. This is set in a discourse of lifelong learning where there may be a focus on employment related learning rather than for learning for leisure. E-learning on one hand may be seen to promote individualised learning but also that it may facilitate economy of resources or deliver just-in-time individualised learning, which is of particular relevance to employment skills.

The literature cited above may indicate that there is vocationalisation of education; that is, education is supported by the government and other organisations where it has direct relevance to the economy. There is a discourse of lifelong learning that suggests learning encompasses all aspects of life including work and leisure. However, funding may only be available for learning that is work related. Some adults, including those with disabilities, may in any case be less likely to engage in learning activities. Educational choices for visually impaired people are limited (mainly to vocational courses). It is physically difficult for some visually impaired people to learn and this may mean, for some, that most of this takes place in a formal setting. This would mean that independent lifelong learning may be difficult for many to initiate and, as will be shown in this study, difficult to participate in terms of accessibility and usability. This may indicate that even if a learner who is blind or visually impaired can participate they will have an inferior learning experience to someone who is fully sighted. This is the key question addressed in this study in relation to e-learning.

Having set the context this review will now focus on the area of blindness and the implications for learning.

Education and Training Opportunities for People who are Blind

Blindness and the implications for learning

This section commences with an examination of definitions of blindness, note that there is a potted version of the definition in the Introduction (Chapter 1). This is followed by demographic statistics and discussion in the areas of employment. Since access to learning is a key theme it is addressed in this section but it should not be confused with accessibility in terms of technology which is discussed later.

Definition of blindness and visual impairment

There are a variety of definitions of blindness incorporating aspects such as ability to work and visual acuity. Two common categories are legal blindness and functional blindness. In the United Kingdom the official definition of blindness is ‘a person is eligible to be registered blind if he or she is so blind as to be unable to perform any work for which eyesight is essential’ (National Assistance Act, 1948). The World Health Organisation (2003) define blindness as being visual acuity of less than 3/60 or corresponding visual field loss in the better eye with best possible correction. In Ireland, blindness is legally defined as being present when there is a visual acuity of 6/60 or less in the better eye or where a field of vision is limited, the widest diameter of vision subtending an angle of 20 degrees or less (EATT, 2003).

Low vision corresponds to visual acuity of less than 6/18, but equal to or better than 3/60 in the better eye with best possible correction (RNIB, 2004, p.1). Most people who are blind do have some vision, its usefulness to them depending on other factors such as motivation, intelligence, levels of illumination and the task being undertaken (Tobin, 1996). 'Only 3% of people registered blind are totally blind, and 97% have some residual vision' (RNIB, 2004). Blindness is linked with age – 67% of the sample was aged 75 years and above as opposed to about 8% of the general population. Tobin (1996) said that due to this there will be a significant increase in the number of people who are blind over the following decade. Ten years later, this is supported by Charles (2007).

According to Douglas and McLinden (2005), visual impairment is a broad term which describes a wide continuum of loss in visual function. There are many aspects of visual function, for example visual acuity (ability to resolve detail), accommodation (ability to focus), field of vision (area which can be seen), colour vision and adaptability to light. It follows therefore that there are many causes, types and severities of visual impairment.

Visual acuity can be measured using the Snellen scale. A Snellen test usually consists of a number of rows of letters which get smaller as you read down the chart. For example, a person with normal vision would be able to read the second line on the chart when 36 metres away. However, if you had a Snellen score of 6/36 you would only be able to read the same line at 6 metres away. In other words you need to be much closer to the chart to be able to read it.

Generally the larger the second number is, the worse your sight is (RNIB, 2008). Low vision corresponds to visual acuity of less than 6/18, but equal to or better than 3/60 in the better eye with best possible correction (RNIB, 2004).

According to The Department of Health (2007):

> At 31 March 2006 157,000 people were on the register of people who are blind which was a reduction of 4,000 (3%) from March 2003. Between March 2000 and March 2003 the number on the register of people who are blind decreased slightly by 1,100 (almost 1%), however since 1982 there has been an overall increase of 45,000 or 40%.
>
> At 31 March 2006 155,000 people were on the register of partially sighted people which was similar to that reported in 2003. This was an increase of around 6,500 (4%) since March 2000 and more than double the figure at March 1982. The large rise from 1982 may be partly due to old registrations not being removed from the register, either through the death of the client or transfer to the register of people who are blind.
>
> It is important to note that 66% of blind and 68% of partially sighted people were aged 75 or over…41,000 (29%) of those registered blind and 39,000 (27%) of those registered partially sighted were also recorded with an additional disability.

An historical perspective

This section looks at developments for people who are blind in terms of educational opportunities. There is little information of the history of education and training for congenitally blind adults and rehabilitation for those who are recently blinded. Since this study is concerned with access to learning by people who are blind it is important to take a very broad view of this and consider the history of education in this area.

Valentin Hauy established a school for blind children in Paris in 1784. There had been some other formal education prior to this with blind children who were blind educated alongside sighted children (McCall, 1997). The movement of schools for the blind spread outside Europe throughout the 1800s to Australia and the United States of America (Kelly and Gale, 1998). There were, around this time and at the beginning of the 18th century, a number of prominent people who were blind who prompted interest in the education of people who are blind. However in the main most people who were blind lived in poverty and were uneducated.

Schools for the blind were well established in Britain by the 1860s. The first one was established in Liverpool in 1790 (RNIB, 2003a). Colleges such as the Royal Normal College started with just 2 students and had over 200 by the end of the nineteenth century. The college was run as a preparatory school taking children aged 5 to 13, and a grammar and high school. The Elementary Education Act (Blind and Deaf Children) was passed in 1893 which obliged local education boards to educate children who were blind and/or deaf from the ages of 5 to 16 years. It is worth noting that the minimum school leaving age at this time for all children was 10 years of age (McCall, 1997).

At the beginning of the 20th century residential schooling had become the norm for blind children. In 1907 the College of Teachers of the Blind was established and it became mandatory for teachers of blind children to gain a diploma within 3 years of commencement of work in that area. Interestingly there was an unexpected increase in the number of children who were educationally blind. This was due to a condition known as 'retrolental fibroplasia', (RLF) which led to severe visual impairment and sometimes other disabilities. It was discovered that the cause of this was the way in which oxygen was administered to premature babies which has now been overcome. This situation of separate education for blind children continued up until the 1970s. As a result of the experiences of St. Vincent's in Liverpool where the most able blind children were sent to a local mainstream school it appeared that blind children could succeed in a mixed environment.

Margaret Thatcher commissioned a report in 1968 into the education of ‘visually handicapped children’.

> At the time educational provision comprised of 18 schools designated for the blind, 19 schools designated for the partially sighted, two schools which were authorised to take both the partially sighted and blind and 8 mainstream school which contained classes for the partially sighted (McCall, 1997, p10).

The report of the enquiry, 'The Vernon Report' recommended, amongst other things, a peripatetic service but it stopped short of full integration.

The Warnock Report (1978) provided the results of an enquiry into children with special educational needs and reinforced the trend towards integration. The Education Act of 1981 specified that children with special educational needs should be educated in mainstream schools where this was compatible with the efficient use of resources. Special schools for children who are blind and visually impaired still exist but they are reduced in number.

In England there are currently four specialist colleges for learners with a visual impairment. However there is an increase in learners with other disabilities such as autism in two of the colleges. The colleges provide residential training for adults in a range of vocational areas. They are funded by the Department of Work and Pensions and the focus is very much on supporting blind and visually impaired adults to move into employment. Alongside the employment focus these colleges will also provide input in terms of 'core' skills such as mobility, living skills, assistive technology enabling skills, and braille with basic and key skills becoming a priority. It is increasingly difficult for adults to get funding to go to a specialist college since there is a focus on employment and colleges have targets to meet in terms of employment outcomes. As discussed above there is the potential for funding pockets to diminish even further.

Statistics

In a survey carried out by Keil (2002) it was found that 59% of pupils aged between 5 and 16 attended a mainstream school, 5% were educated in specialist schools for visual impairment, 32% were educated in other types of specialist school such as those for learning or physical difficulties and the whereabouts of the remainder was not accounted for. For those children post-16, 66% still attended school 24% were in further education, 4% in higher education, 1% in employment and the details for the remaining 2% were not known. This may be compared to Spain where 83% went to mainstream schools and the remainder to special day or residential schools for people who are blind. This comparison with Spain is taken up again below and is useful in that Spain has a different model for education and employment with education being integrated whilst employment is largely not integrated.

In the RNIB report (2001) involving over 1,000 children and young people there were the following key findings:

- Support in many mainstream colleges and universities must improve to meet all the needs of blind and visually impaired learners.
- A considerable number of blind and visually impaired learners do not receive sufficient support for their studies.

In terms of accessibility of, and to, learning and information there were the following findings:

- Under half of the learners who said that large print was their preferred medium actually received it.

- More that one in four had to wait for study and other materials in their preferred format.
- More than one in five found the college/university library difficult to use and a further one in five did not use it at all.
- Not all library records were accessible.
- Nearly six in ten found they took longer to do coursework than their friends.
- One in ten learners said that they did not always get examination papers in their preferred format.
- Almost one learner in five said that they did not have access to all the equipment they needed – e.g. computers, assistive technology. Cost was put forward as one factor and information about the technology another.

Learners in higher education (HE) were least likely to receive materials in their preferred format compared to learners in FE and Sixth Form. Learners in higher education were more likely to have to wait.

It is interesting to note the difference in terms of accessibility to learning materials and information between mainstream, and specialist colleges and schools. The RNIB (2001) found that specialist schools and colleges were better able to meet the needs of learners who are blind:

- Six in ten learners in mainstream provision were usually given access to books in their preferred medium.
- Nine in ten learners in special schools/colleges were usually given access to books in their preferred formats.

McCandlish (2001) in her report for the RNIB on a lifelong learning project found that student trends indicate that the number of adult learners with a visual impairment is increasing, the majority being in the age range 26–40 and a significant proportion aged 40–60. The paper indicates that many older visually impaired people seek learning opportunities outside the further and higher education sectors, and that national and voluntary as well as residential establishments are increasingly involved. However, there is in general low take-up and this may be due to a perceived lack of appropriate provision.

Within the market-place ethos certain groups have always found difficulty in gaining access and are vulnerable to market forces. Their needs may be different, difficult to meet and costly, generating insufficient income or profit (McGinty and Fish, 1993). In part-time education lack of assessment and identification of learning needs is another barrier as well as a lack of pre-course and in-programme study skills. Linking to the paragraph above, lack of knowledge about courses is a problem and students may have reading difficulties linked to their home reading environment (Fellenius, 1999) making it difficult for them to obtain information.

Sacks and Wolffe (1998) found in their comparative study that the US-based visually impaired participants 'spent a great deal of time and effort on schoolwork and on being academically successful and were encouraged in these endeavours by their parents and teachers, who did not encourage them to find jobs'. Parents of both blind and visually impaired student had similar expectations of their children's futures e.g. 25% will graduate from a four-year college course, 47% per cent will get a job. However on the negative side parents of youths who are blind are more likely to expect that they will not make successful transitions.

Studies of the career-development needs of adolescents with visual impairments have found that, compared to adolescents without a visual impairment, they have to engage in more thorough career planning, obtain more information about specific careers and make broader choices of careers with improved perspectives on disability (Wolffe, 1997). Hanye (1998) (again a US-Based study) argues that a missing link for visually impaired people is that they do not gain incidental work experience such as mowing lawns and baby-sitting and therefore it is the quality, setting and reality of the work placements which are important. For Hanye (1998, p.846) the key is 'transforming the business of rehabilitation into rehabilitation businesses'.

Employment and people who are blind

'There are 115,000 blind or partially sighted people of working age in the UK: 96,000 in England, 10,000 in Scotland, 5,700 in Wales and 3,300 in Northern Ireland.

- Three out of four are not in paid employment.
- One thousand young people with sight difficulties enter the labour market each year.
- Four thousand people in employment lose their sight each year. Of these around 25 per cent quickly leave work.
- At least 25 per cent of unemployed blind and partially sighted people would like to work if the opportunities and support systems were in place.
- Half of all employers say they will not employ someone who has “difficulty seeing”.

Of the 30,000 blind and partially sighted people in employment, the vast majority participate in the open labour market with a steadily declining number in supported employment' (RNIB, 2002, p.1). Note this may be because there are fewer supported employment opportunities. This may be compared with Spain which has the highest employment rate for people who are blind, approximately 75% of those of working age. Many are employed by the National Lottery.

In respect of the 25% of visually impaired people in employment the highest proportion are employed as telephonists, but there are also physiotherapists, lawyers, lecturers, clerical workers and factory workers (French and Swain, 1997). This compares with approximately 74.9% of the population in general (UK Online National Statistics, 2004). According to their study on behalf of the Institute of Manpower, Honey et al (1993) found that 31% of employers cited a seeing difficulty as a barrier to employment. This was second to mobility (68%); hearing was next with 16%. Paperwork was perceived to be the biggest problem with safety factors next. They found that people with visual impairment generally required specialist equipment to be supplied such as document readers and converting information into braille. Some workers may work at a slower pace and Johansen (1997) questions the meaning of the word 'employment' in relation to deafblind individuals who are not able to perform ordinary work at the speed and rate expected of their fellow workers. He understands employment to be job-related, motivating and meaningful rather than a means to an income.

Honey et al found that people with disabilities tended to spend longer periods of time unemployed than the workforce as a whole, for example 30% had been looking for work for more than three years. The report concludes that employers fail to provide opportunities for people with disabilities partly because of their own prejudices and misunderstandings. With regard to removing barriers to employment for the visually impaired, Crudden and McBroom (1999) found that one of the strategies put forward by those surveyed was to obtain exemplary qualifications before entering the workforce and then continue with educational and training programmes.

From employees'/learners' perspectives Smith et al (2001), in their study of visually impaired children and young people aged 5 to 25, found that of those who thought they would not end up in their chosen job:

- 19 learners out of 174 predicted they would not end up in their chosen career.
- 8 gave reasons directly related to their sight problems, for example they may experience prejudice or lack of suitable equipment.
- The rest were either not related or not directly related to sight problems.

Wong and Dunn (1998) suggest three major barriers that face young people who are blind when they leave school or college and enter the job market. Firstly that they lack employability skills even though they may be able academically. They often have to spend much of the time out of school hours on school work and thus not acquiring other social skills. This is very relevant to this study in respect of time taken on the learning experience. Secondly they cite employer attitude as being a barrier in that even if employers hear of successes they still regard employing a person who is blind as being too risky. Thirdly there is the problem of stereotyping of employment roles for people who are blind. Little creativity is used in this respect and there is insufficient research into how certain roles could be performed by a blind person.

Summary

The literature review in this section, building on that from the previous section, indicates that:

- There is a Government drive on lifelong learning, delivered electronically.
- The focus for adults is on training for work.
- Education and training choices are limited for people who are blind.
- Employment and training choices are particularly limited for blind adults.
- Once in education or training the learning is difficult to access in the widest sense of the word.

People who are blind may not even have same opportunities as sighted people in terms of traditional learning opportunities. This has significant implications when we think about e-learning.

E-learning

This section covers a range of sub-topics under the e-learning umbrella. Firstly there is a consideration of what is meant by e-learning followed by how e-learning relates to learning theories and learning styles. Human-computer interaction is then considered as it is a logical progression from learning theories and learning styles. How the learner interacts with online learning and how easy it is for them to do so may have an impact on the learning experience. If the materials are not easy to interact with or to navigate around then they may even miss some aspects altogether. This leads to usability and accessibility which is also considered here and it is important to distinguish between the two. The section ends with an overview of e-learning related standards. These standards are the basis on which individualised e-learning could occur if they (the standards) are fully operational or enforced.

What is e-learning?

As was shown in the previous section there is a UK Government drive on e-learning and this is demonstrated in its E-learning Strategy (Department for Education and Skills, 2003b). E-learning and its accessibility to and usability by learners who are blind are at the core of this study. Therefore it is useful to first consider what is meant by e-learning. It should be noted that in this study there is a focus on virtual learning environments and learning objects. The former being generally viewed as a delivery device and the latter content focused.

Education and Learning Wales (ELWA, 2003) on their website define e-learning as 'the use of electronic technology to deliver, support and enhance teaching and learning'. It says it has the potential to transform the learning place and will be effective in a number of modes:

- Learning in the presence of a teacher, trainer or lecturer, whose delivery method is supported and enhanced by electronic media and materials.
- Learning from a remote location through direct interaction with a mentor/teacher via electronic media (such as videoconferencing, e-mail, telephone, interactive television etc).
- Independent learning via an electronic medium with access to on-line support.

> In all cases, there is scope for peer support to underpin the learning process, which will rely increasingly on electronic technology the more physically remote the learner is.

The Department for Education and Skills (Department for Education and Skills, 2003b) in the Government's E-learning Strategy define e-learning as:

> If someone is learning in a way that uses information and communication technologies (ICTs), they are e-learning. They could be a pre-school child playing an interactive game; a group of pupils collaborating on a history project with pupils in another country via the internet; a group of geography students watching an animated diagram of a volcanic eruption their lecturer has just downloaded; a nurse taking her driving theory test online with a reading aid to help her dyslexia – the list goes on and it all counts as e-learning.

According to Govindasamy (2001), e-learning is another way of teaching and learning. In its broadest definition e-learning includes instruction delivered via all electronic media including the internet, intranets, extranets, satellite broadcasts, audio/video tape, interactive TV and CD-ROM.

E-learning may be seen to include hypermedia, multimedia, and simulation which are typically developed by the constructivist approach (Maddux et al, 1997). Liaw (2001) posits that the learning environment basically has the following characteristics:

- Users are more actively involved.
- Users have more controllable opportunities.
- Users have a great deal of control of the interaction between users and machines.
- Users usually aim to accomplish more creative tasks, such as problem solving and critical thinking skills.

E-learning and learning theories

Learning theories and, in particular, constructivism and behaviourism are briefly introduced in this section in order to demonstrate their role in underpinning the design of e-learning. This is very relevant as initially it was thought that the pilot studies might be an examination of learners who were blind working in both a constructivist based and a behaviourist based e-learning environment. It was clear after the exploratory study that this would not work. Nevertheless these aspects are re-visited implicitly in the main study. The premise for this is that a constructivist learning environment is more likely to promote exploratory learning compared to a behaviourist learning environment which may promote linear learning. The hypothesis is that a linear environment is more accessible and usable by a learner who is blind. Fundamentally it is likely to be easier to navigate around.

There is a considerable amount of literature on e-learning which is based on constructivist and behaviourist learning theories, particularly in that e-learning environments can accommodate both of these theories. There is firstly a need to look at these theories in general; that is, outside the computer based learning environment followed by a consideration of learning theories within the computer based environment.

Behaviourism

John B. Watson may be considered to be the founder of behaviourism which came about in the early 1900s. He stressed measuring observable stimuli and responses and measuring learning by what people do, rather than what they think (Chalmers, 2000). Behaviourism also stresses reinforcement. Dalgarno (2001) describes behaviourism as emphasising teaching strategies that involve repetitive conditioning of learner responses. There is an implication that there is only one correct form of knowledge.

Khan (1997) compares behaviourist learning theory with cognitive learning theory. The main factors in behavioural learning are what is observed from the outside, and instruction involves shaping behaviours through stimuli, responses, feedback and reinforcement; web-based instruction can take this form. Cognitivists, on the other hand, place more on internal mental states. Cognitivists put forward a number of learning strategies depending on the type of knowledge to be constructed. This may be direct, instruction, deduction, drill and practice, and induction.

Ireson et al (1999) discuss the goals of education in relation to fitness for purpose and say that much effort has been put into task and needs analysis to enable teachers to target specific needs. This involves behavioural analytic models which analyse individual needs in respect of specific goals. This method is also used in industry to address just-in-time, on-the-job skills training. Ireson et al also suggest that similar methods are used to teach more complex, softer activities such as team working. They go on to say (p.220) that 'although behaviourist methods may not be appropriate for all kinds of learning and learners there can be value in the approach'. According to Hallam and Ireson (1999), behaviourist policies in schools are advocated as:

- a means of improving behaviour
- personalised systems of instruction
- a means of delivering computerised learning.

Constructivism

Constructivism on the other hand may be seen to imply that there may be different constructions of knowledge which may all be valid. Learners construct their own learning, or are enabled to construct their own learning on the foundations of what they already know. It is a learning theory rather than a teaching theory so that the teaching may occur in various forms and utilise different methods.

According to Dalgarno (2001, p.184) there are three broad principles of constructivism:

- 'Each person forms their own representation of knowledge building on their individual experiences.' This is attributed to Kant and later adopted by Dewey.
- ‘Learning occurs when the learner's exploration uncovers an inconsistency between their current knowledge representation and their experience,' this is attributed to Piaget.
- 'Learning occurs within a social context, and that interaction between learners and their peers is a necessary part of the learning process,’ this is attributed to Vygotsky.

According to Neale et al (1999), Vygotsky's theories, the learning situation itself and the role of the teacher/instructor will influence the learning outcome.

Weller (2002) argues that constructivism offers a useful background for developing an online pedagogy but one should be wary of its promises. It has several drawbacks which he puts forward:

- It can be time consuming.
- It can lead to mistaken beliefs.
- It can be frustrating to learners.
- It can be a smokescreen for bad teaching.

In light of the above he argues that constructivist methods should be used with other, more traditional, methods.

Another more recent theory is that of Lave and Wenger (1991) who proposed that learning takes place in a community of practice. These communities of practice are everywhere, in work, at leisure and sometimes individuals are at the centre and sometimes they are at the margins. The idea is that learning is a result of an individual’s input and that of other people involved in what might be referred to as enterprises and that novices can gain knowledge from experts. Their theory has been an important influence on pedagogy in the field of collaborative (online) e-learning. Virtual communities of practice afford the potential for the combination of synchronous and asynchronous communication, access to and from geographically isolated communities and international information sharing (Gannon-Leary and Fontainha, 2007). This aspect was important in informing the exploratory studies and the use of the discussion board to deliver soft skills to younger learners who were blind. It was also underpinning the need for these learners to engage in online collaborative learning in order to prepare for university.

Britain and Liber's paper (2000, updated 2004), proposes a framework for a pedagogical evaluation of virtual learning environments. They apply a conversational framework put forward by Laurillard (1995) and conclude that VLEs should not be evaluated on some notion of quality/features, but on the underlying pedagogical assumptions. This is very much in line with Stiles (2001) who argues that more effective learning may take place in a VLE that is designed using a constructivist approach. Conceicaco-Runlee and Daley (1998) conclude in their study that a constructivist approach allows both learners and facilitators to take advantage of web-based learning because theory focuses on making connections and making meaning in the learning process. Moreover it encourages learners to navigate, create and construct their unique knowledge base.

However, most commercial VLEs such as Blackboard, which was used in the pilot study, may be content centred (Milligan 1999) and therefore designed with a more behaviourist approach. Note that the teacher may have some control as to how the content is arranged. Milligan goes on to say that:

> Alternative models of VLE have arisen, particularly within UK Higher education. These adopt a learner centred approach and provide a set of tools to allow the learner to construct (around themselves) an environment for effective learning, by collecting together and constructing a set of resources relevant to the way in which they have understood the learning material.

Milligan proposes that there may be different VLEs for different groups of learners and this is in line with Neale et al's study (1999), see above.

Fitzelle and Trochim (1996) carried out a survey evaluation of a course web site to investigate the question of whether this approach could enhance student learning, what features are most effective in terms of learning and how best to evaluate the learning features. Although they did not specifically consider constructivism and behaviourism it may be ascertained from their study that students stated that features that might be associated with constructivism were both unhelpful and helpful in contributing to their learning. For example, games and control of learning pace were seen to be helpful whereas the bulletin board was not. Students did not like having all the course texts online. Many electronic courses have been designed in this possibly behaviourist way. It should be noted that since 1996 much research has been carried out in respect of discussion/bulletin boards. For example, the work of Salmon (2000) which examines the use of computer mediated conferencing and emphasises the needs of the learners and the new competencies required in online communities.

The literature seems to agree that a constructivist approach to e-learning may result in a 'better' learning experience and that e-learning lends itself to a constructivist approach. This aspect was of specific interest at the outset of the research in respect of how a blind learner could engage in such an environment. However, much more fundamental questions in terms of accessibility and the quality of the learning experience soon emerged.

E-learning and learning styles

This section has been included as there appears to have been a revival of interest in learning styles due to e-learning in that it enables learning materials to be delivered in a variety of modes to suit individual needs. In terms of this study learning style is considered to be important because:

a. Some of the content used for the sample in this study is available in a different format for learners who are blind i.e. it is text based and sequential.
b. When learners who are blind are interacting with content it is important to identify whether this is the 'best' and/or preferred mode for them to access the content.
c. It may be easy to jump to conclusions about a blind learner's learning style, for example if a learner is registered blind this may not mean they cannot see graphics.
d. There is limited, if any, existing research on adult learners who are blind and learning styles.

One of the key questions posed in this study is whether the quality of the e-learning experience will be the same for a learner who is blind as for a sighted learner? The reasons may be down to the accessibility issues but another factor may be the learning style. According to the literature 'learning style' is seen to be personal preference or cognitive style. Learning style refers to a student’s consistent way of responding to and using stimuli in the context of learning (Hergenhahn and Olson, 1993).

There have been a variety of tests so that teachers can try to identify what format content may be in to best suit the individual learner. There are various categories of learning style. Teachers can identify a learning style using Kolb's learning inventory (1984) which categorised learners as ‘divergers’, ‘assimilators’, ‘convergers’ and ‘accommodators’. This inventory was enhanced by Honey and Mumford (1986) and they developed a learning style questionnaire which is widely used, especially in industry. They identified the categories below:

- Activist
- Reflectors
- Theorists
- Pragmatists.

Felder and Soloman (2003) on their web site provide an online learning styles questionnaire which provides immediate feedback as to learning style and provides information as to how learners can help themselves. According to Felder (1999), when mismatches exist between the learning styles of most students in a class and the teaching style of the teacher, the students may become bored and inattentive in class, do poorly on tests, get discouraged about the courses, the curriculum, and themselves, and in some cases change to other curricula or drop out of school. With this in mind he as developed an inventory of learning styles and an online self-test. He sets out four bipolar categories:

- Activist/Reflector
- Sensing/Intuitive
- Visual/Verbal
- Sequential/ Global – this is much like the field dependent/field independent.

It should be noted that these categories are just the tip of the iceberg. The Learning and Skills Development Agency study (LSDA, 2004) identifies 30 different bipolar categories. According to Witkin and Asch (cited in Chen, 2002) the most widely used categories are field dependence and field independence. With field dependence the learner may approach a task holistically and be very dependent on outside influences. Field independence on the other hand involves the learner seeing the detail and being able to restructure their own knowledge without reference to outside influences. What is significant for this study is that, according to Chen, results from a number of studies show that those who are field dependent prefer linear modes of working in hypermedia whereas those who are field independent prefer non-linear modes of working. This links with the discussion above regarding constructivist and behaviourist theories of learning.

Smith (2002) asserts that the term 'learning styles' is used in a broad way to include both cognitive styles and approaches to learning. She addresses the question of whether learning styles are just a gimmick or whether they can make a significant contribution to an inclusive approach to teaching. She concludes that the classifications she discusses can help teachers analyse who to leave in and who to leave out and it is important that learners are aware of their own style.

It is worth distinguishing between personal preference and cognitive style. 'Research into individual differences suggests cognitive styles have significant effects on student learning in hypermedia programmes' Chen (2002, p.449). According to Riding and Rayner (1998) cognitive style does refer to a students' preferred and habitual approach to organising and representing information.

Barker (1993) takes the view that learning style is the preferred way of learning and that ‘way' may refer to lecture or small-group. He goes on to say that in an individual situation some students will choose books or computers to learn from practical experience and interaction. The latter appears to relate to a blind learner's preferred working medium, for example whether they use braille or a PC to access information. Barker says (1993, p.107) that 'it is possible for individuals to change their learning style depending on the mood, type of material that is to be assimilated and the particular situation they are in'.

Brickell (2001, p.111) concludes that 'the challenge for today's educators is to design and develop instructional multimedia applications that have flexibility in the navigation and cater for individual student's learning styles(s)'.

Smith (2002) analyses a variety of learning styles such as deep and surface approaches and field dependence/independence. She comments on opportunities to accommodate ranges and says that with holist/sequential styles the emphasis on written texts disadvantages visually impaired students whereas the use of sound such as music or dialogue may be helpful to visually impaired students.

Sabry and Baldwin (2003) carried out a study which explores the learning styles and perceptions of undergraduate and postgraduate learners in relation to using the web for learning. Of particular relevance here is the focus on the sequential/global learning style. Also of relevance is the use of Felder's index of Learning Styles (1999). The conclusions they come to which are of relevance to this study are that:

- The majority of learners have a higher preference towards a sequential rather than global learning style.
- 'Learning styles instruments should be used to diagnose and predict probable difficulties that might be experienced by some learners when using Information Learning Systems (ILSs) at early stages of the course in order to take necessary remedial action before it is too late (Sabry and Baldwin, 2003).'
- Identification of learning styles in an e-learning situation may make the learning process more enjoyable and the learner more flexible and autonomous.

Kettanurak et al (2001) support this latter point in that they found in their study that interactivity can positively affect the attitude of learners and that some aspects of enhanced attitude can affect performance.

The implication for this study is that if the e-learning is accessible and usable then the blind learner may have enhanced learning opportunities compared with traditional learning. However, if the e-learning is not accessible or usable then the blind learner may have difficulties in engaging in the e-learning experience. It is possible that the blind learner may be restricted to a more behaviourist (linear) approach to the delivery of the content, rather than a constructivist (exploratory) approach. This may in turn offer a lesser learning experience than otherwise. It was initially thought that learning style may have a significant bearing on the e-learning experience of the learner who is blind and this may well be the case. However, at this stage e-learning was not easily available in an adapted format to meet the needs of different learning styles (see below in the discussion of Learner Information Package). Therefore learning styles was not considered further for the purposes of the studies but should be born in mind for future research. Learning styles are, in any case, under close scrutiny with regard to validity and reliability at the time of writing.

Human-computer interaction

> In general, the less users have to think about where they are or what to do next, the more they can concentrate on the subject matter being presented, and hence the more complete their learning (Apple Computer Inc. 1990 in Brickell, 1993).

Of particular relevance to this study and also included in the conclusion of Brickell's paper is that in the development of computer based instruction, which may include e-learning, programs should take into account both:

- student's learning styles;
- clear navigational aids in that learners should not be so distracted by the medium that they cannot concentrate on the learning materials (Stanton and Barber, 1992).

This is consistent with Kim et al (2001) in their GramStain Tutor study, emphasising the need to reduce a learner's frustration associated with cognitive overload. Kim et al also highlight the need for instruction on how to navigate the content.

Schroeder and Grabowski (1995) say that theoretically the use of graphical browsers should help in selecting a more active rather than passive approach to learning. This might have implications for learners who are blind in that they may not be able to experience more active approaches. However, they found that (sighted) users did not always work well with graphical representation of the content structure. They suggest, though, that graphical browsers draw the learner's attention to important concepts 'facilitating both the organisation and integration of new information' (Schroeder and Grabowski, 1995, p.314). They also say that hypertext has been criticised as adding a cognitive burden by requiring users to remember links just made and connect all this information into a coherent whole. This view is supported by MacEneany (2003) in that hypertext materials are more cognitively demanding than text based materials.

Recker and Pirolli (1995) and Mayer (2003) found that too much freedom may not be good in terms of learning, although the ability to take control of learning and to acquire information in a flexible manner facilitates knowledge transfer.

'One drawback of this (hypertext) structure is the potential for users to become disoriented or "lost" in hyperspace' (Heller, 1990, p.434). This is significant as if this is happening to sighted users then there are implications for blind users. Ford and Ford (1992) found that some learners become uncomfortable when navigating in hyperspace and this may affect performance.

McAteer and Shaw (1995) have carried out research in the area of multimedia and learning within the medical field. They have found that learning is more effective when more senses are engaged. In this study they found that when cortical and visual senses are engaged deeper and more meaningful learning can take place. This may not be peculiar to e-learning, but it is significant for this study as it raises the point that learners who are blind may already be at a disadvantage. Moreover if the blind learner is using materials which are designed to enhance and maximise learning using text and images they may be even more disadvantaged if they are accessing only the textual element. This aspect relates to cognitive load theory and is addressed in Chapter 7. There are many studies outside of the field of visual impairment which show that the multimedia presentation of learning content can lead to an enhanced learning experience and better performance results (Mayer, 2001; Mayer, 2003; Moreno and Mayer, 1999; Najjar, 1998).

Graff (2003) draws together the two elements of cognitive type and navigation in hypermedia. In his study he examines whether providing the user with an overview of the web system assists in facilitating learning and whether segmentation of information aids users on apprehending the interrelationship between the units of information. After a given time using the system users were tested on the information. He found that cognitive style and segmentation has an effect on performance whilst the provision of an overview had little effect. This is of particular relevance to the impact of an overview for a blind learner in hypermedia. Whilst this is not examined in this study it is possible that for some an overview of the system is essential and it may well have an impact on the learning experience. Also of relevance to this study are the differences in cognitive style. Graff uses wholist/analytic and verbaliser/imager. This may be likened to the categories used in this study. Learners who are blind may be forced to be verbalisers. Imagers find it easier to keep track of where they are in the content.

The immediate implications of the findings from this study for instructional designers, suggest that it may be profitable to design web-based learning environments to match the cognitive style of the user. More specifically, this implies designing systems that are less segmented for analytic individuals and constructing pages that are more segmented for individuals who are imagers. The presence or absence of the provision of an overview of the web appears to be of little consequence for effective learning, and, as such, this would at first appear not to be an important consideration for instructional design. However, further investigation is required into the extent to which users engaged with the system overview.

Summary

In this section there has been an overview of learning theories, learning styles and human-computer interaction. These have in general been considered in terms of research carried out with sighted learners and the implications for learners who are blind have been identified. All three aspects feed forward into the studies and lay robust foundation stones in terms of a range of theoretical frameworks. The question is raised as to whether the frameworks can apply to learners who are blind and, in order to progress the argument, the next stage to examine is accessibility.

E-learning and Accessibility

In this section definitions of accessibility and usability are considered and these are a central issue to this thesis. Aspects of accessibility are considered here alongside usability as they are often compared and contrasted. Usability can cover many different areas of design but this thesis is concerned primarily with human interaction with the computer interface. As is discussed later in the conclusion, just because a learning object is accessible it does not mean to say it is usable. There are most likely levels or degrees of accessibility and this in turn is part of usability. In the British Standards Institute Statement of Best Practice on Website Standards (2008, p.1) it is stated that accessibility is 'the practice of making websites usable by people of all abilities and disabilities'. This links then directly with the sub-sections on standards, guidelines and legislation which are discussed within this section.

This is a key discussion point and is expanded upon in the Conclusion. In essence an e-learning experience may be accessible but it may not be usable.

Accessibility and usability

Definitions of accessibility were set out in the introduction and are discussed further here. To re-cap, according to Frontend (2001, p.2):

> Usability focuses on making software, websites and online applications and services easy for people to use. Accessibility may be defined as making them equally easy for everyone to use, including people who may use assistive technologies such as screen readers etc.

This is a useful definition in that it implies that accessibility applies to everyone, not just disabled people. Frontend is a commercial company which provides user-centred interface solutions. They carried out a study in 2001 to identify the type of usability problems that users of e-learning may encounter and to learn from the mistakes which were made. They found (p.3) that some serious usability problems were common, including:

- counter-intuitive reading order of on-screen material;
- failure to relate to the real-world experience of the user;
- poor presentation of key information;
- lack of accessibility, even in the most basic sense.

TechDis (2002b) takes a simplistic view and describes a web page as being 'accessible' when its content can be accessed by people with disabilities. In more general terms they also state that:

> accessibility can mean the ease with which a location is reached or building is entered. For those with disabilities it also means providing equal access to information and the ability to complete a task with supporting tools or assistive technologies such as a screen reader or adapted keyboard when using a computer (TechDis, 2002b, p.1).

The University of Birmingham Web Team (2003, p.1) assert that:

> An accessible site is one which could theoretically allow any user to achieve their goals, regardless of ability or technology. In other words, an accessible website is one which is designed to be as usable as possible to as many people as possible. Accessibility is measured in terms of its potential to satisfy users, rather than how well it satisfies a particular group. This is what marks accessibility as different from usability.

In terms of usability they state that a usable website is one which, for a specified set of users, allows them to navigate and perform tasks effectively. Usability is often measured with respect to a predefined set of users: if those users are able to achieve their goals when visiting the site, then the site is usable.

Chalmers (2000, p.516) in his paper examines user interface improvements in computer assisted instruction and concludes, 'the challenge is upon us to fine-tune computer interfaces to make computers easier to use and, therefore, accessible to all learners'. Chalmers is suggesting that if an interface is usable then it is bound to be accessible to all learners. Hitchcock et al (2001) in their paper on third age and usability go further by saying that 'the key to providing accessible systems to satisfy the needs, desires and expectation of all users relies on an understanding of those users within the context of their activities. Anything else is almost certain to lead to exclusion. This is somewhat reflected in the abandonment of assistive technology'. An important point in this study is that although an interface may be accessible it may not be usable.

According to Nielsen (1993), usability testing is a collection of evaluation methods that is increasing in popularity. It is based on observing how users perform tasks and obtaining feedback from users. This is all fed back into the design process. Lindgaard (1994) suggests four categories of usability issues:

- navigation
- screen design and layout
- terminology
- consistency and match with users' tasks.

Kim et al (2001) in their usability study of the GramStain Tutor (online) demonstrated that a usability study with a small number of users can help identify specific problems in the design of an interface. They identified (p.602) several main points (some of which are relevant in the section on navigation):

- The majority of users did not use the multiple navigational options available in the program.
- Navigational patterns differed based on the training background and content knowledge of the users.

- Several visual cues critical to program use were not discovered by the majority of users.
- Icons representing specific functions were not intuitive for user's perspectives.

Their conclusion is of great significance to this thesis as they recommend from these findings that interface problems be addressed before conducting educational studies that examine how educational software programs affect student learning. Interface problems may be seen to include usability and accessibility issues. They separate navigational features from usability features in their study and take usability features to include animation buttons and the following of instructions.

However, Craven and Brophy in their study (2003) set out the usability questions as including:

- ease of navigation
- execution of searches
- following of links
- overall satisfaction levels.

Luke (2002, p.3) in his study of six courseware environments involving people with various disabilities found that accessibility depends on:

- 'the amount of prior experience with network/online technologies
- the availability of immediate assistance when problems arose
- the presence of (or absence) of clear help files
- the extent of familiarity with a given adaptive technology.'

This study is useful in that in most of the other related studies accessibility is attributed to the design of the website whereas this is looking outside the design of the website/HTML. In essence there is a merging of accessibility and usability and it appears to be a grey area. This aspect may cause difficulty when producing standards and guidelines and, indeed, when following them.

Standards and guidelines

According to Seale (2006), guidelines provide recommendations of good practice, whilst standards offer benchmarks on which to judge practice. Learning technologies have been developed since the early 1970s. At the outset there were no standards in respect of production of software or in delivery mechanisms. Therefore it was/is often difficult to transfer and share content. Until recently there has been no system for cataloguing content as there is in libraries, for example. There has been no system of transferring learner information between institutions.

Mainstream (that is, not related to accessibility) standards are considered here in respect of content, VLEs and learner information. The purpose of including these in this review is that they form the foundations of enabling individualised e-learning for everyone and without these standards individualised e-learning would not be possible. Accessibility standards and guidelines are considered later.

Mainstream standards

1. Metadata

At the foundation of standards is metadata. The interest here is in respect of tagging e-content so that it can easily be identified regarding such aspects as level (target audience), subject and more recently accessibility. ‘Metadata’ is often defined as ‘data about data’; in our context, this can be better expressed as ‘information about content’, e.g. Who wrote it? What is it called? Who published it? When? What’s it about? and so on. *Any* information about content (indeed, *any* information about *anything*) is metadata. If metadata is expressed in a standard way it will be easier for a wide range of content to be searched for both precision and relevance i.e. you won’t find material that you don’t want, and you won’t miss material that you do want (JISC, 2003). There are a number of metadata standards including IEEE and Dublin Core.

2. Shareable content object reference

Shareable Content Object Reference Model (SCORM) is a set of technological specifications for designing web-based learning materials and is a standard developed by the Advanced Distributed Learning initiative of the US Department of Defence (ADL, 2002). Each object represents a single learning objective or lesson and can be incorporated into different courses or learning modules, hence the word 'shareable' in SCORM. Among SCORM goals are to enable interoperability, accessibility and reusability of web-based learning content for industry, government and academia. Navigation in a SCORM environment is more restricted than in other hypermedia as links cannot be created between shareable content objects (SCOs) or outside the SCO (Gauss and Urbas, 2003). Gauss and Urbas investigated individual difference in navigation between sharable content objects. They found that interaction with the module had a strong positive effect on learning outcomes and that individual differences in learning outcomes were significantly affected by individual differences in intrinsic motivation, computer experience and navigation behaviour.

3. Learner information package

Version 1.0 of the IMS (previously known as Instructional Management Systems but the term is now rarely used) Learner Information Package Specification was released to the public in March 2001. Learner Information is a collection of information about a learner or group of learners or producers of learning content. The types of information that would be covered by this specification are: accessibilities; activities; affiliations; competencies; goals; identifications; interests; qualifications; certifications and licences; relationships; security keys and transcripts.

> The intent of the specification is to define a set of packages that can be used to import data into and extract data from an IMS compliant Learner Information server. A Learner Information server may exchange data with Learner Delivery systems or with other Learner

> Information servers. It is the responsibility of the Learner Information server to allow the owner of the learner information to define what part of the learner information can be shared with other systems (IMS, 2003).

The Accessibility for Learner Information Package (ACCLIP) v1.0 Final Specification was approved by the IMS Technical Board in July 2003. This aspect is picked up below although it should be noted that this specification intends to address the needs of those beyond disabilities.

Adaptive technology is of relevance here as it begins to address the goal of creating a level playing field in that it has the potential to adapt the delivery mechanism (so long as it is e-based) and the e-content to individual needs, be it concerned with learning styles and/or usability needs. What it may not be able to address at the moment, and what is most likely not considered, is adapting the assistive technology to the individual. For the time being this remains a 'bolt-on'.

Brusilovsky (2003, p.487) states:

> Adaptive hypermedia is an alternative to the traditional "one-size-fits-all" approach in the development of hypermedia systems. Adaptive hypermedia (AH) systems build a model of the goals, preferences, and knowledge of each individual user, and use this model throughout the interaction with the user, in order to adapt to the needs of that user.

Brusilovsky concludes that, amongst other things, the studies summarised in his paper provide evidence that users with different knowledge levels of the subject may appreciate different adaptive navigation support. This alongside standards such as Learner Information Profile (LIP) could provide highly individualised learning experiences and leads in appropriately to the sections on standards and guidelines. It should be noted that neither guidelines nor standards are legally enforceable in the UK. This issue is considered further, together with legislation, in the conclusion.

Standards and specifications on accessibility

This section is a continuation of the section above which looked at general standards in e-learning. In some respects it would have been useful to have them all in one place; however, their separation in an accessibility section highlights the fact that accessibility was never considered at the outset of the standards and as such is only a 'bolt-on'.

Accessibility standards

It is important that metadata is developed that addresses skills and interactions needed to access e-learning rather than using general categories of disability such as those of visual impairment, hearing impairment and motor and cognitive difficulties. One advantage of this is that some learners will have more than one disability. There appears to be a gap between the metadata specifications for assistive technology and those for learning objects that could possibly be bridged by using a vocabulary of ‘learner characteristics.’

Seale (2006) describes two sets of robust standards and these are set out briefly here together with the recently published British Standards Statement of Best Practice (British Standards Institute, 2008).

1. IMS Global Learning Consortium Standards

In July 2003 the IMS released two new specifications for sub-schemas that define a means to describe accessibility preferences and learner accommodations:

- IMS ACCMD: Access for All Meta-data (IMS 2004)
- IMS ACCLIP: Accessibility for Learner Information Package (IMS 2003).

The ‘accessibility’ data structure includes the following elements: language, preference, eligibility and disability in the Learner Information Package. This specification adds the AccessForAll element under accessibility because it is intended to address the needs of learners beyond those with disabilities. The disability element is deprecated henceforth (IMS, 2003).

There are three types of accessibility choices:

- display (how the user interface and content should be presented)
- control (alternative ways of controlling a device)
- content (specification of auxiliary, alternative or equivalent content requirements).

These aspects are relevant not just for the disabilities they set out, these being visual, hearing, motor and cognitive, but also for others learners who may be using a personal digital assistant (PDA), have low bandwidth or work in a noisy or quiet environment, for example. Learners would enter their own preferences in respect of such aspects of assistive technology, preferred media and format, possibly via an online questionnaire. Administrators could enter information on such aspects as assessment accommodation.

ACCLIP has been tested in the Barrier-free project (Research Centre for Advanced Science and Technology, 2003) and a sample of media-rich content was used as this is often the hardest to adapt for individual needs. To accommodate the learners who were blind and to provide additional commentary on the video audio descriptions were created: spoken descriptions of the visual content that usually fit into the pauses in the soundtrack. Outside specific projects ACCLIP will be little used at this stage in the game.

It should be noted that it is not compulsory to adhere to these standards in the United Kingdom.

2. The Learning Federation Accessibility Specification for Content Development

These are a set of standards developed in Australia and New Zealand and specifically address accessibility in terms of online curriculum for schools. The Federation (TLF) aims to maximise learning opportunities for all students. They have created a range of user accessibility profiles. These are for vision impairment, hearing impairment, physical impairment and cognitive impairment. In terms of vision impairment the profile (The Learning Federation, 2008, p.5) is:

> Vision impairment includes tunnel vision, loss of vision in different parts of a person's visual field, colour blindness, poor acuity, loss of centralised vision and severe vision impairment. Complete blindness is not the most common vision impairment. Students may be born with vision impairment or may become vision impaired through illness or accident.

The Federation have developed a wide range of standards, specifications and guidelines relating to the development of web-based content and which cover, alongside accessibility, rights management, third-party intellectual property, technical specifications, metadata, the Learning Object Repository and Exchange and TLF editorial styles.

3. British Standards – Statement of Best Practice

This document, 'Defining, implementing and managing website standards', was published in April 2008 and is a Publicly Available Specification (PAS). It sets out a best practice approach to defining, implementing and managing website standards. Whilst it is mainstream in nature, accessibility appears to be at the heart of its ethos and in many senses it is not a bolt-on in this document, although it should be noted that it is about the application of website standards and not the standards themselves.

Accessibility guidelines

There are a number of guidelines and specifications set out in terms of accessibility and the web and/or e-learning. The Centre for Educational Technology Interoperability Standards (CETIS, 2003) represents FE and HE in the United Kingdom in terms of standards in the international arena. There are a number of special interest groups (SIGs) one of which is the Accessibility Group. Its aim is to make implementers of content and systems for learning technology in the FE and HE sectors aware of accessibility issues.

1. World Wide Web Accessibility Initiative

The World Wide Web Accessibility Initiative (WAI) provides guidelines for web content, authoring tools and user agents. 'WAI, in co-ordination with organisations around the world, pursues accessibility of the Web through five primary areas of work: technology, guidelines, tools, education and outreach, and research and development' (WAI, 2008).

> The power of the Web is in its universality. Access by everyone regardless of disability is an essential aspect (Tim Berners-Lee, W3C Director and inventor of the World Wide Web).

There are 14 general principles or guidelines set out by the WAI:

1. Provide equivalent alternatives to auditory and visual content.
2. Don't rely on colour alone.
3. Use mark up and style sheets and do so properly.
4. Clarify natural language usage.
5. Create tables that transform gracefully.
6. Ensure that pages featuring new technologies transform gracefully.
7. Ensure user control of time-sensitive content changes.
8. Ensure direct accessibility of embedded user interfaces.
9. Design for device-independence.
10. Use interim solutions.
11. Use W3C technologies and guidelines.
12. Provide context and orientation information.

13. Provide clear navigation mechanisms.
14. Ensure that documents are clear and simple.

There are also 3 levels of accessibility, known as priorities:

- Priority 1 – minimum level of accessibility which may exclude some people with disabilities.
- Priority 2 – there will be some people who will not be able to access the web-based content.
- Priority 3 – most people with a disability will be able to access the content.

The emphasis is on web pages rather than e-learning, although some e-learning content may well be web pages or set out in a website and so the basic principles may apply. Note also that the emphasis is on accessing rather than using.

2. IMS Guidelines for developing accessible learning applications
According to its website, 'The IMS Global Learning Consortium develops and promotes the adoption of open technical specifications for interoperable learning technology. Several IMS specifications have become worldwide de facto standards for delivering learning products and services. No fee is required to implement the specifications.'

The White Paper (version 1.0, 2002) 'IMS Guidelines for Developing Accessible Learning Applications,' covers 5 main areas of disability:

- People who are blind.
- People with low vision.
- People who are colour-blind.
- People who are hard of hearing or deaf.
- People who have physical difficulties.
- People who have language or cognitive difficulties.

These guidelines set out six principles in respect of accessibility:

- Allow for customisation based on user preference.
- Provide equivalent access to auditory and visual content based on user preference.
- Provide compatibility with assistive technologies and include complete keyboard access.
- Provide context and orientation information.
- Follow IMS specifications and other relevant specifications, standards and/or guidelines.
- Consider the use of XML.

3. Website testing

Coyne and Nielsen (2001) have produced a set of methodology guidelines for testing websites and the intranet with users who use assistive technology. These guidelines are based on previous studies they conducted to gather data and insights for the report 'Beyond Alt Text: Making the Web Easy to Use for Users with Disabilities' (Nielsen Norman Group, 2001). This study is discussed in more depth in section 5.2. In this study it was found that it was six times more difficult for someone using a screen reader, and three times more difficult for someone using magnification, to use the internet than someone using no assistive technology.

The guidelines cover such categories as:

- trust, Consent forms, Pictures and Videos;
- using Video and Still Cameras;
- conducting studies on site;
- specific tips for Screen Reader and braille sessions;
- specific Tips for Motor Skill Assistive technology sessions;
- recruiting and preparing participants.

There has been a significant amount of research into accessible web interfaces in terms of access to websites. There has been a great deal written about how to make websites accessible to people who are blind and/or users of screen readers. There has been relatively little research into the accessibility and usability of e-learning. However, the research into web interfaces is relevant here in that the web interface may constitute part of the e-learning experience. According to Luke (2002, p.1), 'A significant portion of the population is at risk of being excluded from online learning environments. People with learning and/or physical disabilities may be prevented from participation due to problems in the design of the learning technology itself and/or with the pedagogy directing its use.'

4. Guidelines and VLEs

As early as 2001 Pearson and Koppi set out to investigate means of making HE inclusive and accessible to people with disabilities through the use of educational technology. The guidelines were produced as the result of an evaluation of WebCT in practice at the University of New South Wales (UNSW). The methodologies included an evaluation of the courses by the researcher, discussions with and a survey of designers, interviews with students with disabilities and student evaluation of accessibility of online courses. The evaluation was based on W3C Guidelines (see above), the Bobby website and courseware design. The guidelines covered such areas as use of graphics and other visual items, use of screen readers and their limitations, tables, colours, pdf and other read-only file formats.

Doyle (2001) produced guidelines on how to make modules accessible in Blackboard 5.5. These guidelines include a quick tip guide which describes what to do and why you need to do it. Areas covered include:

- A quick tip guide e.g. use solid background colour, avoid use of more than ten links per page.
- How to upload accessible materials e.g. some screen readers are not able to read tables; for assistive software users ‘click here’ on an image map may not be accessible.

- Advanced information on the latest version of Blackboard and accessibility issues, for example, Blackboard has a frame structure and frames can be difficult/impossible to navigate through especially with older style screen readers.
- Further improvements in the latest versions including accessibility issues.

Additionally, TechDis commissioned a report (2002a) which outlines research undertaken to investigate the accessibility of VLEs. The VLEs were selected, which included Blackboard and WebCT, because they were part of the Joint Information Systems Committee (JISC) interoperability pilots. A questionnaire was issued to VLE vendors which covered areas such as:

- Whether there is an accessibility statement.
- Whether advice on accessibility is provided.
- Whether there is advice on e.g. tables, multimedia, images and image maps etc.

The initial response rate was poor with only Blackboard and WebCT indicating high levels of commitment to achieving accessibility. The report concluded that there are a range of guidelines and checklists available, but there is a need for providers to address accessibility and that institutions need to consider the accessibility of a VLE as a contributing factor in making a purchasing decision.

Summary

Seale (2006) considers accessibility guidelines, standards and legislation in some depth. She concludes (p. 47) that the aim of these is to change practice, but that practice is not changing due to:

- confusion over which guideline and /or standard to adopt;
- confusion over the difference between guidelines and standards;
- difficulties in interpreting and applying guidelines and standards.

She states that what would be useful are detailed accounts of how other practitioners have interpreted, implemented and applied the standards, guidelines and legislation.

It should be noted that compliance to these standards and guidelines does not necessarily mean that web-based resources will be accessible. For example, it is possible to run a website through Bobby and 'get approval' without it being accessible. Even if it is accessible it does not meant that it is usable and this may have a serious impact on learning, which is at the crux of this study. Dunn (2003) in her conclusion says that guidelines can be flawed, are open to interpretation and they do not ensure usability. Simply checking a tick box can not ensure a positive learning experience for the end user.

This section has examined e-learning in respect of what it is and how it relates to learning theories and learning styles. These aspects were considered important in the early studies, but it was found that in fact much more fundamental questions such as usability and accessibility needed to be addressed. It has also considered what is meant by usability and accessibility. Emerging standards in the area of e-learning may facilitate individualised learning, access and usability issues. There are, however, conflicting standards. Standards in respect of accessibility are beginning to emerge. However, it should be noted that none of these are compulsory/enforceable by law. Organisations can insist that e-learning delivery, technology and content meet certain standards. However, some providers may state that they meet standards such as W3C when they do not.

ICT and Blindness

It was not felt necessary to look at ICT issues for learners who are sighted although e-learning issues for this group were examined. This section first considers the number of people who are blind using computers and the internet. Some of the difficulties that this group encounter and how they cope are examined under the sections on assistive technology and navigation.

General computer use by people who are blind

Network 1000 is a project funded by VISION 2020 UK and carried out at the University of Birmingham (Douglas et al, 2007). The broad project aim is to 'generate information regarding the needs, circumstances and opinions of people with a visual impairment in the UK' (2007, p.34). One aspect of this is about evaluating the effectiveness and access to ICT and access technology. In the study it was found that computer use is clearly linked with age, with older visually impaired people far less likely to use computers. In their paper they argue that ICT may offer benefits which include access to information and a way to employment. However people who are visually impaired perceive a range of barriers which include cost, availability, accessibility of technology and access to training.

In the United States 51% of people (all ages) with no disability regularly use a personal computer in comparison to 13% of people with vision problems. While 23% of people without a disability have never used a computer, 70% of those with a visual problem have never used one. 17% of employed people without a disability have never used a computer, in comparison to 31% of employed people with vision problems (Lighthouse International, 2002).

Internet use by people who are blind

In Europe 11% of the population has visual, learning, cognitive, auditory or physical dexterity disabilities – enough to affect their ability to access the web, and this is expected to reach 18% by 2020. (Frontend.com, 2001). 30.6% of 3 to 24 year olds who are blind or who have a severe visual impairment in the United States (out of a population of 267,000) access the internet from home (NTIA and ESA, 2002).

In the USA the majority of people with no disabilities (57%) report having internet access (at home or elsewhere), in comparison to one fifth (21%) of people who have a vision problem. Of employed people without a disability 64%

have internet access (at home or elsewhere) in comparison to 54% of employed people with vision problems. The differences in computer use and internet access among those with and without disabilities decrease slightly when considering only people who are employed (age 25-49), Lighthouse International (2002).

Gerber and Kirchner's study (2001) looks at access (in respect of a computer and connection being available) to the internet for different groups of visually impaired people and how this might relate to age, employment and education. Other papers focus on access (in respect of actually getting to and reading the material once on the internet); for example, Sager (2000) and Flowers et al (2001) identified that 79% of colleges' home pages had accessibility problems.

Gerber (2002) found that blind and visually impaired people were willing to put up with frustration, high costs, imperfect technology and additional time input because of the benefits of essentially being able to increase their independence.

As far as can be reasonably ascertained, the literature in the specific area of people who are blind and e-learning is very limited, other than in terms of accessibility and usability issues. There is research in related areas such as special education and learning environments; for example, Neale et al’s study (1999), where constructivist learning theory was used as a basis for a framework to evaluate the behaviour of the participants as well as the design quality of three different VLEs. The focus of this study was with children with behavioural/learning difficulties and the VLEs were virtual environments, such as a shop; therefore there are limited ways in which it is applicable to this proposal. The study enabled them to make recommendations as to improvements in design and they concluded that it is possible that a behaviourist approach may be better. It should be noted that in this study the learning environment was a virtual environment simulating experiential learning, such as a supermarket, where the learner can select goods, take them to the check out and pay for them. 'In practice it was found that the teachers always provided some directive or instructional role. Without teacher initiation or instruction for the next task, a student may not progress through the VLE.' Neale et al (1999). This finding is very relevant to this study as it reflects back to the first paragraph of the review and the importance of accessing information and learning completely independently. This may be true for anyone using a VLE, not just somebody with a learning difficulty. It may be easy for anyone to miss an important feature. Therefore a blind person would be able to navigate within the environment more easily than in a constructive environment which may be non-sequential and have little guidance as the student is expected to learn independently.

Assistive technology

This section commences with an overview of screen readers, followed by an examination of magnification. This is followed by a consideration of access to technology and training. The technology may be complex to use particularly as it is being used on top of other technology. It is sometimes referred to as access technology rather than assistive technology for this reason.

The RNIB (2003b) describe assistive technology as ‘a specialised piece of equipment or software which is used by someone with a disability to improve their ability to use a computer. Types of assistive technology include screen readers, refreshable braille displays, screen magnifiers, voice recognition, closed captioning, alternative keyboards and mice.’

Assistive technology is defined in the glossary section of the TechDis (2002b) website as 'Information and communications technology designed to compensate for impairment and/or limitations in disabled users.'

Douglas (2001) refers to 'access technology', rather than 'assistive technology'. He says that (p .360) 'access technology refers to technology (usually software) which is used in conjunction with mainstream software in order to provide “access” to the underlying functions'.

Roulstone (1998) uses the term 'enabling technology,' but is in general referring to new technology. He defines (p.10) new technology as covering 'mainstream, off-the-peg technology and specialised technologies purposely designed to allow disabled workers to function in a conventional work setting’. In the light of this and other aspects he critiques the deficit model of disability and adopts a social barriers model. He argues that new technology under the social barriers model can redefine the major barriers to disabled people in the workplace i.e. environmental, technical and attitudinal barriers. This environmental aspect is discussed in Douglas (2001) in relation to WHO classifications of 'activity' and 'participation'. 'Activity' is concerned with individual performance in activities and 'participation' is concerned with involvement on a society level. Douglas posits that a visually impaired child's limitations in activities and restrictions in participation are more or less directly related to the visual impairment. He goes on to say that the manipulation of environmental factors may improve performance in both areas.

According to Bhargava (2003) blind and visually impaired people often interact with more computational devices than their sighted counterparts. He says people who are blind have intimate relationships with the digital assistive technologies. They use a range of tools to access information, but they generally do not use these tools to create their own computational artefacts. He seems to be taking a wide view of assistive technologies as he is including a digital cane. Bhargava documents the use of an existing computational construction kit and its use to write programs to control a programmable brick, ‘a microcomputer that can interact with the world via sensors, speech synthesis and numerous other actuators’ (p.10).

a. Screen readers

A screen reader is a software program that allows a blind person to read text on the screen and identify some graphics such as buttons on a toolbar or icons on the desktop. The user hears the information through a speech synthesiser on the computer’s sound card. A screen reader also allows the user to control the computer using the keyboard rather than a mouse. The screen reader will tell the user about all aspects of the page – what text is on it as well as the menu items. Many of the keyboard commands that a blind person uses are the same keyboard commands that a sighted person can use on their PC, such as the Windows standard keystrokes. For example, the File menu can be opened by pressing Alt-F. A blind person also uses special keyboard commands that are created by the screen reader. For example, most screen readers offer a keystroke to read the information in the title bar or in the status bar. Web pages can be navigated by using the tab key to move around links on a page or between pages. Pressing the enter key will activate a link. The cursor keys can be used to read pages and also navigate. There is usually a links list facility: a shortcut which will bring up a list of links on a page where the cursor keys are used to move up and down through the list. The list can sometimes be sorted into alphabetical order and to show only recently visited links. Usually pressing the first letter of a link within a list will move the cursor to that link.

Screen readers are generally very verbose and a new user may only be able to cope with speeds of around 150 words per minute, but an accomplished user has the speed set at around 250 to 300 words per minute; this is similar to average reading speeds (TechDis, 2003). Users may have to listen to elements several times to find out where they are:

> Great skill is needed to navigate the World Wide Web using a screen reader and keystrokes. An effective user will typically use a mixture of tabbing around links, cursoring up and down the page and bringing up a links list (if available). A screen reader may not read everything that is on a web page. Users may have to listen several times to get a mental map of where they are, what is on the page and where to go next. Too many navigational elements, often repeated on all pages, can be very time consuming. A screen reader presents users with pages in a linear fashion, and the user tabs from link to link and moves down with key arrows etc. If the information is too hard to find the user will naturally give up. Items not available through keyboard strokes will be missed out altogether' (TechDis, 2003).

There is a number of screen readers/screen reading software packages available. Craven and Brophy (2003) found that the more advanced screen readers do allow greater control of navigation and that expertise also had a big impact on the success of a task. More advanced screen readers in this case include JAWS, Supernova and WindowEyes. The former two are the screen readers which have been used in this study. Bowman's study (2002), again in the library field, used WindowEyes and compared the accessibility of a number of academic databases. Whilst many of them were accessible Bowman concluded that WindowEyes was effective but very time consuming to learn how to use, 'learning to use a screen reader requires concentration, patience and a commitment to use the tool frequently in order to maintain skills' (Bowman, 2002, p.5). Axtel and Dixon (2002, p.2) in their review of Voyager 200 an integrated library system note that, whilst it is essential to involve users in evaluation, the user who is blind only knows what is on the screen from what the screen reader is 'telling' them. Therefore it is vital to have someone who can see what is on the screen to test the site for accessibility. It has been found that accessing the internet with a specially developed talking web browser was superior in terms of functionality and ease of use (Lau, 1997). However, it should be noted that since then there has been a move away from this sort of access and that there is little use of talking web browsers. This is because it may be easier to use the one screen reader to access a range of applications.

Craven and Brophy, as a result of their study, state that access to the most up-to-date software enables greater control. However, it should be noted that the most up-to-date assistive technology may not be compatible with other software and operating systems.

D'Amour and Roy (2002) in their presentation at CSUN (California State University annual assistive technology conference) described their comparison of JAWS and IBM's Home Page reader in terms of web access. They compared such features as keyboard access and reading of tables and frames. Home page reader came out significantly better.

It is important to note that not all people who use screen readers are blind. Some people who have dyslexia or learning difficulties may use a screen reader. Some people who are blind use a screen magnifier (see below) support when using the Web.

b. Screen magnifiers

> A screen magnifier is hardware (lenses) or software that increases the size of the text or images displayed on a computer screen. Screen magnification programs are used to enlarge text and graphics and can also provide focus within a small area with an enlarged cursor or pointer. The more powerful programs have many other attributes which are very helpful including font smoothing at high levels of magnification so that a letter can appear without jagged edges even when it fills the entire screen (TechDis, 2003).

This type of magnification is known as projection magnification and is capable of producing a clearer image as well as a larger image. Magnification of greater than x4 may be difficult to use in a web-based environment and screen reader support may be needed.

c. Access to assistive technology

People who are blind have limited access to assistive technology unless they are in education or in employment where they may be entitled to the ‘Access to Work’ scheme or support from employers. For private use even if they do have access to assistive technology it is possible that it will not be the most up-to-date products due to expense (see below) and that many suppliers update their products on an annual basis.

Assistive technology can be expensive; for example, a screen reader such as JAWs costs, at the time of writing, around £800. The user will also need to have a personal computer or laptop and peripherals such as printers and scanners, increasing the cost to around £1,400. They will then need to purchase broadband internet access on top of this to maximise opportunities for communication and independent access to information. Such equipment and facilities will not be viewed as being essential to independent living and therefore there is no funding available for it. Some libraries and associations for the blind, for example, may have equipment available but use of this would be limited. Some charities will support funding of such equipment but increasingly this must have a work-related focus.

One of the biggest barriers in terms of access to assistive technology in the United Kingdom is the lack of interaction between social services and the National Health Service (European Commission, 2003). This is because, for example an individual's need for assistive technology may be identified by an organisation in one government service but either not referred to another service or, even if it is, there may not be any funding available.

According to Douglas et al (2007) people with a visual impairment who did not use computers often identified socially based causes as barriers. These barriers include:-

- cost
- availability and accessibility of equipment
- availability of training.

Some people who are blind may have access to equipment and training through a local association for the blind but generally speaking access to training by appropriately qualified and expert teachers is not available unless the person is in education or training for work.

d. Training

Gerber, in her previously referred to study (2002), concludes that the potential exists for computers to balance some of the effects of visual impairment and provides equal opportunity. This is very much in line with the fourth key question posed in the study, that is, whether the quality of the e-learning experience is the same for a learner who is blind as for a sighted learner? However, Gerber identified a number of barriers which include lack of training and lack of training materials. In her study which involved mainly people who had had a sound education, she found that most of them had had no training at all and were largely self-taught. It was also identified that trainers did not have time to get to grips with the technology either. This latter point is also picked up by Corn and Wall (2002) in their survey of the use of technology and multimedia presentations by teachers of students with visual impairments. They found that the teachers were more at ease with general technology rather than the assistive technology. They found that teachers would use simpler technologies when adapting materials even if these were not the most appropriate. Two of the most important recommendations to come out of this survey are:

- The need for targeted assessments in respect of assistive technology.
- Identify the basic skills and knowledge for teachers of assistive technology and make sure these are kept up-to-date.

In relation to lack of teacher knowledge, Abner and Lahn (2002, p.103) found in their survey of teachers of learners with visual impairments that the teachers did not, in general, feel competent to teach assistive technology. '93% of the teachers surveyed used the internet and 88% per cent used email, but the level of telecommunications use was not being transferred to the students, given that only 8% of the students used the internet.' Douglas (2001) also points out that new technologies are often complex and that teachers must have high levels of competence to exploit the technology's potential.

The Learning and Skills Council (2006) set out in their strategy for improving education and training for people with learning difficulties and/or disabilities that by 2010 there will be a fully qualified workforce in the Further Education system, including those working with learners with learning difficulties and/or disabilities. They state that there are insufficient specialist qualifications for all staff and a lack of appropriate professional standards which severely limit the capacity and capability to deliver. It is not clear at this stage what the nature of the specialist qualifications might be but the focus is on staff teaching and supporting learners with disabilities to obtain mainstream qualifications at the very least. Specialist qualifications at the moment come second. With a move to regionalisation, inclusive education and changes in funding there is a strong possibility that expertise may be spread thinly and it may be watered down. The University of Birmingham provide a distance education programme for specialist teachers of children with a visual impairment. More recently the programme utilises online learning facilities including a chat facility and a discussion board. In two studies relating to this problem-based online learning and teaching resources, McLinden et al (2006 and 2007) recommend that more induction is necessary to the ICT aspects of the course. This is important here in that if the teachers have robust skills with ICT then they are better placed to support learners who are blind and visually impaired and who may be using similar ICTs/online learning. Alongside the course is a set of standards and guidelines specifically related to teachers in Further Education produced by the Visual Impairment Centre for Training and Research (VICTAR, 2007) at the University. Aspects of these standards specifically relevant to this thesis include:

- How to make learning programmes more accessible to learners with visual impairment and why this is important.
- The role of information technology in affording modes of learning attractive to potential learners with visual impairment *(for example access to the internet through JAWs)*.

The above review may show that there are a number of issues with screen readers and magnification, not least that the technology is often difficult to use and expensive to buy, and training may be inadequate.

Navigation and users who are blind

Barnicle (2000, p.106) comments that 'software applications with a graphical user interface have been a major source of concern within the community of computer users who are visually impaired since the first GUI was introduced in the early 1980s'. Fifteen years later they say it is little different. They found that both novice and experienced participants had difficulty completing certain tasks efficiently and successfully. Participants were unable to achieve a high level of success. Barnicle says that employers are increasingly looking for high rates of success and they posit that a success rate greater than 80% is necessary. They did not carry out a comparative study with sighted users but do suggest this would be the next step.

Three important studies in the field of visual impairment and the accessibility and usability of e-learning are those by Coyne and Nielsen (2001); Craven and Brophy (2003); and Morley et al (1999).

1. Coyne and Nielsen's study (2001) is particularly relevant as some of their methods were used in this study. The goals of the study (p.8) were 'to learn how people with low vision, no vision, and motor-skill challenges use assistive technology and the Web and to find examples of usable and unusable designs'. There was a quantitative study carried out which involved 60 participants. 20 used a screen reader, 20 used screen magnifiers and 20 did not use assistive technology. In the qualitative study, 15 used screen readers, 12 used screen magnifiers, 8 used braille devices and 9 used assistive technologies. In both parts of the study participants were asked to carry out tasks relating to finding information in different websites. In the qualitative study the researchers had more interaction with the participants. In the quantitative study the participants were timed. The tasks included buying a Janet Jackson CD and finding out the names of Elvis Presley's parents. All participants were familiar with the assistive technology and most of them were employed. They found (p.10) in their study that sighted users using no assistive technology were:

- about six times as successful at completing tasks as people using screen readers, and
- three times as successful at completing tasks as people using screen magnifiers.

They go on to say sighted participants were significantly:

- less frustrated,
- more satisfied and

- more confident (Coyne and Nielson, 2001, p10).

In the study it was also found that there was a very close relationship between actual success and how confidence, satisfaction and frustration were rated. After completing each task in both parts of the study, the participants were asked to rate their confidence, satisfaction and frustration on a 7-point Likert scale. The study found that the sighted participants who used no assistive technology were ‘about six times as successful at completing tasks as people using screen readers and three times as successful at completing tasks as people using screen magnifiers (enlargement software)’ (Coyne and Nielson, 2001, p.10). It also revealed that the sighted participants were significantly less frustrated, more satisfied and more confident than were the participants who were blind.

2. Craven and Brophy (2003) concur with Coyne and Nielsen in that visually impaired people have to spend more time searching for information than sighted people. They found that the time spent can be reduced considerably if simple design features are included. These features may include a logical and meaningful menu, a search facility and a strict limit on the number of links per page. The objective of this study was 'to develop understanding of serial searching in non-serial digital library environments, with particular reference to retrieval of information by blind and visually impaired people' (Craven and Brophy, 2003, p.2). The steps in tests used by Craven and Brophy were broken down into ‘serial’ and ‘parallel’. This enabled comparison between the number of times people moved from page to page (or site to site) with the number of times they have to move around a page. Tasks included looking for a current weather forecast and looking for men's suits priced between £100 and £200 as well as library databases. The tasks were not timed but participants were asked to stop when they thought they had satisfactorily completed the task. Semi-structured interviews were carried out to provide data on emotion, feelings and experience. The studies show that users who are visually impaired have to spend more time navigating around a page than sighted users and need a greater variety of keystrokes. It was observed that screen readers forced users

to navigate pages in a serial way which was not always appropriate for the design of the page.

Both Coyne and Nielsen’s and Craven and Brophy’s studies showed that users with visual impairments have to spend more time navigating around a page than sighted users and need a greater variety of keystrokes. They also observed that screen readers forced the users to navigate pages in a serial way that was not always appropriate for the design of the page. Non-completion of tasks occurred in both studies, as did intervention by the researchers. Intervention highlights the issue of dependence. These findings were in line with those of Barnicle’s (2000) study which examined the interaction between graphical user interfaces and screen readers. Even though many of the obstacles encountered by users were slight, the cumulative effect led to delay and sometimes to non-completion of the task.

3. Morley et al (1999) conducted a study with nine blind users of a hypermedia system that made use of a non-visual interface, non-speech sounds and three input devices. They found that apart from the design issues, the users enjoyed the chance to explore in a nonlinear manner and ‘were excited by the multi-media presentation, which gave them access to a wider variety of information than ever before’ (Morley et al, 1999, p.25). Their most important recommendations as to design, other than general usability issues, may be seen to include:

- an interface with a range of input and output devices to suit a range of users e.g. novice to expert;
- non-speech sounds to provide feedback rather than text;
- user configuration available;
- produce interesting and varied hypermedia – taking as much care, if not more, than for visual systems.

Barnicle (2000) found in his study to examine the interaction between graphical user interfaces and screen readers that, even though many of the obstacles encountered by users were slight, the cumulative effect led to delay and sometime to non-completion of the task. Non-completion of tasks occurred in both of the above studies as did intervention. This latter point again highlights the issue of dependency.

Summary

This section shows that a majority of people who are blind do not use a PC, let alone use the internet and/or engage in e-learning. It has been argued that once a user who is blind has access to the internet they may find it six times as difficult to use as a sighted person. Teachers must have a high level of competence to teach internet and related skills and that these levels are not being met. If learners who are blind are to use e-learning on a level playing field then the literature indicates that this is extremely difficult because of:

- barriers to accessing a computer;
- lack of opportunity to obtain suitable training;
- accessing an online environment with assistive technology;
- using the online learning materials.

Conclusion

In the above review it may be seen that it is difficult for learners who are blind to access education and employment in general. There is a Government drive towards e-learning in an effort to address just-in-time individualised learning needs to improve workforce skills and the economy. Assistive technology can allow access to the internet but there is very limited research in relation to the use of e-learning by learners who are blind. The *sequenced* questions that need to be answered are therefore:

1. Can a learner who is blind access e-learning?
2. Can a learner who is blind engage successfully with e-learning?
3. Can a learner who is blind engage on the same basis as a sighted learner? For example do they differ in terms of time taken and ease of use/usability?
4. Will the quality of the e-learning experience be the same for a learner who is blind as for a sighted learner?

This concludes the first part of the literature review. This section has examined underpinning themes and has enabled the researcher to understand and present the context of e-learning and blindness. Most importantly it has elicited four key questions that must be answered in respect of whether e-learning can offer a level playing field for visually impaired learners. Now the thesis considers the methodology required to answer these questions.

CHAPTER 3

METHODOLOGY

Introduction and Overview

> Don't fit your proposed study to your favourite approach (Gorard 2003, p.11).

This chapter is concerned with the reasoning behind the choice of methods of data collection and the analysis of the data relating to the exploratory and pilot studies. Methodology ‘involves the theory and analysis of how research should proceed, how research questions might be best addressed and the criteria against which research findings might be evaluated’ (Maynard, 1994, p.8). A range of methods was used and this is because the research question was developed over a number of years through the process of several small but related studies. This development moved from a focus on qualitative methods to a mix of both qualitative and quantitative methods (blended method). The rationale behind it and the development of a theoretical framework are described in this chapter below.

The setting up in 2000 of an Information and Learning Technology (ILT) Team at a specialist college for blind and visually impaired learners offered a unique opportunity to investigate the use of e-learning by learners with a visual impairment. When the team started out little or no work had been done in this specific area. With the main remit being the preparation of learners for transition to further education (FE), higher education (HE) and the workplace, there were many avenues that needed to be explored in terms of e-learning and learners who were blind.

As identified in the literature review, there were a number of questions to be answered and as such were like stepping stones. The study developed through four main stages and in terms of methods of collecting and analysing data and the literature there is a great deal of linkage. Also, for the purposes of this chapter, the development of a methodology is considered as a planned developmental process. Within this chapter there are signposts to the relevant chapters in the literature review. In this respect the path of the development has been influenced by the research question at the time. These questions have been like stepping stones which lead progressively to addressing the broader aim of gaining a clearer understanding of the issues surrounding the potential of e-learning to support visually impaired people's learning.

1. Initially there was the question of whether a blind learner could **access** e-learning. (Observation during the first pre-pilot showed that this was possible).

2. This developed into the question of whether a blind learner could **engage** in e-learning. (Observation during the second pre-pilot showed that this was possible).

3. Then whether they were able to **access** and **engage** on the same basis as a sighted learner – with a focus on ease of use and time taken. (Quantitative data from the pilot indicated that this might not be the case).

4. The final question, or stepping stone, was the extent to which the **quality of the learning** for a blind learner was equal to that of a sighted learner. The main study re-visits methods from the pilot to further examine the findings therein. An extension of the pilot to examine the quality of the learning that takes place was to follow and the methodology is explored further in Chapter 7.

It is worth noting that previous studies, by the researcher using feminist methodologies, had been carried out on gender and the use of ICT, and lifelong learning and learners with a visual impairment. The approach had been successful and insightful and it was initially thought that this type of approach could be applied to this project.

Importantly, as already indicated, the research questions are *sequenced*. That is, question two is only relevant if question one is answered positively. Similarly, question three is only relevant if question two is answered positively, and so on. To this extent the methodology chapter proved difficult for the researcher to write because the methodological direction of the work evolved as the research unravelled. Arguably the first research question is a relatively easy one about ‘access’ and it leads to a more complex comparative question about ‘quality of learning’. Either way, the research questions demand different approaches.

The solution to this dilemma is to provide a methodology chapter which gives an overview of the general approaches taken and how the methods were developed through two initial exploratory studies and then a pilot study. Exploratory study 1 was concerned with research question one (can a blind learner *access* e-learning?). Exploratory study 2 was concerned with research question two (can a blind learner *engage* in e-learning?). The pilot study was concerned with research question three (can a blind learner access and engage on the same basis as sighted learners?). The consequence of the approach is that the findings of the studies become ‘revealed’ to the reader by implication rather than presentation of the studies themselves. Nevertheless, this approach seemed the most efficient way of presenting the research journey taken by the researcher.

The following sections are described below:

- ethical issues
- initial approaches
- exploratory study 1
- exploratory study 2
- pilot approach
- validity and reliability
- conclusions.

Ethical Issues

This section examines first the issue of empowerment followed by an overview of issues relating to the exploratory, pilot and main studies. Further specific issues are discussed in more detail in the relevant chapters.

A primary consideration was that the research should have some influence in improving e-learning for people who are blind and visually impaired. Alongside this it was initially felt important that the research should in some way be empowering. Empowerment, according to Seale et al (2008) is about process and outcome. As an outcome they view it as being about attainment of choice and control. They see the process of empowerment as being about people developing increased skills to take control of their lives. The initial thinking behind the research was largely in-line with this, but in some ways more about the process of learning that there are choices. In retrospect the definitions given by Seale et al (2008a) are more useful.

In line with feminist research methodologies referred to above and discussed below Duckett and Pratt (2001, p.833) 'would encourage research that seeks not just to include visually impaired people into research activity, but ensure that the research roles visually impaired people occupy are sufficiently empowering'. They believe that, amongst other things, 'the over-arching aim of research should be to further the empowerment and inclusion of visually impaired people'. It is worth noting that Duckett and Pratt (2007) found in their review of academic literature relating to research into visual impairment and the inclusion of visually impaired people in this research that, since the earlier studies, their call for greater use of studies which would include empowerment had not been realised. However they do state that there is an indication that the social model of disability has had an impact on national and international policy.

In the wider field of disability research but directly related to e-learning, Seale, Draffan and Wald (2008b) drew on the related fields of participatory design of participatory research for the Lexdis Project. 'The overarching aim of the study was to explore the e-learning experiences of disabled learners within the University of Southampton in order to increase understanding of the many complex issues and interactions introduced by disabled learners' requirements for accessible e-learning, compatible assistive technologies and effective learning support.' They argue that e-learning policy and practice should be guided more by an empowerment model.

Roulstone (1998), in his national study of people with disabilities, technology and employment, states that there is an absence of disabled people's voices in related research. He says this is more than a methodological shortcoming; rather it is about researchers adopting an assumption about the value of their ideas over those of the researched.

In terms of the specific questions posed in this study relating to ICT it was considered at any early stage that empowerment, as such, might pose difficulties if that was to be a primary aim. This became increasingly a concern as the questions posed demanded that related methods became more quantitative in nature. The first exploratory study required the researcher to work on a one-to-one basis with the learners. This would have been useful in terms of maintaining confidence with the technology and this, as such, could be seen to be empowering in respect of skills gained. However, this is not empowering in the political sense for an individual as identified by Roulstone above, although collective studies may have political influence. The second exploratory study required the researcher and two assistants to work with a small group of six learners in an action research scenario. Again this was empowering in terms of skills gained and these skills were learned alongside discussion of life skills and issues so that in one sense this research was empowering for individuals. The pilot study was perhaps the least empowering as there was a focus on skills and the tasks involved were quite difficult. The ethical issues raised in this study are discussed at length in the conclusion.

The following aspects refer to the main study and relevant sections of the British Educational Research Association Guidelines (BERA, 2004):

1. Permission was sought from the Principal of the specialist college to carry out the studies. The author had a Criminal Records Bureau (CRB) check which covered working with young people and vulnerable adults. The author is a qualified teacher of 11 to 18 year olds and has a great deal of experience of working with this age group as well as with adults with disabilities.

2. The research process for the pilot and main studies was explained fully to each individual and each individual signed a consent form which also stated that they could withdraw at any point. This was a very important aspect in that for the exploratory and pilot studies the author was the participants' teacher and it would have been possible that the learners felt that they had to engage in the process. During the explanation and the request for them to participate it was made very clear that they did not have to and it was entirely their own decision.

3. Participants were not identified by name and were allocated a number both in the thesis and during the data collection. Participants were videoed and this data analysed but there are no published photos. In the unlikely event that somebody broke into the secure area and watched the videos they would not be able to identify participants as it is only their hands and fingers that have been videoed. It is extremely unlikely that they could identify the voice. In addition the data is not, as such, of a highly sensitive or confidential nature and it would most likely not embarrass or harm anybody in the very unlikely event that it was revealed.

4. Data was stored on a password protected computer. A copy was made and stored on CD and kept in a locked drawer together with the original paper-based data.

5. In terms of disclosure of harmful or illegal behaviour it is very unlikely that this would occur in this study. However, if it had occurred and disclosure was necessary then the participants would be informed of this. If non-

disclosure was to occur then comprehensive notes would have been made and stored in case they were needed for future reference.

6. In respect of the main study participants could receive a copy of a research article focusing on the outcomes of the study if they wished. In terms of the performance tests each individual was given immediate feedback on their performance.

Initial Approaches

This section on initial approaches to the methodology relates to the initial work prior to the pilot. These approaches were an important part in identifying the research area, the research question and gathering qualitative data at the outset. As set out above the initial question was whether a learner who was blind could access e-learning and observation indicated that he or she could. The second question was whether a blind learner could engage in e-learning.

Research methods are techniques for gathering evidence (Bird and Hammersley, 1996), and there appears to be two opposing approaches: quantitative and qualitative. Quantitative research involves collecting facts and studying their relationships. These methods include questionnaires, surveys and attitude scales. Quantitative research has been influenced by, and is associated with, the natural science model of research where there is a focus on that which can be measured, causal relationships and generalisation. However, ‘researchers adopting a qualitative perspective are more concerned to understand individuals’ perceptions of the world’ (Bird and Hammersley, 1996, p.6).

These methods include case studies, informal observations (the method used in the exploratory studies) and in-depth interviews and were developed by social scientists in the 1960s as it was considered that quantitative methods were inappropriate for studying aspects of human beings. This may be because they do not take into account individual experience, and a person’s life might only be really understood in relation to what goes on around them in society. However, it should be noted that the difference between the methods is not that clear-cut, for example some questionnaires may contain qualitative features such as open-ended questions, whilst some in-depth interviews may result in responses that may be quantifiable. Moreover, the terms can be seen to be the two extremes of a continuum. Some studies combine both methods and Hammersley (1993) argues that this is not exploited enough.

Robson (2002), in respect of approaches to social research, eschews the positivistic view of science. He makes a case for critical realism and a pragmatic approach which encompasses mixed method studies and this is the approach used in this study. Gorard (2003) argues that numeric evidence forms the basis of good qualitative studies and moreover that there should not be a distinction between the two approaches.

The above argument is supported by Mason (2006a) who posits that qualitative thinking is a good starting point for missing methods and that there are research strategies that transcend the quantitative/qualitative divide. She argues that data and methods should be linked rather than meshed and that there should be ‘development of ‘multi-nodal’ dialogic explanations that allow the distinctiveness of different methods and approaches to be held in creative tension, (p.9).

Brannen (2009) states that mixed methods are indeed a growth area but not new and refers to studies going back as far as 1918 where data such as statistics, diaries and newspapers articles were combined. She puts forward an argument that the increase in mixed methods is due to a number of trends. Most importantly for this study is the trend towards funders seeking to commission research that meets policy and practitioner, that there is a need for research to be more customer/end-user focused. This would imply that one reason a researcher might choose a mixed method approach would be to gain a more complete picture of a situation (complementarity). This is in-line with the first of the six strategies, based on purposes of using mixed methods, put forward by Mason (2006b). In this case the purpose is for mixing methods for a close-up illustration of a bigger picture, or for background Molina-Azorin (2009) found in the context of business studies as a discipline, that this purpose was the least used, the most used being facilitation, that is to develop and test theory or to improve the measurement instrument.

For the purposes of this study it is considered that a mixed method for the purpose of complementarity would best enable the research question to be addressed and this is discussed further below.

Feminist and related methodologies

In terms of epistemology the researcher set out to help enable oppressed groups to engage more fully in education and lifelong learning opportunities. From the start of the project, particularly the work carried out prior to exploratory study 1, there has been a focus on issues of social exclusion, equality and diversity. It was initially thought that aspects of feminist modes of research, particularly in-depth interviews, could begin to shed light on the research problem. These were methods previously used by the author in terms of examining issues of gender and computers and lifelong learning and learners with a visual impairment. This was a dissertation as part of a Masters Degree in Education (Lifelong Learning). In the study participants were invited to explore their experiences of ICT in relation to previous experience and career expectations and to reflect and consider their future options. The author/researcher’s role was one of a facilitator and the intention was that the interviews would be carried out on an equal power basis. The methods were successful in terms of collecting qualitative and quantitative data which gave considerable insight into the relevant issues as well as effecting positive personal change in some of the participants (that is the research was emancipatory).

Qualitative methods are often regarded as the quintessential feminist mode of research since feminists have used and adapted these methods, for example auto/biography and life-history, and, more recently, emancipatory research. These have been used to ‘give voice’ and to empower women so that they are aware of their own subjectivities and oppression and change may be brought about (OU, 1997a).

Feminists have rejected quantification for several reasons, and this has come from three main sources (Jayaratne and Stewart, 1991):

1. Firstly, its association with positivism and what constitutes science. ‘Science is characterised in terms of the objectivity of its method and the value-neutrality of the scientist,’(Maynard, 1994, p.7). However, it may be argued that scientific research is not value-neutral. Scientists in the past have been, in the main, male and science has developed from a male perspective. Also, what to research, who to research and how to research it has been selected by someone, so that there is already a strong element of subjectivity. Hammersley (1993) raises doubts as to what the natural science model is. Feminist research, on the other hand declares subjectivity quite openly: ‘to do feminist research is to put the social construction of gender at the centre of one’s inquiry’ (Lather, 1988, p.292). However, some mainstream academics may see it as being ‘unscientific, politically motivated and biased’ (Jayaratne and Stewart 1991, p.221).

2. Secondly, women were disillusioned with traditional research, for example in respect of power relationships. Quantitative methods usually involve the researched being subordinate and just a source of data. This may also be the case in interviews, where the interviewer is an academic and is more powerful because of her position. Empowering research attempts to address the power problem (see below). However, there may be situations where the researcher is less powerful, for example in relation to class, race, gender and disability. In the Education and

Gender Study Guide (OU, 1997b) it is argued that men, as with non-disabled women carrying out research on disabled women, would need to take a non-disabled person's perspective, but they can not ‘give voice’ to disabled women.

3. Thirdly, there is concern that quantitative research supports sexist and racist attitudes in that it may demonstrate difference but that it does not try to understand it. Qualitative research does try to understand and this may create problems with analysis and interpretation. It should be noted that it is not the purpose of this research to understand these types of difference, rather to understand accessibility issues. Holland and Ramazanoglu (1993, p.281) argue that there is a need to acknowledge this complexity and say that ‘feminists have had to accept that there is no technique of analysis or methodological logic that can neutralise the social nature of interpretation’.

Roulstone (1998) draws on a social barriers model for understanding and providing insights into the lives of disabled people. He uses this to replace the deficit model about which he says that 'technology would not be significant except for its impact on the deficits of the disabled person. Technology then has a corrective function, one that corrects an individual's shortcomings' (p.11). From a social barriers perspective the inadequate employment demand for disabled people is 'due to the disabling nature to the employment environment and to the negative employer attitude to people with impairments' (p.12). If applied to an educational environment then the social barriers model would be appropriate to this study. The barriers for people with a disability can be addressed by the designers of the learning materials. This is addressed more fully in Chapter 6 in respect of cognitive load theory in that the designers can reduce the cognitive load required to engage effectively in the learning experience.

Postmodernism focuses on multiple subjectivities, which would have the advantage over a feminist standpoint in that it could address the cross-cut of class, race, gender and disability. It was specifically this approach (used in the author's Master's study of gender and computers) that was judged to be of significance in examining the issues relating to e-learning and blind people. It is seen as the way forward for many feminists, but it may have only limited use in research because of its fragmented nature, and there may not be a base for collective action. Postmodernism challenges the dualisms such as mind versus body, subject versus object, male versus female which create a hierarchical system (Lather, 1988). It can be seen at this point that this may cause some problems with the qualitative and quantitative debate described above. It was argued that it might be quite legitimate to use a quantitative method of research but this is clearly at odds with postmodernism.

There has been a move towards quantitative methods in feminist research. An example is the research by Kelly et al (1992) which is concerned with what young people choose to tell in a self-report questionnaire. They do not confine their research to the questionnaires, but make notes on other aspects, such as students' expressions and positions whilst filling out the forms. Therefore they are adapting the 'hard', scientific method to a 'softer' method more in keeping with feminist research. They argue that questionnaires allow for anonymity and that some people may reveal more under these circumstances. Their main point is that 'what makes research feminist is less the method used, and more how it is used and what it is used for' (p.236). They also argue that since qualitative research has been the definitive feminist approach, this has marginalised work such as theirs, or 'where the participants are men, or the focus on institutions and/or written texts'. Their research shows that quantitative methods have much to offer feminism. This is much in line with Robson's pragmatic approach, as above, and the approach adopted in this thesis.

Exploratory Studies

Exploratory studies are referred to as ‘studies’ for ease of reference. However these were not as such formal studies but rather informal data collection carried out as part the of author’s normal teaching practice

Exploratory Study 1

The pre-pilot was carried out as the initial stage of hypothesis generation. Initial investigation indicated that some blind people would not be able to physically access (i.e. by using a screen reader) learning via VLEs. It was not known at this stage whether and/or to what extent the concept of a VLE would pose usability problems. There was no or very limited literature existing at the time in respect of the use of VLEs by blind learners. Any literature was more in the form of guidelines and research into the use of the internet. With this in mind the pilot was intended initially to:

1. indicate the extent to which a blind person could access a VLE;
2. establish an observation schedule;
3. establish an analytical framework;
4. establish a framework of questions.

It was clear that a feminist approach as discussed above was not appropriate. Data about the sociological backgrounds of individuals was not relevant at this stage although data concerning previous experience and attitudes to ICT would have been useful. At this stage the research was exploratory in nature. Data was collected by informal observation. Written observation notes were made and these were set out in a table in order to identify incidences of difficulties or ease of use. The researcher sat alongside the participants and gave instructions as to what was required and help when difficulties arose. Axtel and Dixon (2002) recommend a sighted user working with a user who is blind in that it is essential to know what is visible on the screen, what the screen reader is detecting and what the blind user may not be accessing. In addition there is the experience of the blind user which may not be replicated by a sighted user switching the screen off. This may be in line with Morris (1992) who argues that only disabled women can carry out research on disabled women; however, she does say that others may have a role to play. This can be a difficult area to address ethically, and links to specific ethical issues set out at the end of Chapter 4, and in terms of equality and diversity. The person who is blind should be in a better position than a sighted person to assess whether an environment is accessible. However the extent to which an environment is accessible will vary from person to person mainly in terms of their experience and expertise. It can be difficult for someone to accurately assess accessibility for someone who is less skilled. This may also apply to sighted people.

It was not possible to make direct comparisons since both learners used different VLEs and an observation schedule was not possible since some functions were not available in all the VLEs, or if they were they were not accessible. The learners' general comments were also noted which covered areas such as frustration or suggestions for improvement.

It soon became clear that the next question at this stage was whether it was possible for a blind learner to access a VLE independently with a screen reader and if so how this would work.

Exploratory Study 2

At this stage, the second pre-pilot, an action research approach, alongside questionnaires regarding prior experience, was used to gather information about how learners could best interact with the VLE. This was considered to be appropriate as the previous study had shown that VLEs could be accessible. Learners could benefit from the VLE being used as a teaching tool and it would not be a ‘waste of their time’ just simply working with the researcher to further explore the features of the VLE. Lewin coined the term 'action research' (AR) in 1944 and described it in more depth in a paper published in 1946. Lewin saw it as being participatory, having a democratic impulse and making a contribution to social science and social change; characteristics that are relevant to modern AR but in a different way. Kemmis (1988) says that the choice of research method depends on the presumed character of the object of the research. He goes on to say that educational research is justified by reference to its contribution to educational reform, and therefore almost all educational research is policy research and has the aim of influencing educational practice through local or system wide policies about curriculum and pedagogy. AR may go one stage further and in some cases is seen to be emancipatory and should be used to address social injustice. All of these aspects were applicable to this thesis.

Kemmis (1988) asserts that AR places control over the process of educational reform in the hands of those involved in the action, and that AR may have more validity than conventional educational research in that only those actually involved in a social situation can truly understand it; this links back to Morris (1992). Educational research is often invalid because it is separated from the object that it claims to understand, that is the classroom practice of teachers. A large part of conventional research is based on positivistic social science (the dominant tradition) and set against this is the argument that AR is said to be imprecise. Related to this is the notion of AR being an emancipatory process. Weiner (1989), writing from a feminist perspective, criticises mainstream AR in that it only addresses professional self-improvement. Gender researchers are more focused on outcome as mainstream is focused on process. Gender researchers see AR as being emancipatory and Stenhouse (1975) agrees with this both for the teacher and for the learner. Weiner concludes by saying that AR should aim to increase both professional self-knowledge and social justice.

Pilot Approach

Methodological challenges

The two exploratory studies provided evidence that people with a visual impairment could both access and meaningfully engage in e-learning. The research now focused upon research question three – can a blind learner access and engage on the same basis as sighted learners? This research question has a different feel to the previous two questions because it has a comparative dimension to it. The question is concerned with whether one group can do more of something than another group – that is can sighted learners engage *more* in e-learning than learners who are blind? This required more quantitative and positivistic approaches.

This was challenging to the researcher. Not only did it offer technical challenges of developing different research approaches suitable for the research question, but it also challenged some of the methodological assumptions that had initiated the research and guided the design of exploratory studies 1 and 2. As outlined, some of the inspiration for the research as a whole was feminist and related approaches, with a particular interest in research as emancipatory. Some of these research traditions are suspicious of quantification. Nevertheless, the researcher felt (and feels) that research which seeks to understand a situation in any depth can draw upon research that seeks to quantify. The epistemological challenge remains however. The original research was fuelled by a belief that visually impaired people did not have a 'level playing field' in relation to access to e-learning. It seemed difficult to reconcile this belief with a more *positivistic* approach which seeks to *objectively* compare the engagement in e-learning between people who are blind and sighted people.

Robson (2002, p.20) gathers together a number of assumptions about positivism:

- Objective knowledge can be gained from direct experience or observation and it is the only knowledge available to science.
- Science separates facts from values.
- Science is largely based on quantitative data.
- All scientific propositions are founded on facts – hypotheses are tested against facts.
- The purpose of science is to develop universal causal laws.

- Cause is established through demonstrating empirical regularities.
- Explaining an event is simply relating to a general law.

> It is possible to transfer the assumptions and methods of natural science to social science.

Gorard (2003) comments that policy-makers and funders demand evidence that includes numbers. In contrast, students of social sciences tend to avoid numbers. This links directly with the quote at the start of the chapter 'Don't fit your proposed study to your favourite approach' (Gorard, 2003, p.11). There was a strong feeling by the researcher that a qualitative approach may be preferable as previous studies relating to ICT had to some extent been emancipatory and highly supportive with a sharing of the power base based on feminist research methodologies.

The emerging research questions were clearly indicating a need for quantitative data and this presented a tension as, for the researcher, this went against previous experience and a feeling of addressing social justice. However, on the other side of this was the desire to influence policy in respect of e-learning developments, and, indeed, request for data by quasi-government organisations at that time for data relating to disability and the use of e-learning. The informal nature of the work combined with low numbers of participants meant that any potentially interesting issues that were identified would require follow up research using more formal methods. In addition and what is different with this whole study compared to previous studies carried out by the researcher, is that actually it is the technology that is being tested. Attempting to test ICT and provide an emancipatory experience is probably fairly ambitious; however, this did work successfully in the second exploratory study. Such an approach may prove to be difficult with larger numbers, not least because of the amount of time involved.

Whilst case studies can convey powerful messages and be highly insightful they demand the attention and engagement of the reader in terms of time and energy input. Relevant data in the form of numbers and graphs can have an immediate impact and may convey, more than quantitative data, that they have been the result of a rigorous and objective process. This is of course not necessarily the case, as Robson (2002, p.23) states as part of critiques of the 'standard view' in relation to social research, 'Standardisation and distance from the research object do not guarantee objectivity because the perceptions and meanings of the researcher penetrate the research process.'

The above aspect is significant in the case of the exploratory and pilot studies. The author was close to the participants in that she was already teaching them on a regular basis together with the fact that she had an employment remit to research accessibility. However by the time of the main study she was no longer in a teaching role at the college. She was therefore in a position to take a step back and had time to reflect on the earlier processes.

Emerging conceptual framework

A consequence of the pilot study requiring a comparative and quantitative approach was an emerging requirement for the research to embrace notions of measurement – notably measurement of engagement in e-learning. The literature review and the pilot studies had made a distinction between accessibility and usability of e-learning. These, it was argued, were prerequisites of true engagement in e-learning – i.e. participating in the learning experience. It was this conceptual step which helped the researcher start to develop a conceptual framework which distinguished between *accessing*, *using* and *doing*:

1. **Accessing** is concerned with getting to the information. For this study this will involve assistive technology i.e. a screen reader or magnification.

2. **Using** involves navigating around the VLE. This will involve moving between pages and around pages.

3. **Doing** is concerned with activity or task performing which may be reading instructions, reading and posting a message, uploading a file, opening Word and thinking. Ideally doing should mainly involve learning.

It was this framework which became central to the pilot study as a method of exploring how visually impaired and sighted learners differed in the time and effort they were putting into these related tasks. With this emerging approach notions of validity and reliability became progressively more vital.

Validity and Reliability

> Validity tells us whether an item measures or describes what it is meant to measure or describe (Bell, 1993, p.64).
>
> Reliability is concerned with the extent to which a test or procedure produces similar results under constant conditions on all occasions (Bell, 1993, p.65).

In the studies so far very small numbers of participants have been involved so it is not possible to make general conclusions. However, the numbers were large enough to give indications of possible trends. The group of learners used in exploratory study 2 was a different group from the one used in the pilot study. The group (aged 16 to 19 years) was to a great extent more homogenous in terms of their age, their level of expertise, experience with ICT and level of study, but not in terms of disability. This was a likely scenario as it was a study based on action research methods i.e. it was a normal teaching situation. The pilot group differed greatly in its composition. The learners were adults with ages ranging from 20 to 55, a wide range of skills and experience with ICT, sighted, partially sighted and blind learners, and a range of levels of study. Again the purpose was to gather information to enable hypothesis generation.

For the pilot study it was decided to ascertain what learners were doing at any point in time when working in a VLE and this relates directly to the framework of accessing, using and doing as described above. At this stage the aim was to measure how much time was being spent on specific tasks and activities. In doing this and in terms of reliability there is the possibility of misinterpretation of what the learner is doing at a given point in time (point sampling); in this case 10 second intervals. It may appear that, for example a learner using no assistive technology spends little time navigating as this is momentary and may not be captured with the ten second interval method. This could be resolved by working with the learner using the video or the learner thinking out loud whilst they are carrying out the task. The former approach may be useful but difficult if the participant is blind, and in any case extremely time consuming. However, the latter may result in cognitive overload as the learner would have to be analysing whether they were accessing, using or doing at the same time as carrying out the task and using assistive technology.

The process can be quite time consuming especially if the researcher doing the analysis had not been present during the videoing. It is recommended that these two tasks should be done by the same person and ideally the latter task be carried out by two researchers. Learners may feel under pressure doing this sort of ‘test,’ and great care was taken to explain that it was the software that was being tested and not them. This approach does not indicate the quality of that learning or how much learning is taking place, but it does begin to quantify how much time is spent on accessing. This begins to put a measurement on how accessible a VLE is to the individual. In general terms e-learning delivery mode or content are said to be accessible or not accessible. This is, in the main, directed at groups of people usually categorised under four main types of disability (hearing impairment, visual impairment, motor impairment or cognitive difficulties). For example, the WAI guidelines indicate accessibility in terms of priorities and the extent to which the guidelines are followed may make web-based information more accessible to more groups of people. However, this does not take into account individual needs or the needs of people with more than one disability.

Conclusion

From the above it can be seen that the informal studies revealed questions that could be refined and tested in further research. It can also be seen from the above that there has been a development of the research methods from a qualitative approach to a more positivist stance. A mixed method approach, involving both numeric and text data (Cresswell, 2003), evolved with an emphasis on the quantitative side.

This was in part due to the previous research experience of the author when a qualitative approach had been used successfully to study the relationship between ICT and gender in a framework of lifelong learning. There was a danger that the author had been trying to fit the proposed study to their favourite approach (Gorard, 2003). This linked in with the direction of the Literature Review at that time, particularly in terms of learning theories

The demands of the questions posed have in part been the cause of this. The conceptual framework necessitated the collection of hard data in the information in relation to the amount of time spent on accessing, using and doing in the VLE. There was also a mix of hard and soft data collected relating to satisfaction of engaging with the learning tasks. This involves in essence a numerical value being given to a subjective rating. Nonetheless the qualitative data has been useful in terms of evidence and also in informing teaching practice.

The methodology is re-visited in Chapter 6 alongside the literature review which focuses on cognitive load theory (CLT). CLT can be measured in a number of ways and for the main study this is by time, perception of mental effort and performance tests. All of these require the collection of quantitative data. However, the perception of mental effort is a subjective rating and is, in this respect, similar to the satisfaction ratings which are also used in different formats for the main study.

CLT had not been considered in the exploratory and pilot studies. The focus had been on the conceptual framework of accessing, using and doing. In the pilot study it was found that the learners who were blind were spending a significant amount of time accessing (approximately a third of the time) and using (approximately a quarter of the time) compared with the sighted learners who spent no time accessing and approximately a fifth of the time navigating. It was hypothesised that not only did the learners who were blind have an additional task to contend with, that is the use of the assistive technology in isolation, but that they were carrying out this additional task at the same time as doing. It was possible that this additional work and effort would have an impact on the quality of the learning experience and that there was an additional cognitive load for the learners who were blind. Initial investigation into CLT showed that there might be features of this that could be used to analyse the e-learning experience for learners who were blind in comparison with learners who were sighted. These aspects are considered further in the Literature and Methodology Revisited, Chapter 6.

CHAPTER 4

EXPLORATORY STUDIES 1 and 2

Introduction

This chapter sets out the two exploratory studies which trace the development of a conceptual framework of accessing, using and doing as described in the methodology. The key question to be answered at this stage and as indicated in the literature review and methodology was whether a person who was blind could access VLEs.

The studies came about as result of the author's teaching role of teaching learners who were blind how to use the internet using a screen reader. Alongside the teaching role another aspect of her remit was to identify VLEs that could be used by a learner who was blind. The purpose of this was to prepare learners for transition to HE so that they were not held back by any difficulties with using a VLE. Such difficulties may involve accessibility issues and these would need to be identified in advance so that work-around or alternative activity could be identified. As noted in the Methodology, the term 'study' has been used for ease of reference, because as such these are not formal studies but informal observations carried out in a normal teaching role.

Initial investigation had indicated that some people with a visual impairment would not easily be able to physically access (that is by using a screen reader) learning via VLEs. This initial investigation was carried out by a sighted user using a screen reader to access a VLE such as a discussion board, multiple-choice questions, uploading assignments and content. It was not known at this stage whether, and/or to what extent, the concept of a VLE would pose usability problems. The study was intended initially to indicate whether it might be easier for a visually impaired person to use a content-based VLE (more linear in nature) or a learner centred VLE (less linear in nature). It was hypothesised that the content-based VLE would be easier (more usable and more accessible) for a blind person to use as the learning would be presented in a linear fashion and there would be a set path through the materials. This would be in contrast to the learner centred VLE with a less directed pathway, and more scope for non-linear navigation and interaction with other learners and tutors via discussion boards and chat rooms.

The study was also carried out in order to establish an observation schedule and to identify a conceptual and theoretical framework.

It should be noted that at the time this study was carried out there were large numbers of VLEs available both for industry and for education. Technology was less advanced with low bandwidth which often meant that interaction with web-based VLEs could be very slow or completely unsuccessful, disregarding the accessibility and usability issues.

Exploratory Study 1

The Scale and Scope of Exploratory Study 1

Initial exploration involved the author observing two learners who were blind navigating around a VLE. The VLEs had been pre-selected, the criterion being that at least some of the links and frames were announced by the screen reader.

There were two participants (Learner A and Learner B) and both of these learners had no useful sight and used screen readers. Neither of the learners had experience with VLEs. Learner A was experienced with ICT, using a screen reader (JAWS) and could browse the World Wide Web successfully and generally, independently. Learner B had limited ICT experience but was not confident in ICT or screen reader (Supernova) use and could not browse the World Wide Web independently. Informal, semi-structured observation was carried out with each learner on a one-to-one basis.

The author was already working with the learners in terms of acquisition of internet skills. As previously discussed it was made clear to them that they were under no pressure to participate in the research. Permission was sought to use observations and anonymous quotes where necessary in respect of published papers during the course of this research. This is particularly important as the College in which they were based operates in a relatively small arena and subjects might be identifiable. The purpose of the research was always explained and discussed with the participants. Robson (2002) points out that there may be ethical problems associated with captive populations such as those in a residential college. Participants may be in a less powerful position and this aspect is discussed further below.

It was decided to introduce the learners to an intranet environment to begin with. The intranet at the College consisted of a large number of linked web pages containing text content and was created to be accessible to the least confident/computer literate of learners and was designed to work with the screen reader Supernova. Two VLEs were used and for the purpose of this study they are called VLE1 and VLE2. These were demonstration versions of VLEs available at the time of writing, but they are no longer available. Both had similar features in that there was a content area, discussion board, chat facility and an assessment facility.

Method

In session one the research was explained to the learners and they were introduced to the College Intranet. Course materials that they were familiar with were used. They were guided to the home page and shown how to get to the learning materials. They were then asked to navigate around the site. They were offered help with keystrokes and other features when needed.

In sessions two and three they were introduced to the VLE. The similarities and differences to the College Intranet were explained. They were guided around and observed accessing materials and various tools including a discussion board and chat facility. They were not asked to navigate the VLE independently.

The purpose of this method was to:

- ascertain whether they found the web-based materials on the College Intranet easier to access than the non web-based network;
- find out how this could be improved and highlight any areas of difficulty;
- prepare the learners for using a VLE;
- find out if the VLE was accessible with a screen reader;
- find out how easily the learners could independently access materials and use the collaborative features;
- find out what the learners found difficult and what they found easy.

The data which had been collected as written notes from semi-structured observation was analysed as below and this was carried out by analysing the data in a table. This was separated into a section for each learner and against these headings the observation sheet was divided into screen reader and learning environment design. A score of one, two or three was given on whether the screen reader coped with the site or whether the site was designed well. There was no score given for the learner's use of the learning environment. The learner's experience/ability in this respect has already been discussed. Written observation notes were made and these were set out in general terms in a table. This highlighted any repeated areas of concern. The learner’s general comments were also noted.

Written observation notes were made and these were set out in a table. It was not possible to make direct comparisons since both learners had entirely different skills levels. An observation schedule was not used since some functions were intermittently unavailable in the VLEs (due to bandwidth issues) or were totally inaccessible and therefore it was not possible to follow a set schedule.

Results

The College Intranet

Learner A had problems with the screen reader. This was because the College Intranet was developed to work with Supernova and Learner A uses Jaws. Both learners were able to navigate around the web pages and did not get lost. Learner A accidentally closed the College Intranet down (this was a common problem in a VLE at the time as the designers assumed you are using clickable navigation buttons rather than the Windows shortcut keys). Learner B closed down the browser accidentally. This s a problem that occurs quite easily with keystrokes and occurred when using the VLEs in the later studies. This is particularly important as at the time some VLEs had a log out procedure which meant a user could not log in again for 20 minutes. They both seemed to be very confident about where they were going and how to get back to the home page. Both learners preferred accessing material in this way rather than using the college network and drives. Learner B had found it extremely difficult during his course to access materials via the college network and often gave up in frustration. He was able to access learning materials, read them and he did not have to worry about saving them to his user area.

Learner A said that from a blind person's point of view there should be as many links as possible to cut down the amount of text that has to be read through. This is an interesting point as there is often a tendency to try to cut down the number of links.

Learner B also suggested that it might be a good idea to build in tones to show where the learner is on a page such as how far down they are in which case the tone may be lower than if they were at the top of the page. However, he did add that this would not be useful if you had a hearing impairment. He also suggested that any links should be in alphabetical order. He also wanted a very quick and easy way of taking notes (which there was not); 'this is supposed to be easy and be a tool'.

Virtual Learning Environments

VLE 1

Learner A was comfortable logging in. He went straight to a frames list without being prompted. Unfortunately the frames were poorly labelled so they gave no indication about what the content was about. It is very important when designing an online learning environment that links and frames are labelled appropriately so that a screen reader will announce them. The table below sets out a list of frames with the name of the frame on the left and what was actually in the frame on the right.

Table 1 List of frames, name and actual content

Name of frame	Actual frame
Main LSE	Logo
Pop up windows	Address bar
Navigation	Course Contents
Hidden	Main Frame

The material was called 'About Best Practice' but it was difficult to find this out from what was announced by JAWs. The only way to do this was to switch the virtual cursor off, then reformat the page by pressing F5 and then put the virtual cursor on. Learner A found it extremely difficult to access any learning materials at all. He found it difficult not to use the standard Windows navigation buttons. It is necessary to use the back and forward buttons to move between pages that involves additional tabbing.

In the assessment activity JAWs announced that the page had no links but in fact it had three and this appeared to be quite a common problem. Learner A was able to read the assessment activity. However, it was not possible for him to submit an answer. This particular activity required submitting your answer as a Word document. It was not possible to do this. Learner A was not able to tab to the browse button without going into forms mode which is relatively complicated. He used Alt and cursor left to return to the home page and then exited completely by accidentally repeating the keystroke combination, Alt and cursor left.

Learner B found the verbosity very irritating. It did seem to work well with speech but Learner B very quickly closed the VLE down without logging out. Consequently he could not log back in as technically he was already logged in and he could not proceed with this stage of the exploratory study.

VLE 2

Learner A was becoming quite used to VLEs and the format by now. Learner A was able to read all of the home page including the calendar. He brought up a frames list which was well labelled but unfortunately these labels did not always correspond to what was expected. That is, what the screen reader was announcing was not synchronised with the position of the cursor. He was able to go to the menu and found the links by tabbing; however, what the screen reader announced was not on the screen. Once in the main frame the links list was easy to use and Learner A was able to navigate immediately to the required course which was labelled as 'Beh'. The links list here was difficult to use as many of the link names began with ‘image/’ so it was impossible to put them into alphabetical order or use the initial letter as a shortcut. The back and forward links at the top of the frame did not have alternative text. However, once into the learning materials the screen reader worked really well. There was a multiple-choice quiz (MCQ) on this page but it was very difficult to find the start of it. Learner A suggested there should be a link to the start. It was difficult to navigate around the MCQs and Learner A suggested it would be preferable if a new window opened up for each question. If all the questions are on the one page navigation can be difficult.

Learner B very quickly said he preferred this second VLE and this was due to the names of the links being very clear and easy to follow. JAWs announced the main frame straight away but Learner B had to tab 12 times to get to the main content. Learner B thought that the links on the left-hand side should be at the bottom of the page. 'Learners want to get to the content as soon as possible,' and 'There are too many frilly bits.' Learner B suggested that it could be voice-activated. Learner B found the message board difficult to follow and it would not work entirely with speech. The chat would work with speech but was not easy for Learner B to use especially as he had not used this type of online tool. The conference tool did not work fully with speech and it was not possible to start a new thread. Learner B then accidentally closed the browser down using Alt F4 (standard Windows keystroke) to close a window.

Analysis

Accessibility and usability issues

The pilot showed that it is important to separate the accessibility, usability and pedagogical issues. If the learner cannot physically access the materials and the collaborative tools then it is neither possible to assess the usability, nor to shed any light on whether they would find one particular pedagogical model easier to use than another. Note that this aspect was abandoned at an early stage and the reasons are set out in Chapter 3.

The pilot also shows that parts of the VLEs were not accessible to speech users. A simple intranet was accessible and was easy to navigate even for a less experienced user. A demonstration version of a VLE is not sufficiently reliable for this sort of testing and full versions would need to be acquired for further research.

Pedagogical issues

Both learners enjoyed using the College Intranet and preferred using it to the VLE. They could access the Intranet relatively easily and could engage with the learning materials. It was not clear whether they could engage with this method of learning more easily than their usual method of learning, nor gauge the quality of the learning.

As stated above and explained in Chapter 3, comparison of a learner who is blind's use of a VLE based on constructivist learning theory with one based on behaviourist learning theory would have been overly ambitious at this stage of the research.

Implications for the Next Stage of the Research

It was felt to be important that the learners are observed using a VLE they are already familiar with (College Intranet). If a learner cannot perform the task due to accessibility problems they should be prompted for the purposes of the research as this may still provide valuable insights. It is vitally important, though, that the access software allows them to perform the task independently. This would be necessary to boost self-confidence and would otherwise be disempowering. With further studies of a comparative nature being considered it was necessary to identify how much additional support, if any, would be necessary since the need for additional support may impinge on the validity of the research. The observation should be task-based and it would be preferable if all the learners involved were carrying out the same task. At the time of this study there were a limited number (possibly only two) VLEs that were accessible to screen readers. However, these VLEs were still difficult to use and this is explored further in the following chapter. Consequently it would neither be practical nor ethical (see below for further consideration of this aspect) for one learner to have to learn how to use two different VLEs based on two different learning theories.

There needs to be more focus on learner feedback; for example, what they find difficult, what they found easy, what they would like to be different and what would make it easy for them? This will be easier to do once they are used to the learning environments. It was not possible to get sufficient feedback from the exploratory studies as they were not familiar enough with the interface.

In the medium term it was felt useful to carry out these hands-on exploratory observations which could be videoed as it was very insightful to watch the learner using the software and easier to take notes. Assumptions had been made about the software, and the level of accessibility and usability had been overestimated. This could be due to the researcher being sighted and relates back to the previous discussion of methodology (Morris, 1992) in that a sighted person cannot truly engage nor experience using the VLE as a blind person.

Interim Conclusion

It was found in this study that a VLE *could* be accessible to a blind learner in that it could be navigated around and that tasks could be carried out, such as accessing a discussion board. In general the VLEs were more inaccessible than accessible and independent use by a blind learner would be almost impossible. Some aspects were not particularly accessible and a learner who was blind may need support in these areas; this is significant as it would mean that they could not access the VLE independently.

The two participants enjoyed the experience and it appeared that learning could take place but that the accessibility and usability aspects might impinge on any learning. The next study seeks to use a VLE in a real learning activity. The study also seeks to ensure that the research is relevant to the participants and therefore addresses some of the ethical challenges identified in exploratory study 1.

Exploratory Study 2

Introduction

This study is the second of two exploratory studies which trace the development of a conceptual framework of accessing, using and doing as described in the methodology. In the first study it was established that a VLE could be, at least partially, accessible to a learner who is blind. If the VLE is at least partially accessible then there is the possibility for learning to take place; however, it is possible that the accessibility and usability aspects might impinge on the extent and quality of the learning experience.

Exploratory study 2 focuses on using a VLE as a learning tool and, in particular, the use of the discussion board in relation to developing understanding of topics such as teenage pregnancy, drugs and alcohol. The study shows that learners who are blind can use a VLE to learn successfully and that they can enjoy the learning experience despite it causing some difficulties.

The Scale and Scope of Exploratory Study 2

Overall aim

This study examines an existing educational programme for learners who are blind or visually impaired where transitional skills were delivered via a virtual learning environment, this being Blackboard initially. Learners transferred part-way through the programme to a different virtual learning environment (WebCT). The reason for this was to compare the two VLEs in terms of accessibility. At the time these were two of the most widely used VLEs.

Transitional skills – the Electronic Soap Group

The ‘Electronic Soap Group’ was set up at the college as a response to a request to find an innovative way to deliver transitional skills. Transitional skills at the college are defined as, ‘Skills that enable learners to manage continuous change and personal development.’ In the discussion board such subjects as teenage pregnancy, alcohol and drugs were discussed in the context of a popular soap. As well as developing understanding of personal development, the programme would enable an innovative approach to enhancing communication skills. Learners could feel more confident about expressing their views and experiences in an electronic, relatively anonymous forum than in a face to face situation. At the same time the use of a VLE would develop ICT skills and help prepare learners for Higher Education where they would be likely to be using a VLE in their studies. The programme lasted six weeks with learners attending one two hour session per week supported by three members of staff.

Participants and their background

The five learners involved were all aged between 16 and 19 and had very high level IT skills, both in general terms and in the assistive technology, where appropriate. Table 2 below sets out the gender of each learner involved, the assistive technology used by each of them and disability apart from visual impairment. Additional useful feedback was gleaned from a tutor who uses a screen reader and who, again, has a very high level of IT skills.

Table 2 List of learners, gender, assistive technology used and disability

Learner	Gender	Assistive Technology	Other
A	M	Jaws	Hearing impairment and mobility problems
B	M	Jaws	Dyslexic
C	M	Jaws	None
D	M	None	Motor – uses keystrokes generally
E	F	None	Hearing impairment

The group members were sent questionnaires by email (see Appendix 1) at the beginning of the course to establish:

- assistive technology needs;
- how long they had been using a computer;
- what they used it for and how frequently;
- use of email, the internet, chat and discussion boards;
- what they expected to get from the Electronic Soap Group.

Three of the five learners used JAWs and the other two used no assistive technology although one had a hearing impairment and the other had a motor impairment which meant one-handed operation of the mouse or keyboard. All of them had been using a computer frequently for at least 3 years. They used it for course work and used the internet for email, chat, games, research and news. All the learners used email at least twice a week but some were accessing email four times a day. The three Jaws users had been using the internet for six months to one year. This was very surprising considering their general high level of expertise. Amazingly, up to six months before the pilot Learner C, when in a mainstream college, needed to have web pages read by a sighted user. None of the learners had used a VLE before and only one of them had used a discussion board, although all of them were frequent users of chat. The internet, for all the participants, played a significant part in their life, learning and leisure. It is clear that the three that had only recently been introduced to the internet may have been deprived of a significant amount of life, learning and leisure for a number of years. All of the learners expected to learn about social issues relating to transitional skills, but none of them mentioned learning about the technology.

Method

Blackboard questionnaire

This questionnaire (see Appendix 2) was emailed to learners at the end of the pilot and covered the following areas:

- Logging in
- Navigation
- Specific questions about features e.g. discussion board
- Preferences between face-to-face and online
- What had been learned
- Support.

WebCT questionnaire

This was identical to the Blackboard questionnaire and emailed to learners when they returned to Blackboard.

Additional evidence

Evidence was collected on videotape, from observation notes, screen shots and the discussion board. Semi-structured interviews were also carried out as part of another study. These interviews covered social background and use of information technology, as well as a discussion of navigational strategies. This latter information is of relevance here, together with informal observation as it has formed the basis of a framework in respect of navigational skills using assistive technology and a virtual learning environment.

Results and Analysis

Blackboard questionnaire

The responses of only four participants are recorded here as Learner D started with WebCT.

Learner C had problems logging in initially. This was caused by a problem with forms mode which is needed when a web page is set up as a form. It was not possible to invoke forms mode (use the Enter key in the user name box in order to tab to the next form field to type in the password). The alternative to this is to change the cursor mode. The tutor using Jaws also had problems with this. Clearly this is very frustrating if the learner cannot even get started. This was the only area where technical support was requested outside the face-to-face sessions. There were no problems with navigation. C kept a familiar location in mind at first and used the links list. All were happy with and enjoyed using the discussion board. A, B and C preferred a mix of face-to-face discussion and discussion board. E preferred discussion board because of her hearing impairment. All were happy with the facilities such as home page creation and accessing content. Uploading an assignment was not on the questionnaire as they did this at a later date. A and B said they had learned how to use a discussion board whilst C and E said they had learnt to use a discussion board and had learned about other issues/viewpoints. Only A would have liked a longer introduction. This is understandable as A joined later than the others and possibly missed out on some aspects. This is important as there may be a tendency for this to happen to latecomers.

WebCT questionnaire

Learner D had not taken part in the pilot and WebCT was D’s first experience of using a VLE. Logging in posed problems as there was a password problem and then learners were required to add themselves to a course. This could be done by the tutor and would be preferable as this caused a lot of confusion. However, after the first login and adding courses there were no more problems with these aspects.

In respect of navigation, Learner A found that there were links, names and graphics that lacked meaning. Problems were overcome by using the links list for Learner C and Learner E used the back button to navigate. All except Learner B got lost and would ask for help. There were two comments (including one from the tutor) that indicated that navigation was difficult but they could not pinpoint why. All learners found that the discussion board was not very well organised, but this was partly due to the fact that there were no sub-forums and this meant all the messages were separated at thread level, that is different topics were all linked together. Learner B found it hard to use this discussion board and learner E found it difficult to find new messages. Learner A and B did not like using this Web CT discussion board. Learner C liked all discussion boards and Learner E found it ‘OK’ but preferred Blackboard. Learners A, B and C liked a mixture of discussion board and face to face discussion, but Learner E preferred discussion board because of a hearing impairment and they could follow what was being said.

The home page was quite easy to create but the learners said it was boring with not very many options. Learner A did not do this but there were extremes from Learner C who found it ‘a nightmare’ to use and Learner E who found it straightforward. Three learners except Learner B found it easy to access content.

All learners stated that they had learned about VLEs but nobody mentioned the transitional curriculum content. All learners except E thought they would have liked more information in the beginning. Technical support, both face to face and online, was found to be satisfactory although Learner E commented that it was often difficult to get help in the face-to-face situation. This was because there was a significant amount of individual support needed, even though there were usually three staff present.

Evidence from the discussion boards and classroom-based discussion

Several online and classroom-based discussions took place in respect of the use of discussion boards and face-to-face sessions (the evidence for this is set out above, with all of the participants but one preferring a mix). Some of the comments from the discussion board are set out below.

A selection of quotes from the discussions in Blackboard:

> When I am in an ordinary group discussion, I cannot always hear what others are saying and I don't always like to ask them to repeat what they have said. With Blackboard I don't miss anything.
>
> Well, in my opinion there are advantages and disadvantages of the teacher talking to you all the while. It helps the information to sink in if a teacher is babbling away to you for half an hour or so, then giving you work to complete to see how much you really understand about the subject in question. I love this discussion board. It gives everyone a chance to say what they think whenever and however they want. It presents a challenge. How can I express myself in a message? If I am angry how do I convey this??....... I can't wait to read other people’s views.
>
> I think that using the computer is interesting because it is a new way of learning that is challenging. I think that interactive learning is good because you get to learn about other things. I am also pleased with this discussion board because it is giving people a chance to chat and chatting with people that you do not know very well.
>
> I like using computers, face to face is ok but it can become boring over a long period of time. I also feel that I can express myself more freely in a forum.

> The advantages of an electronic set up is that it is accessible at any time, you can keep a written copy of what exactly is said so that you can refer back to it at any time. I think having an 'online lesson' would be good for those who live quite far out in the country for example, but with all the typing it could be a bit slower than normal classes – it is sometimes easier to explain things in speech rather than writing.

A selection of quotes from the WebCT discussion board:

> Hi everyone, I think that so far, WebCT is cool. It is very easy to use, although it took me a bit of time to get used to it. Can't wait to start discussing topics of interest.

> I think that WebCT seems good and I think that it is harder thing to use than Blackboard. I also think that the WebCT is quite a bit more complicated than Blackboard. I also think that we could do a lot more with WebCT.

> The system (WebCT) doesn't say re: before the message. Therefore you don't know if the message you are about to open is a reply or not.

> I am afraid that, so far, I am more impressed by Blackboard – it is easier to use.

> Yes, it is better that we send and receive mail through the same server, in this case, WebCT, but I also liked the idea of Blackboard sending email but you receive it in your "default" mail client programme.

In terms of preference between Blackboard and WebCT it was evident from the classroom-based discussions that the learners using screen readers preferred Blackboard but the learners using no assistive technology preferred WebCT. However, what is more important and what is demonstrated in the comments above was the enthusiasm experienced by some of the participants and how the activities did address the objectives for the programme, that is to enhance communications and to enable deeper understanding of transitional issues.

Evidence from informal observation

It was observed that the learners who were blind were experiencing more difficulties than the sighted learners in navigating in areas that were unfamiliar to them and that it was more difficult for them to problem solve, that is, navigate back to a familiar area if they become ‘lost’ (a framework for assessment of skills was formulated as a result of these observation and is discussed further below). The learners who were blind requested more assistance than the learners who were sighted and in general were taking more time to complete tasks.

The additional time and difficulties most likely occurred because:

1. The VLEs were organised to be used intuitively in a visual way, in that they were designed for sighted learners.
2. There is the issue of the ‘bolt-on’ effect of the screen reader. This partly relates to the issue above in that VLEs were not designed for use with screen readers and partly to the screen reader software additional not synchronising with the web interface. For example on one occasion Learner B was posting a message on the discussion board. He navigated successfully, but slowly, to the board and wrote two paragraphs on a transitional issue. It appeared to take him a significant amount of time and mental energy/effort to do this. As he was submitting the message he clicked on the wrong option, cancelling the message which disappeared. The reason he clicked on the wrong option is that the screen reader was announcing at a different speed to where the cursor was actually positioned on the web page (in this case a latency effect).

It was whilst reflecting on this particular incident that the author identified that there were three main areas of activity (navigating, using the assistive technology and task performing) in which a learner who was blind would be engaged in whilst in an e-learning environment and that in order to address this in a teaching situation it would be useful to compare this with the experiences of sighted learners (for the sighted learners there would be two areas of activity navigating and task performing) in that gaps could be identified and strategies designed to address any issues.

Assessment of navigational expertise

As a result of the above observations and data suggested categories of navigational expertise for learners using screen readers were developed and are set out below. This may vary depending on what the learner needs to do. Therefore if the learner only needs to access linear linked web pages then they need only operate at level 1. If they are using the internet independently and frequently visiting the same web pages then they need to operate at Level 2. However, if they are to use a virtual learning environment effectively then they will need to be operating at Level 2/3.

A learner may appear to be able to navigate effectively and may indeed think they are. The level at which they navigate may depend on the way they have been taught/trained. Since web pages in general are difficult for someone using a screen reader to access and read there may be a need to start out at Level 1. Some learners will be able to progress through the levels on their own whilst some may need additional support and training to progress. Level 2 may be sufficient for a learner to access web pages but there are additional skills necessary to use a VLE effectively and learn. Therefore careful assessment of skills is necessary and specific training and/or intervention given accordingly to enable the learner to move towards Level 3. This may be particularly pertinent if the learner is working in isolation.

Suggested categories of navigational expertise

Level 1 – Linear

The learner:

- uses links to navigate between and within pages;

- may lack confidence;
- cannot solve accessibility and usability problems;
- may only be engaged in passive learning.

Level 2 – Linear/exploratory

The learner:

- uses a mixture of links and cursor to navigate within pages;
- can sometimes resolve problems;
- tends to stick to set patterns;
- is reasonably confident;
- may sometimes be engaged in active learning.

Level 3 – Exploratory

The learner:

- uses a mixture of links and cursor to navigate;
- can usually solve problems and will experiment with different strategies;
- is very confident;
- may be engaged in active learning where appropriate.

This framework was a useful starting point in assessing the skills of a learner who is blind and has implications for staff development as it will not be only ICT specialists who will need to assess these. The author used this framework within her normal teaching practice and to identify participants in the studies that followed on from the exploratory studies.

Conclusion

In this study the participants were able to use the VLEs successfully for learning. They quickly became familiar with the set up of the discussion boards. The level of discussion in the discussion boards indicated that learning was taking place in terms of transitional skills, that is, in-depth discussion, exploration and reflection on the participant's own and others' life skills. It is very important to note that these participants were what might be termed as expert users of ICT and AT. If they had not been then there may have been a detrimental effect on the learning outcomes.

Specific ethical issues

There were three ethical issues which arose which had not previously been foreseen. All are related to involving student participants in research which may not have practical value to them:

1. Firstly, there is the problem of asking the learner to carry out tasks which are of little or no use to them. Being able to use a specific VLE is not necessarily a transferable skill; they may be unlikely to encounter it again and they would be better engaged spending the time learning a more transferable skill. However, it was felt important and necessary to find out if a blind person could access and use a VLE. If it could be shown that an experienced and expert user of assistive technology could not do this then this might save less experienced users from having to struggle with it. This was realised early on in the pre-pilot and, for this reason, only learners with a high level of IT skills were asked to participate.

2. Secondly, closely related to this issue was the problem of transferring from one VLE to another. For example learners were, after six weeks, required to change from Blackboard to Web CT. The reason for this was to try to find out which one was easier to access and use. This would not be repeated in the future. Whilst there were some similarities between the two VLEs, there was also confusion. This may have meant that the data from the questionnaires in respect of preference was not reliable.

3. Thirdly, it was initially planned to compare VLEs with different screen readers but with the same learner. However, there is a problem with someone changing to a screen reader that they are not comfortable or familiar with as the keystrokes will be different. A very limited number of learners will use more than one screen reader. This was identified in the

pre-pilot and for this reason participants were asked to only use their preferred screen reader.

It was at this early stage that a theoretical framework that could help analyse the impact of the use of ICT and AT on the learning experience was being considered.

It was felt necessary to carry out a more systematic study of blind learners using a VLE and, in particular, with them using other aspects of the VLE apart from the discussion board. It was also felt important to find out how much time was being spent by blind learners using the VLE and how this time was allocated to different tasks. In general it was felt that these tasks could be divided into accessing (using the assistive technology), using (navigating) and doing (other tasks which may include learning). In terms of the conceptual framework of the pilot and main study, that is accessing, using and doing, these exploratory studies were crucial to determining whether a VLE was accessible to a learner who is blind as a learning tool. The need for further work on accessing, using and doing with a focus on the effect on learning was identified which could be coupled with an adapted satisfaction rating which would relate to the learning experience. This would need to be carried out with learners who are more experienced with the VLE. It appeared that learning could take place but that the accessibility and usability aspects might impinge on any learning. This conceptual framework is discussed further in Chapter 5, the Pilot Study.

CHAPTER 5

PILOT STUDY

Summary

This pilot study examines responses of new users to two VLEs, WebCT and Blackboard. Participants carried out a set of five tasks based on key features of the VLEs; that is, features that learners would be required to use on a regular basis to access content in a university or mainstream college. In addition a satisfaction survey was used to measure confidence with the technology, how frustrating the learners found the tasks and how satisfied they were with the way they carried the tasks out. Learners were generally satisfied even though in some areas the tasks were difficult (particularly for two of the participants).

Central to the pilot study was the development of a conceptual framework which makes a distinction between different activities learners are engaged in when working with VLEs – accessing, using, and doing. This framework was used as the basis for developing a structured observation schedule in which learners actions were categorised and quantified. This enabled different learners' engagement with the VLEs to be compared. Results showed that the framework has potential for making these comparisons, and indicated that visually impaired learners take longer to carry out activities on VLEs than their sighted peers, and spend proportionately less time engaging with learning activities because more of their efforts are given to accessibility and usability tasks.

Introduction

The two exploratory, largely qualitative, studies indicated that learners who are blind and who are very competent with ICT and assistive technology were able to access and navigate around a VLE and use it successfully for learning, and that they could enjoy using it. The studies were designed to address research questions one and two:

- Initially there was the question of whether a blind learner could **access** e-learning.
- This developed into the question of whether a blind learner could **engage** in e-learning.

The focus of this pilot study is research question 3 which seeks to find whether learners who are blind could access and engage in e-learning *on the same basis as sighted learners* with a possible focus being on time and ease of use. This would require a comparative study and as a result there would need to be a move to quantitative methods in terms of standardisation of approaches to the levels of engagement participants experienced (which would include a measure of time taken and ease of use). The literature review and the pilot studies had made a distinction between accessibility and usability of e-learning. Accessibility and usability are prerequisites of true engagement in e-learning – i.e. participating in the learning experience. Exploratory study 1 demonstrated that blind students could access VLEs using screen reading software (although this was not always easy). Exploratory study 2 was encouraging because it demonstrated that blind students were able to engage in meaningful learning activities through VLEs. Again, in spite of the challenges they faced, students were enthusiastic about the potential of VLEs in supporting their learning. What was required was a vocabulary, or ‘conceptual framework’, which could capture the blind students’ ‘whole’ experience when working with the VLEs. A way of doing this would be to distinguish between *accessing*, *using* and *doing*:

1. **Accessing** is concerned with getting to the information. For this study this will involve assistive technology i.e. a screen reader or magnification.

2. **Using** involves navigating around the VLE. This will involve moving between pages and around pages.

3. **Doing** is concerned with activity or task performing which may be reading instructions, reading and posting a message, uploading a file, opening Word and thinking. Ideally doing should mainly involve learning.

The framework gives a structure to the learning experience, and the aim was to enable identification of tasks and activities that learners were engaged in at a particular point or points in time. The hypothesis was, at this stage, that learners who are blind spend a limited amount of time learning in a VLE, and much of their focus and energy is put into using and accessing. The framework would test how different learners divide their time, bearing in mind that this may be down to preference rather than whether assistive technology is used or not.

The Scale and Scope of the Pilot Study

This study explores responses of seven users to WebCT and Blackboard using a set of five tasks:

- accessing content
- reading and posting messages on the discussion board
- creating a simple home page
- answering an online quiz – a multiple-choice test
- uploading and sending an assignment.

Of the seven participants, two were sighted, four were blind (and used a screen reader) and one was visually impaired (and used magnification software). All these learners had a high level of IT skill and were volunteers giving up free time to participate. The learners were pre-selected based on observation by the author, application of the assessment framework described at the end of Chapter 4 and also consultation with their tutors. It was important that participation did not impinge on other activities.

All the learners except for one were over the age of 19. In the previous study the learners were all aged 16 to 19. It was decided to use older participants as informal observation had indicated that these learners found ICT more difficult to use than younger learners and they could be the group most disadvantaged in a mainstream learning situation.

Table 3 List of learners, age, gender, assistive technology and VLE used

Learner	**16-19 or mature**	**Gender**	**Assistive Technology**	**VLE**
G	Mature	F	None (sighted)	Blackboard
H	Mature	M	Jaws	WebCT
I	16 to 19	M	Supernova 5.02	WebCT
J	Mature	F	None (sighted)	WebCT
K	Mature	F	Jaws	WebCT
L	Mature	M	Jaws	Blackboard
M	Mature	M	Magnification	WebCT

Method

Learning material and general procedure

A scheme of work was developed as the training on using a VLE would be delivered by different tutors. The course was devised to be delivered over six weeks, or in six separate one hour sessions with each session covering a different feature (accessing content, discussion board, creating a home page, uploading an assignment, reading and posting a message and doing a multiple-choice quiz). After learners had completed the scheme of work they were timed and filmed carrying out the tasks. Timed tasks were filmed using a digital recorder and this was transferred to videotape. Notes were taken at the time, but with one person filming it was not always easy to do this.

Each participant followed the same scheme of work, lesson plans, induction and performed the same tasks. This task was piloted with the two sighted users to ensure that there were no bugs and to identify any problem areas.

Questionnaires

Participants were given an initial questionnaire which asked about their experience with IT and, in particular, use of computers, the internet, email, discussion boards, online chat facilities and VLEs. All the learners had had at least two year’s experience using ICT with Learner L having the most at 27 years; learners M, L and G having 10 to 15 years experience and the rest two to three years each. All the participants used email on a daily basis. All except for Learner K used the internet on a daily basis and all apart from Learner K had been using the internet for at least one year. Three of the learners (M, L and I) used chat regularly and Learner K had used a VLE and a discussion board previously

A short subjective survey using a 1 to 7 Likert scale satisfaction rating was also used and administered after each task. Learners were asked to rate their satisfaction in terms of confidence with the technology (1 being not at all confident, 7 being highly confident), frustration carrying out the task (1 being high frustration, 7 being not at all frustrated), and overall satisfaction with the way they carried the task out (1 being not at all satisfied and 7 being very satisfied). This survey was based on the satisfaction survey used by Coyne and Nielsen (2002) and is described further in the Literature Review.

Observation schedule – accessing, using, and doing

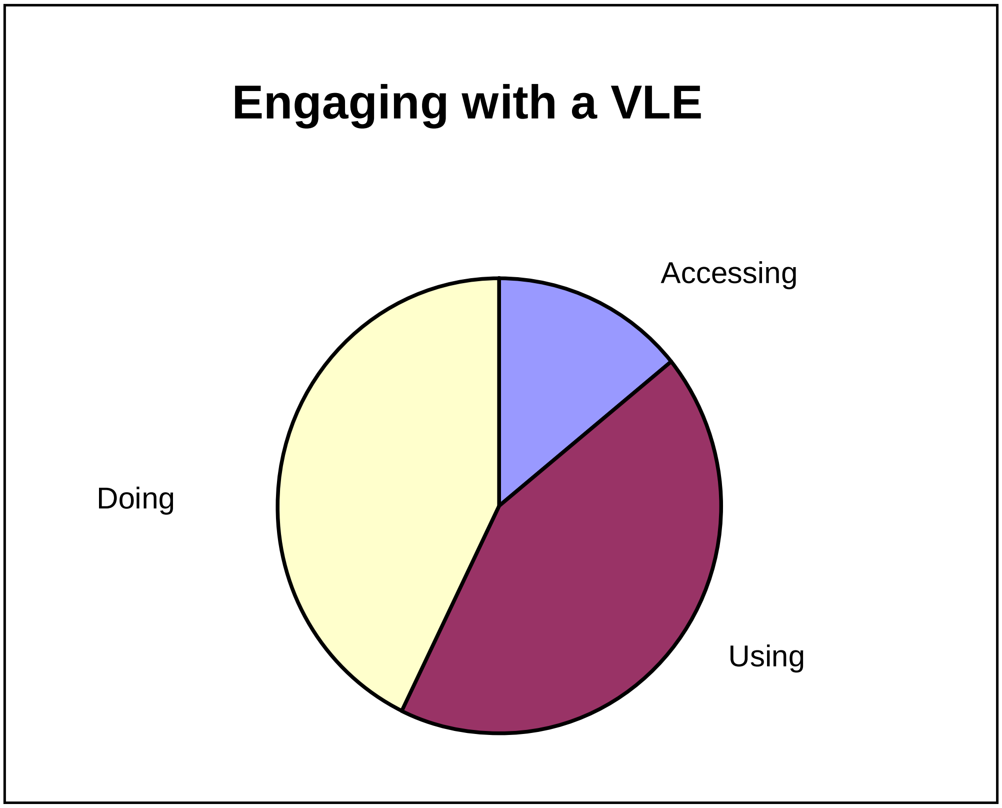

Figure 1 Engaging with a VLE – accessing, using and doing

Figure 1 above shows the types of activity a learner might be engaging with in a VLE. These tasks, accessing, using and doing are described further below. Ideal proportions might be the majority of the time spent doing with a small amount of both accessing and using:

1. Accessing applied only to those who are blind and involved the use of assistive technology. In this study, it occurred when the focus of the cursor left the learning object and went outside this frame. In this case, the participants had to spend time navigating back to the learning object as a result of the functionality of the screen reader within the learning object. Accessing also included the time spent listening to additional navigational information on each page.

2. Using involved navigating. For the sighted participants, it meant clicking on links or buttons, and for the participants who were blind, it meant tabbing or cursoring around the links or buttons, or using a links list.

3. Doing was mainly concerned with learning and involved activities such as reading, listening, answering, checking and reinforcing.

Method

Participants and learning materials

A form, with column headings: Interval, Actual Activity, Accessing/Using/Doing and Comments/Notes including errors, was used to record information taken from the videotapes. A 10 second bleeper was used and at these intervals it was noted down whether the learner was using, accessing or doing. The 10 second observation method was used successfully by Douglas and Long (2003) in their study regarding observation of students with a visual impairment carrying out copy typing tasks. Additionally a note was made on what they were actually doing, for example reading a message, inputting a web address. Comments were added particularly in respect of whether there was a user or system error, or whether the learner had had to be prompted.

The coding of the observations was carried out by the author. To ensure that the observation schedule was reliable, two researchers had conducted inter-rater reliability tests of the schedule at the pilot stage. Of the 274 observations, there were only two differences between the two observers' scores (reliability was > 99%). However, on consultation it was found that these differences were errors, and agreement was reached (reliability was 100%).

The process can be quite time consuming especially if the researcher doing the analysis had not been present during the videoing. It is recommended that these two tasks should be done by the same person and ideally the latter task be carried out by two researchers. Learners may feel under pressure doing this sort of ‘test’, and great care was taken to explain that it was the software that was being tested and not them.

Results and Analysis

Satisfaction ratings

Figure 2 Overall satisfaction by the learner

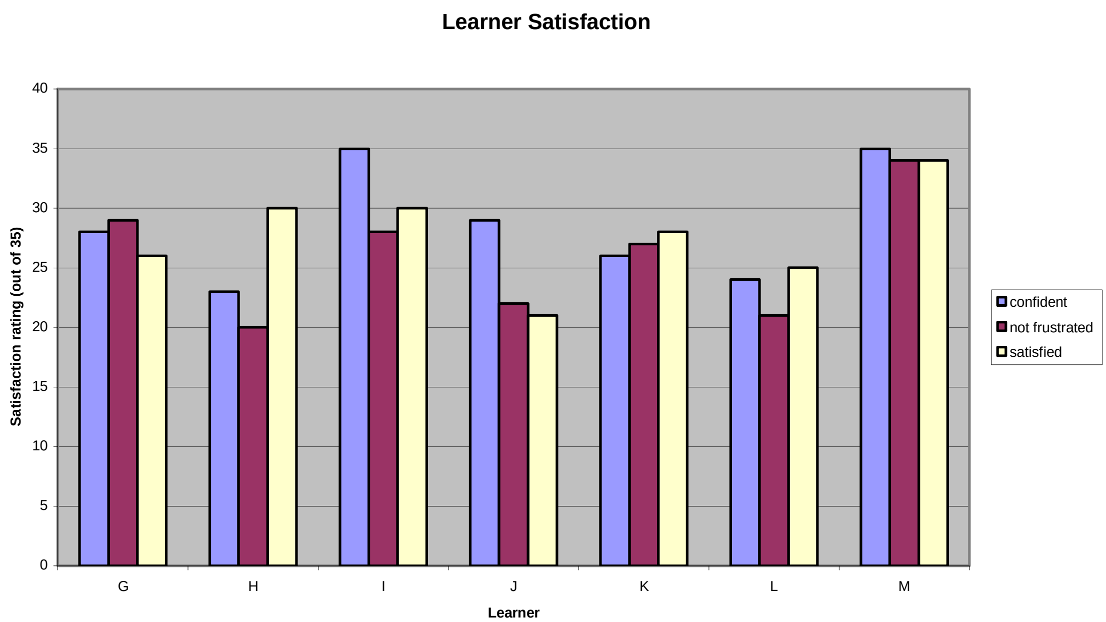

Figure 2 above is a graph showing that out of a rating of a maximum value of 35, all users gave ratings in terms of Confidence in the technology, Lack of Frustration with the technology and Satisfaction in the way they performed the task, between the values of 20 and 35. The scores for Confidence ranged from 23 (Learner H) to 35 (Learners I and M). The scores for Lack of Frustration ranged from 20 (Learner H) to 34 (Learner M). The scores for Satisfaction ranged from 21 (Learner J) to 34 (Learner M). The mean rating across all three measures was highest for Learner M (34.7) and lowest for Learner L (23.3). Three learners each rated Confidence and Satisfaction most highly; only Learner G gave Lack of Frustration the highest rating.

In terms of comparison between learners who were blind, sighted or visually impaired there was virtually no difference between the first two groups (a mean of 77.5 for the blind learners and 79.3 for the sighted learners). The learner who was partially sighted gave an overall rating of 103.

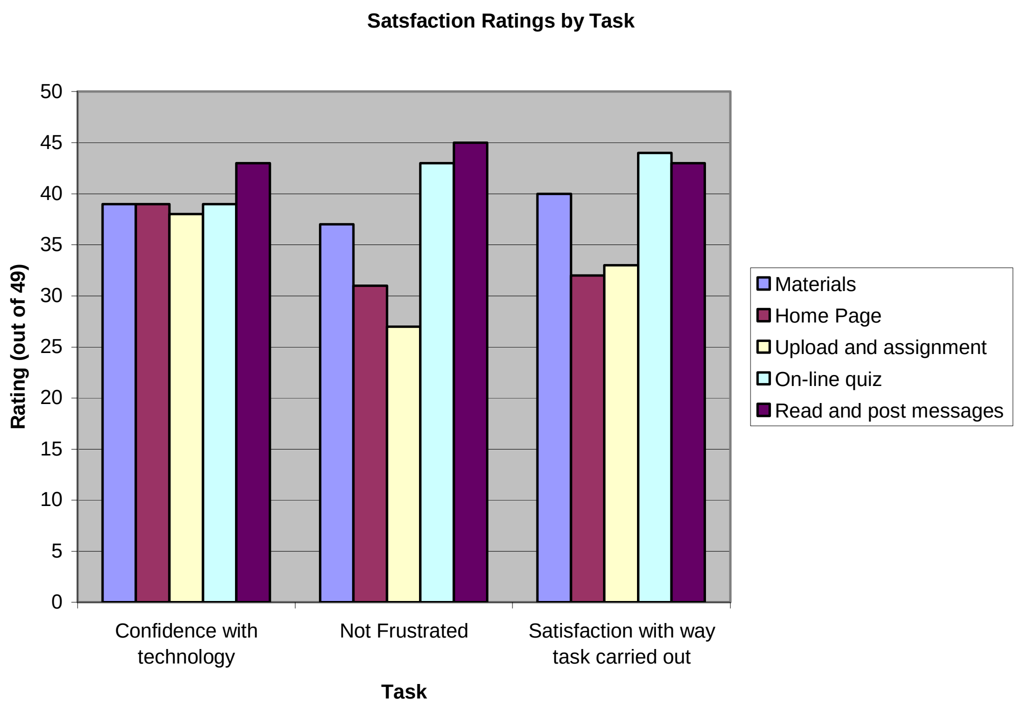

Figure 3 Satisfaction ratings by task

Figure 3 above shows satisfaction ratings by task. Learners were most satisfied with reading and posting messages. The reason for this may be that they did this every week so they would have had more practice at this than the other tasks. None of the learners gave a score of less than six. The online quiz was second which was surprising as this is quite difficult to do with a screen reader. However, it is possible to get a set pattern of answering the questions in terms of navigating this and learners were observed as being very pleased that they could carry this task out and seemed to enjoy it. All the scores were six or above apart form learner J who gave five for satisfaction and learner H who gave one for confidence. This may be because there had been difficulties in carrying out the task on previous occasions. It is quite noteworthy as this learner is very confident in using technology and found a solution to this problem. This may have implications for learners carrying out real online assessment since it is particularly important that they can have full confidence as this could add/lead to anxiety and result in a reduced outcome/lower mark than might otherwise be expected.

Accessing the materials had a relatively low score. It was a task that they would have carried out on more than one occasion; however, it is felt that the learners were not given enough instruction on navigation in this area. It was taken for granted that this was not as complicated as perhaps some of the other tasks, and was more intuitive. Again, learner H was least satisfied with this task despite being a particularly competent user. Learner L was also frustrated in doing this. Observation showed that this was one of the greatest areas of difficulty.

Creating a home page was an activity they had only done once before and was done in the first or second week of the course. It was not a task that was revisited; consequently, they may have forgotten how to do it. Everyone apart from learner M had a score of less than 20 for this (out of a possible 21). The sighted users had higher scores than the learners using a screen reader. This was the same for uploading an assignment. Confidence here was generally five or above apart form learner L who gave two. This task caused the greatest amount of frustration. It is quite complicated, particularly for those using a screen reader where there are no visual clues.

There seemed to be no significant differences between the two VLEs; however, as described below, creating a home page and uploading an assignment in WebCT were particularly difficult areas. Generally learners were most dissatisfied with the home page and file upload facilities followed by accessing the content. The main exception was the difficulty encountered by H and the problem with JAWs and the multiple-choice quiz.

In terms of comparison between learners who were blind, sighted or visually impaired and overall satisfaction with each task the learner who was visually impaired was more satisfied with each task than the other two groups. The greatest difference between the other two groups was in respect of the home page with the sighted learners being two points more satisfied than the blind learner. The latter groups were on average about one point more satisfied with accessing the materials, uploading content and reading and posting than the sighted learners.

Videotape Analysis

Accessing, using and doing

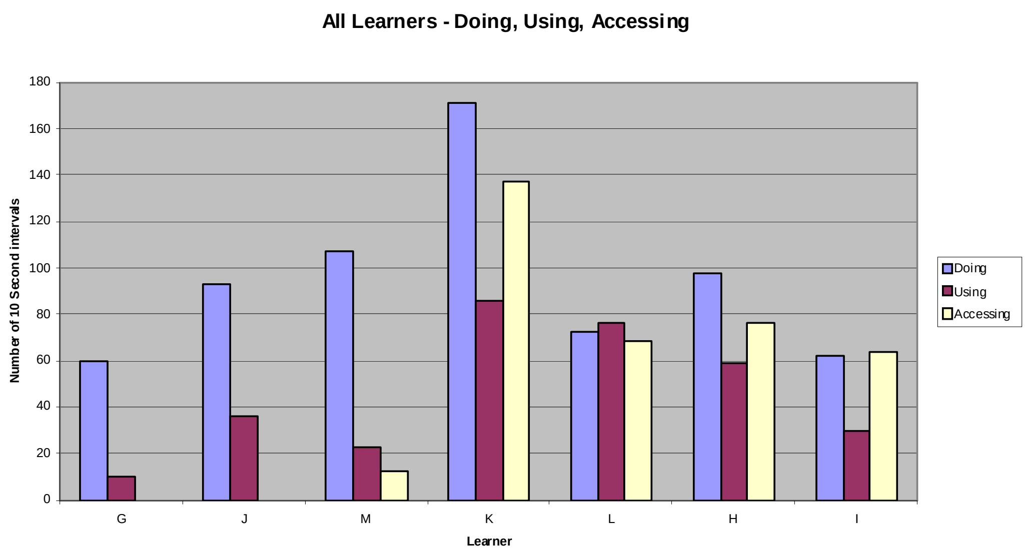

Figure 4 All learners accessing, using and doing

As mentioned previously, all participants were experienced in the use of IT, with the assistive technology (although Learners K and I were using a different screen reader from the one they usually used). Both usually used Supernova 4.2; K changed to JAWs and I changed to Supernova 5.02. Clearly there are some differences in skills and the implications of this are discussed in general terms below.

Table 4 Learner, assistive technology used, total time taken, VLE used and % accessing, using and doing

Learner	Assistive Technology	VLE	Total Time Taken (mins)	Accessing %	Using %	Doing %
G	None	Blackboard	11.6	0	14	86
J	None	WebCT	21.5	0	28	72
M	Magnification	WebCT	23.7	8	16	76
K	Jaws	WebCT	65.7	35	22	43
L	Jaws	WebCT	36.0	31	36	33
H	Jaws	Blackboard	38.8	33	25	42
I	Supernova 5.02	Blackboard	26.0	41	19	40

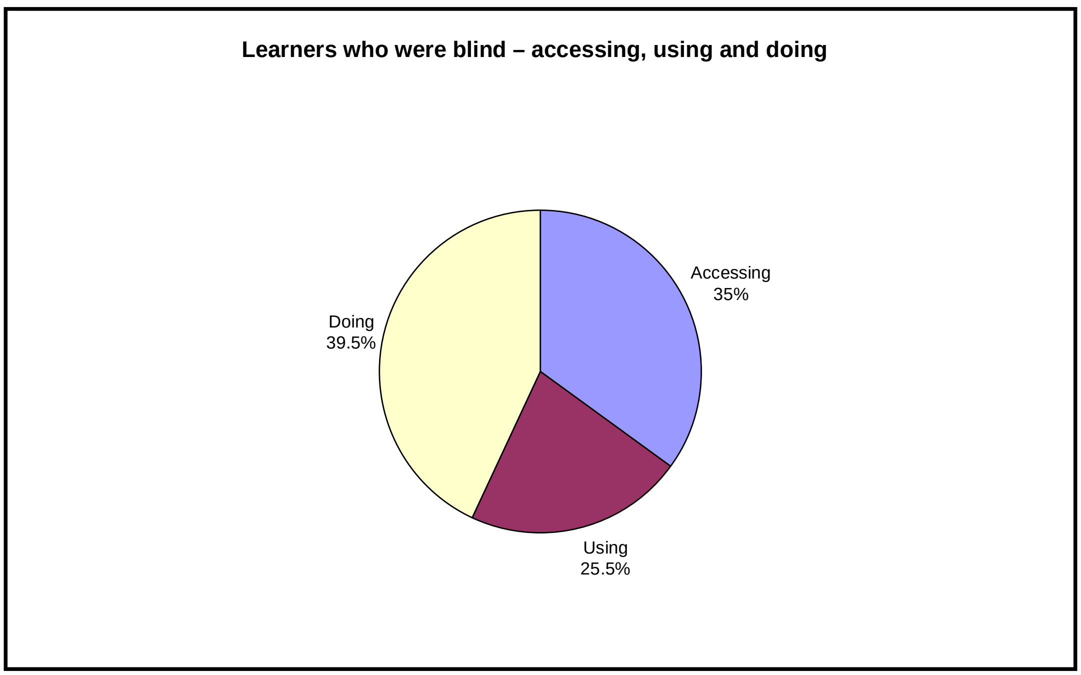

Figure 5 Learners who were blind and % time spent accessing, using and doing

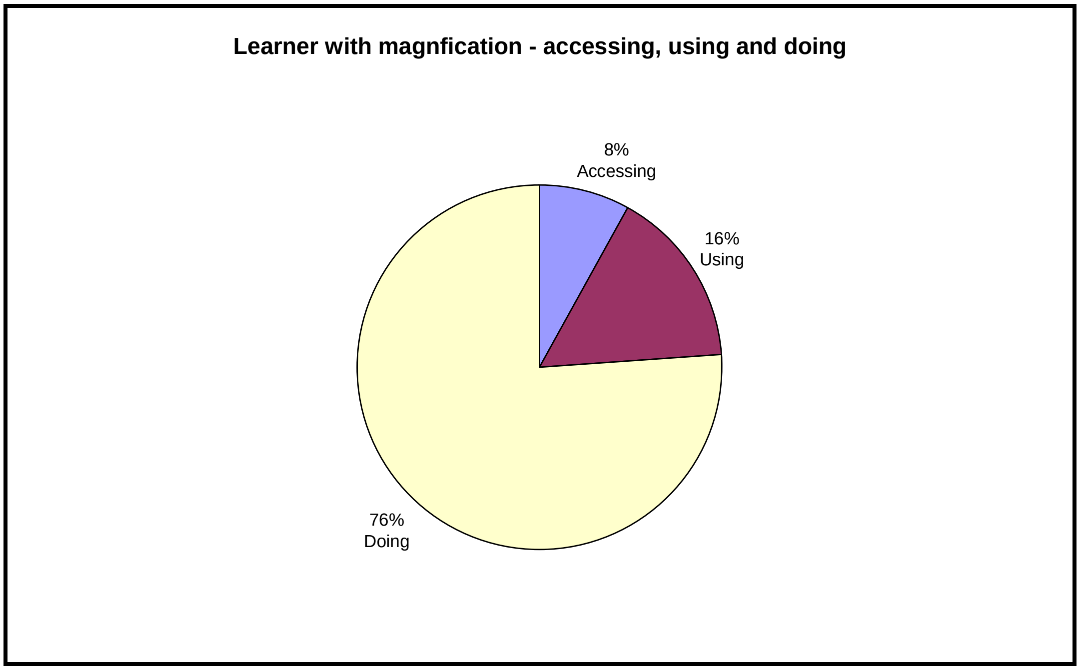

Figure 6 Learner using magnification and % time spent accessing, using and doing

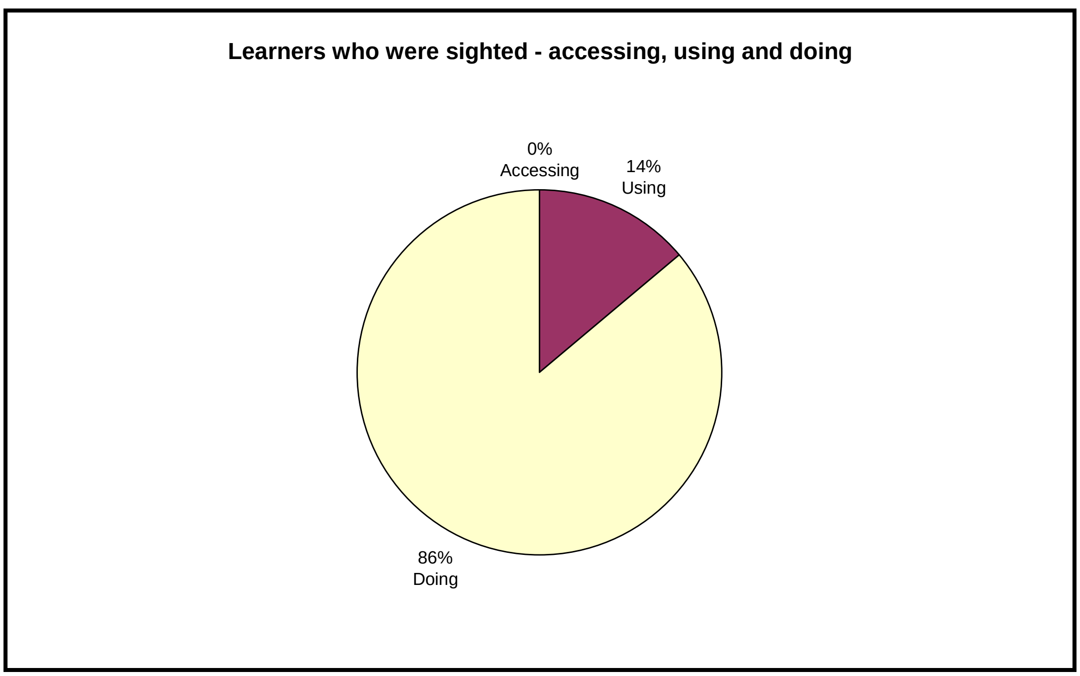

Figure 7 Learners who were sighted and % time spent accessing, using and doing

Table 4 above shows learners, their assistive technology and the VLEs they were using as well as the times as percentages spent doing, using and accessing. The charts 6.5 to 6.7 focus on the time spent accessing, using and doing between the three groups. In general terms it can be seen that the learners using no assistive technology or magnification spent significantly more time, two to three times more, doing than the other learners using a screen reader. It should be noted that the learner using magnification was using it at a low level (x2). If he had been using it say at a higher level then it is possible that it would be more difficult to access the VLE than with a screen reader. All the learners using screen readers spent more time overall on the task than those using no assistive technology. Only J came close to the other scores, but this was because J spent minimal time on writing answers.

It is difficult to make comparisons between VLEs and assistive technologies due to the different amount of time the learners spent on various tasks i.e. spending more time reading and posting messages/writing longer messages. Learner G and Learner L may be compared up to a point as they spent similar amounts of time actually doing the task, but as can be seen from the above table L spent only 33% of the total time on doing whilst G spent 86% of the time on doing.

G spent roughly six times the amount of time doing as using. J spent three times the amount of time doing as using. G made only two small errors (which were corrected) and did not get lost at all, whilst J had several problems particularly in respect of uploading the assignment and the home page. J was not navigating in a logical way which resulted in a lot of mis-clicks and to-ing and fro-ing. This would account for the increased amount of time spent using. The home page and the upload assignment are less intuitive in WebCT and this created problems and may account for some of the extra time doing.

Learner M (using magnification in WebCT) spent three times the amount of time doing as using and accessing together (twice as much time using as accessing). The accessing was mainly accounted for by the scrolling in the multiple-choice quiz. M made only one small error and did not get lost at all. K had a lot of problems and would possibly not have completed any of the tasks without prompting. K spent half the time accessing and using and the other half on doing and spent almost as much time accessing as doing. A lot of the doing time was spent on typing responses to the emails and writing text for the home page.

Learner L using WebCT and JAWS spent twice the amount of time using as I but less time accessing. L was using different strategies for accessing and a combination of cursoring and tabbing; however, L did not use a links list and would have benefited from this on several occasions. L spent approximately equal amounts of time on using, accessing and doing and therefore twice as long accessing and using as doing.

Relationship between satisfaction ratings and accessing, using and doing

Although G made only one error (which was rectified) and worked in a systematic way G was not 100% satisfied with any of the aspects of the test and was least satisfied with accessing the content and uploading the assignment.

Uploading the assignment presented so many difficulties that H lost confidence after this and needed to have confirmation of any steps that were taken for a while. This was reflected in the satisfaction ratings where H was very frustrated with the technology although had some confidence in it and was satisfied with the way the task was performed. The satisfaction ratings were fairly neutral for the materials although H navigated around these very well for the last two tasks. H was also not at all confident with the technology for the online quiz and this was because he had experienced difficulties previously. H did, though, manage the task reasonably well.

Learner I was fairly frustrated in uploading the assignment and was least satisfied overall with the home page. He may have benefited from some assistance/additional practice in using the VLE. Learner I does have some residual vision and this enabled him to understand the layout more easily than if he was totally blind. Learner I spent equal amounts of time doing and accessing and 50% less time on using.

From the satisfaction ratings L was not over confident. L was very unsatisfied in every respect with the upload and fairly frustrated with accessing content. L also gave a relatively low score to the home page task which is not surprising as it is not intuitive even if you can see.

M was very satisfied in respect of confidence, the technology, frustration level and the way he carried out the task awarding almost full marks overall. This is not surprising as M was able to carry out all the tasks with virtually no click errors. M worked methodically and it is possible that this was aided by the use of (X2) magnification which focuses well in the WebCT layout.

In general the results above show that there was very little difference in the satisfaction ratings between learners who were blind and learners who were sighted. The learner who was visually impaired was more satisfied that then other two groups.

The learners who were blind spent 35% of their time accessing, 25.5% of their time (mean 40.5 minutes) using and 39.5 doing. The learner who was visually impaired spent 8% of his time (26 minutes) accessing, 14% using and 78% doing. The sighted learners spent 14% of their time (mean 16.5 minutes) using and 85% doing.

Compared to the sighted learners the learner who was visually impaired was satisfied and took a relatively short time to carry out the task. The learners who were blind took a relatively long time to carry out the tasks, 35% of the time of which related to accessing but were almost as satisfied as the sighted learners.

Conclusion

Previous studies (for example Doyle, 2001) have focused on accessibility and usability issues within the VLE as well as practical tips and guidelines for tutors in respect of content. Many of the issues highlighted within these studies were encountered in this study. Some of the issues and problems are specific to a VLE, such as the multiple-choice quiz usability problems in Blackboard, and many issues are generic such as the browse button in the file upload.

The pilot study was more quantitative in nature than the earlier exploratory studies and examined responses of new users to two VLES, WebCT and Blackboard, using a set of five tasks based on key features of the VLEs. Four of the learners were blind, one was visually impaired and two were sighted. In the satisfaction survey learners generally were more satisfied with reading and posting messages on the discussion board and least satisfied with uploading an assignment. A conceptual framework of accessing, using and doing was successfully used (in that it provided a valid, reliable and useful observation schedule) to analyse the amount of time taken by different people on different tasks. In general terms it could be seen that the learners using no assistive technology or magnification spent significantly more time, two to three times more, doing, which could involve learning, than the other learners using a screen reader. All the learners using screen readers spent more time overall on the task than those using no assistive technology. These learners were almost as satisfied as the sighted learners with carrying out the task in terms of, confidence in using the technology, whether they felt frustrated and whether they felt satisfied in the way they completed the task.

It was not possible to fully compare the two VLEs involved. Aspects that were omitted include, for example, use by tutors who were visually impaired and features such as the virtual classrooms, use of online help, different types of online quiz-style questions, email and calendar functions. Participants would need to be using the VLEs over a greater period of time than in this study, and this may mean that they are more familiar with the features. However, in as far as the study went it was found learners encountered similar problems with both VLEs. There were a few accessibility problems that were attributable to the VLE, for example the browse button problem in the file upload. Accessing content and taking a multiple-choice quiz may be more usable in WebCT, whilst creating a home page, uploading an assignment and using the discussion board may be more usable in Blackboard.

Analysing tasks by looking at how much time was spent on doing, using and accessing has shown that learners using a screen reader are spending up to three times longer accessing and using than sighted users. The complexity of the tasks may mean that it is not possible to aim for an ideal ratio between these aspects. However, the aim is to reduce the amount of time and effort involved with efficient use of the assistive technology to find out what is on a page/site which will reduce the amount of time involved in navigating. Efficient navigation will reduce the amount of time spent on accessing. Appropriate use of cursoring, tabbing and links lists will result in more efficient access. Within the VLE it is likely that more time is spent navigating than accessing. It is vital therefore that teachers of learners who are blind are expert users of assistive technology and web-based applications in order that the learners can optimise their skills. VLE design and use should then focus on reducing these aspects. In order to give further insight into this phenomenon there was a need to introduce a theoretical framework. It was hypothesised that the learners who were blind had to deal with an additional cognitive load compared to the sighted learner in terms of accessing the learning content and navigating around it.

In terms of her own teaching practice and the author's remit of identifying an accessible VLE it was decided that on reflection neither of the VLEs that both of the VLEs assessed would be too difficult for most of the learners at the College to use, particularly as this might involve some on a distance learning programme. However, there was the issue of disempowering the small number that could use it and this aspect is followed up ion the conclusion. Further research of VLEs continued at that stage.

In summary this pilot was successful in that:

1. A new, valid, reliable and useful observation schedule (namely that of the conceptual framework of accessing, using and doing) was designed and implemented. In other words the method piloted in this study enabled clear observations and comparisons of accessing, using, and doing.

2. The hypothesis that learners who are blind engage in a VLE differently from sighted learners was tested using the above framework. Although there were small numbers involved in the pilot, there was evidence to demonstrate that there is a difference, and there was an indication of the nature of this difference. The learners who were blind took a relatively long time to complete the tasks and spent much more of their time accessing and using compared to the sighted learners, but were only slightly less satisfied. This is explored further in the main study. In other words the method used enabled clear comparisons to be made between blind and sighted users.

On the basis of these very positive results there was a need to reflect on the pilot and develop the ideas further with a view to exploring the quality of the learning experience for learners who are blind. In the following chapter cognitive load theory is introduced alongside the revised methodology used for the main study.

CHAPTER 6

LITERATURE AND METHODOLOGY REVISITED

Introduction and Overview

Chapter 3 was concerned with the methodologies for the two exploratory studies and the pilot study and a development of the research methods from a qualitative approach to a more positivist stance was described.

Chapters 4, 5 and 6 traced the development of and the answers to the questions posed via three of the four stepping stones. It was confirmed that learners who are blind could access an e-learning environment independently and that they could learn and enjoy learning in it. The pilot study described in Chapter 6 saw the successful application of the conceptual framework of accessing, using and doing, and there were some clear indications of a need for a further study and the direction that this might take.

In this chapter, cognitive load theory (CLT) is introduced as the theoretical framework used to underpin this study, to analyse the data and to begin to identify and measure the quality of the e-learning experience. The introduction of CLT is a significant turning point in the thesis and in this chapter both the literature and methodology are re-visited. The conceptual framework of accessing, using and doing which emerged in the pilot study was a useful descriptive tool which gave a clear method of explaining what tasks learners who were blind were engaged in compared to the sighted learners. However, the concern for this study was the impact of the length of time taken to complete tasks, and difficulties as observed for learners who were blind in the pilot study on the learning performance. It is argued that CLT could provide an insight into this phenomenon and importantly that it is predictive in nature. In addition to CLT, literature relating to early and late-onset blindness and supra-normal auditory and tactile abilities is described here and considered further in the conclusion. The reason for this is that this links with cross-modal reorganisation of information in the brain. The hypothesis is that learners who are blind may have additional working memory available since they are not using up the visual channels, and that these channels can be opened up for other senses.

This chapter commences with reflections on the positive and negative aspects of the methodology and method relating to the pilot study in Chapter 6 and the implications of these for the main study. This is followed by an examination of CLT including the types and measurements of cognitive load. Specific aspects of visual and auditory channels, split attention, modality and expertise reversal effect are also addressed.

Reflections upon the Pilot Study and the Implications for the Main Study

In this section the positive and negative aspects of the pilot study are identified and the implications for the main study considered.

Positive aspects relating to the pilot were:

1. The participants were generally satisfied in terms of confidence with the technology, not being frustrated with carrying out the task and the way they carried out the task. Out of a rating of a maximum value of 35, all learners gave ratings between the values of 20 and 35. However, this survey did not give any information relating to the learning experience and how this compared with their usual method of learning. In addition there was no qualitative information collected particularly in terms of the reasoning behind the responses.

2. The conceptual framework was a useful tool for analysing how much time was being spent on different tasks, that is, accessing, using and doing. The agreement between the observers evidenced that the data was reliable. The same framework would be useful for the main study and its efficacy would be enhanced if the tasks were more constrained

than in the pilot study. In the pilot, whilst the tasks were all in a VLE, they ranged from quiz-style questions to participation in a discussion board. The additional amount of time spent accessing and using for the learners who were blind indicated that this increased time was having an impact on the execution of the tasks and that not only did the tasks take longer but the tasks appeared to be more difficult for this group. This latter point was evidenced more by the observer than by the learners, as was apparent from the satisfaction survey. Accessing the content and navigation was taking longer for the learners who were blind than for the sighted learners (accessing did not apply to the sighted group) and it was clear that they had to cope with an additional burden which might be having an impact on the learning experience; that is, **they experienced an additional cognitive load.** It was at this point that the theoretical framework of cognitive load theory (CLT) was identified as being of potential use in further analysis and an extensive review was carried out in this area and presented in this chapter.

3. It was found in the pilot study that a comparison between the experiences of the sighted learners and the learners who were blind could be of value. However, in the pilot there was a very small group consisting of two sighted learners, three learners who were blind and one learner who was partially sighted. In addition the age range, sex and experience of using assistive technology and ICT were diverse. The main study would need to be much more focused with fewer variables and a larger number of participants in order to facilitate the validity of the data and its analysis.

4. A framework for assessing the expertise of learners navigating in a web-based environment was formulated and this is described further in chapter 10. It was decided not to develop this further in the main study, but nonetheless it was a useful spin-off from the action research and has implications for staff development which is considered further in Chapter 10, the Conclusion.

Negative aspects relating to the pilot were:

1. The tasks were too complex for some of the participants. This relates both to the fact that the tasks were not generally accessible to someone using a screen reader and that not all of the participants had sufficient skills levels in using ICT and assistive technology. The implications for other studies here are that the participant must have a high level of skill and that the tasks must be attainable.

2. There was no means of measuring the quality of the learning experience. Performance in the quiz-style questions would be an indication of quality of learning. To investigate the effect that accessing has on using and doing, and potentially on the quality of the learning experience there would need to be a comparison between learners who were blind and sighted learners. An interest in outcomes of learning as well as processes of learning is important in better understanding participants learning experiences. Also learning outcomes could also relate to the measurement of cognitive load. This is discussed further below.

3. There was insufficient data relating to what the learners found particularly difficult. One problem again was the number and range of different tasks. As noted above this could be resolved by concentrating on one type of learning experience and systematically analysing the participants' experiences with all aspects of the learning material (for example page by page). Deeper analysis of one specific task would, through observation, give greater insight into what a learner was doing at any point, particularly in terms of learning.

Cognitive Load Theory

Background to cognitive load theory

According to Chandler and Sweller (1991) CLT is concerned with 'the manner in which cognitive resources are focused and used during learning and problem solving'. Gerjets and Sheiter (2003, p.33) assert, 'The main goal of the theory is to guide instructional design decisions.' CLT originated in the early 1980s in the work of Dr John Sweller who was carrying out experiments at the University of New South Wales, Australia. According to Sweller, reflecting more recently on the origins and development of CLT (Clark et al, 2007, p.314), 'the origins of CLT came about because of a failed experiment relating to the way in which people learn while solving problems. CLT has continually based its instructional recommendations on the outcomes of controlled experiments'. Sweller also states (Clark et al, 2007, p.329) that 'a limited working memory affects all of our activities when dealing with novel information, including perceiving information and understanding instructions'. It is this important aspect, that is, working memory, which is addressed next.

Working Memory

The model of working memory was first put forward in 1974 (Baddeley and Hitch). The key point is that working memory is restricted and it is in the working memory that information is processed. In essence information is stored in the long-term memory and then retrieved by the working memory to be processed in order to, for example, problem solve. Information in the long-term memory is stored in the form of schemas which can be defined as 'a construct which allows problem solvers to group problems into categories in which the problems in each category require similar solutions' (Cooper and Sweller, 1987, p.348). Britton and Black (1985) set out a 'cognitive work bench model' to model this process. Since working memory is finite then for the purpose of this study it may be seen that part of the working memory is being taken up by the effort needed to use the assistive technology. This would be additional for the blind learners compared to the sighted learners who do not have this particular load. However, it should be noted that there is potentially the additional load of the visual experience for the sighted learners that the blind learners do not have, in that their working memory is taken up partly by processing images.

This links to the three assumptions put forward by Mayer and Moreno:

> Firstly human information processing consists of two separate channels in that there is assumed to be an auditory/verbal channel for processing auditory input and verbal representations and a visual/pictorial channel for processing visual input and pictorial representations (2003, p.44).

So it may follow that presenting information in both a visual and auditory format may increase the available working memory and therefore decrease the cognitive load. This is called the modality effect (Jeung, Chandler and Sweller, 1997). Further to this, there is a second assumption that the working memory in each channel is separate from the other (Chandler and Sweller, 1991; Baddeley, 1986). A limited amount of processing takes place in the verbal channel and a limited amount in the visual channel. A question to be asked here is that, if the visual channel is not being used then is there additional capacity in the verbal channel? The third assumption here is that in order for meaningful learning to take place there needs to be a significant amount of processing in both channels. Mayer (2003, p.11) states, ‘The basic requirement in multimedia learning situations is that learners be able to hold corresponding visual and verbal representations in working memory at the same time.’

Closer examination of cognitive load theory

'Cognitive load may be viewed as the level of *mental energy* required to process a given amount of information. As the amount of information to be processed increases, so too does the associated cognitive load. Cognitive load theory suggests that effective instructional material promotes learning by directing cognitive resources towards activities that are relevant to learning rather than to processes that are an adjunct to learning' Cooper (1990, p.1). Cooper goes on to discuss schemas (mental constructs which enable learners to categorise problems and store them in the long-term memory and which they can draw on to solve problems). Efficient storage and retrieval of these schemas may result in less cognitive overload in the working memory.

The main problem which occurs for the learner who is blind using a screen reader is the additional amount of information that has to be stored in the working memory in order to navigate a web page. This may be exacerbated as there is no easy method of marking points of interest. This additional load may be influenced by the designer in terms of navigational aspects, but instructional design is probably aimed at a sighted learner. Therefore, unless the materials are specifically designed for a learner using a screen reader this load is not likely to be minimised. These difficulties may make navigating a web page take longer and make problem solving more complicated; consequently, there will be fewer schemas created making it more difficult for the learner who is blind to problem solve.

Cognitive load theory suggests that effective instructional material promotes learning by directing cognitive resources towards activities that are relevant to learning rather than to processes that are an adjunct to learning. It is generally accepted that performance of a task decreases when there is exceptionally high or exceptionally low cognitive load (Teigen, 1994). Performance may decrease with high cognitive load due to there being insufficient space in the working memory to process information. With low cognitive load performance may decrease due to an individual putting in less effort to problem solve. According to Paas, Tuovinen et al (2003) task characteristics that have been identified include task forma, task complexity, use of multimedia, time pressure and pacing of instruction. Also, relevant learner characteristics comprise expertise level, age and spatial ability. Only highly spatial learners are able to take advantage of contiguous presentation of visual and verbal materials.

The types of studies where CLT has been used have been related to examining the effects of the use of worked examples compared to traditional design (Zhu and Simon, 1987), the combination of text and graphics (Tabbers et al, 2000) and the method of presentation (Bruenken et al, 2004).

Types of cognitive load

Relating to the discussion above, Paas, Renki et al (2003, p.2) further categorise cognitive load into 3 types:

1. Intrinsic cognitive load, which relates to element interactivity required in learning materials. A task can be broken down into elements. When there is only one element, then the task can be described as having low element interactivity. This means that an element can be learned in isolation. When there are a number of elements, the task can be described as having high level interactivity and elements cannot be learned in isolation. Intrinsic cognitive load is concerned with the subject matter and is outside the control of the designer. This can be stored in the working memory, which may only cope with a small number of interactivities. Schemas (learning from previous experiences) are stored in the long-term memory and can be drawn upon automatically to aid current learning/problem solving experiences and this is known as automation.

2. Extraneous (ineffective) cognitive load occurs when 'working memory resources are used for activities which are irrelevant to schema acquisition and automation' (p.2). In this context this may include use of the screen reader and problems associated with design of the learning materials for sighted learners i.e. navigational issues. Extraneous cognitive load can be influenced by the designer.

3. Germane (effective) cognitive load is concerned with the combination of elements of working memory to create schemas and thus enhance the learning experience. An example of this would be navigation and learning design specifically directed at the blind learner. This can be influenced by the designer, for example an overview of a page within the learning object may be read out by the screen reader. Cooper (1990, p.8) concludes by saying, ‘Learning of essential material is enhanced by eradicating all non essential information.’ This

may take more time but it may enhance the learning experience. It may be seen that one way of defining good design is that it optimises the use of the working memory by decreasing extraneous cognitive load and increasing germane cognitive load.

Measurement of cognitive load

Subjective task ratings are, according to Paas, Renki et al (2003), the most commonly used measure of cognitive load. Tabbers et al (2000) used a scale ranging from ‘very, very low mental effort’ to ‘very, very high mental effort’ on a nine-point scale when comparing 11 different diagrams and the effort invested in having to understand them.

Bruenken et al (2004), in their paper on direct measurement of cognitive load in multimedia learning, set out a number of ways in which cognitive load may be measured and these include:

- time on task
- rating of difficulty of task/perception of mental effort
- performance outcome.

A higher amount of time spent on a task may indicate an increase in germane or extraneous cognitive load. That aspect is important for the design of this study where there is a comparison between two groups of learners and where it was shown in the pilot study that learners who were blind took up to three times as long to work through the learning materials compared with sighted learners. Although it was shown that some of this time was possibly due to the assistive technology and difficulties with navigation (which, given the discussion in this chapter, are arguably additional cognitive load). However, it could be in some circumstances that a person simply invests more time on a task than another person because they have a different style of learning. As Paas, Tuovinen et al (2003, p.66) state ‘it is quite feasible for two people to attain the same performance levels; one person needs to work laboriously through a very effortful process to arrive at the correct answers, whereas the other person reaches the same answers with a minimum of effort'.

In terms of ratings scales it can be questionable as to whether a person is able to rate their own level of mental effort invested in a task. Paas (1992) was the first to demonstrate that people are able to do this in the context of CLT. His study examined training strategies for attaining transfer of problem solving skill in statistics. Paas states that the type of scale used is not critical; the choice of category scales, magnitude estimation and the presence or absence of verbal labels makes little difference. Furthermore, subjective measures are easy to obtain, non-intrusive, easy to analyse and have very high face validity. The type of scale used in his study was a 9-point symmetrical category scale, whereby the perceived amount of mental effort was translated into a numerical value.

Another method to be noted here is dual-task measurement, which is a key method used in CLT/working memory research. The method involves a secondary task of, for example, simple sustained activity, the performance of which is supposed to reflect the level of cognitive load imposed by a primary task (Paas, Tuovinen et al, 2003). Types of secondary task might include finger tapping and random number generation (Dennis, McArthur and Bruza, 1998). This is of particular relevance for learners who are blind as they may well in effect already be carrying out a secondary task in their use of the screen reader for accessing the information. This is in effect being measured in the accessing, using and doing framework and can be used to compare effort in terms of time between sighted and non-sighted learners. This method was not used in the main study because learners who are blind, as will be discussed in their use of assistive technology, are already carrying out an extra activity to access the learning materials. However, if the aim were to compare cognitive load in respect of say two different types of e-learning materials, or indeed e-learning materials and another format (for those using a screen reader), then another task might be a useful technique.

Paas, Renki et al (2003) posit that a visual dual-task approach may be a promising alternative. They refer to Bruenken et al (2004) where a visual secondary reaction time task was used to measure the cognitive load induced by multimedia instruction. A visual secondary reaction task of course could not be used with participants who are blind.

Finally, in terms of methods of measuring cognitive load there are physiological techniques which are based on the assumptions that an increase or decrease in cognitive load will result in physiological change such as heartbeat, brain activity and pupillary (pupil) response. Studies which involve the measurement of brain activity, for example by Positron Emission Tomography (PET) imaging, are described below. Paas and Merrienboer (1994) found the heart rate method too intrusive, invalid and insensitive to subtle fluctuations in cognitive load. The cognitive pupillary response has been found to be highly sensitive to changes in cognitive load. Studies in this area are not of direct importance to this thesis as it would not be possible to measure the pupillary response of the learners who were blind.

Bimodal training would be difficult with learners who are blind because interacting with the learning object alone would be limited to auditory output and the only variance could be different voices or sounds. If external materials could be added then tactile diagrams or braille would be additional media. These external media would most likely result in additional time to complete the task.

It is important to note that, in terms of which type of cognitive load is being utilised, none of the measures of cognitive load have been able to differentiate between the three types of cognitive load – intrinsic, extraneous and germane.

Visual and auditory channels and blindness

It is important to consider here the notion that people who are blind might have enhanced auditory capacity. Systematic studies have shown that people who are blind perform some non-visual tasks better than those with sight (see below). Neuro-imaging studies have suggested that areas of the brain normally devoted to vision become active when people who are blind perform nonvisual tasks, but much remains to be learned about the nature and extent of this phenomenon. It is therefore possible that there is additional capacity for verbal and auditory processing in the working memory for the learner who is blind. Whilst they are not benefiting from the visual aspects they may have additional capacity to process sound. There may, therefore, be additional capacity to process schemas and to store information in the long-term memory to enhance problem solving.

In 1999 Röder et al carried out a study where they compared behavioural and electrophysiological indices of spatial tuning within central and peripheral auditory space in congenitally blind and sighted people. They found differences in the scalp distribution of brain electrical activity between the two groups that suggest compensatory reorganisation of brain areas in participants who were blind. This may contribute to an improvement in relation to their mobility resulting from an increased ability to perceive sounds in the locality.

Voss et al (2004) carried out a study in which they investigated auditory abilities in far-space in early and late-onset individuals who were blind. They were able to demonstrate for the first time that even participants who had late-onset blindness develop above-normal spatial abilities suggesting that significant compensation can occur in the adult. They hypothesise that these spatial skills are so critical for an individual to navigate through their environment that they invest significant neural and cognitive resources to develop strategies to cope with their disability.

A study by Pascual-Leone and Hamilton (2001) showed that sighted adults deprived of vision for a period of five days displayed activation of the visual cortex in response to tactile stimulation. In addition, a study by Buechel et al (1998) showed via PET imaging (Positron Emission Tomography which measures the amount of metabolic activity at a site in the body and a computer reassembles the signals into images) that activation of the visual cortex during the reading of braille material and auditory word processing took place in both early and late-onset participants who were blind.

In relation to cross-modal plasticity (reorganisation of the brain), Kujala et al (1997) showed that plasticity between sensory modalities is possible even in adults. Cohen et al (1997) conclude that blindness from an early age can cause the visual cortex to be recruited to a role in somatosensory (touch, temperature, body position and pain) processing and they propose that this cross-modal plasticity may account in part to the superior tactile perceptual abilities of people who are blind.

Split-attention and modality

In terms of multimedia content using pictures and text, if a picture is complex then there is a split-attention effect whereby the sighted learner cannot look at a picture and read associated text at the same time. However, if the text is presented in an audio format then they can look at the picture at the same time as listening. Tabbers et al (2000) carried out two experiments in respect of CLT theory, split-attention and modality effects. They found that preventing visual search by adding visual cues to the diagrams was effective. However, they found that replacing text with audio did produce a modality effect but it was the opposite of what they expected. The learners reading text scored higher in the performance test than the learners using audio, but there was higher mental effort expended by the learners reading text on the test which may explain the result. Tabbers put forward three explanations for these effects, all of which are relevant to the current study:

1. Firstly, the average mental effort for the learners using audio was lower than the average for the learners reading text which may have been because these learners were less motivated. A possible reason for this lower motivation is that they had to wait for the audio to download and as a result they lost interest. In such a study it is therefore important that the technology is fast and reliable. Tabbers et al (2000) posit that listening to audio may be more tiresome than reading and this can lead to lack of motivation in a task. If this is the case, then learners who are blind are already at a disadvantage as they can only obtain the information through the medium of audio.

2. Secondly, there is the issue of time taken on learning and the impact on cognitive load. In Tabber's study the participants spent an average of one hour on the task which may have had a negative impact on the cognitive load as concentration and attention span may be reduced over one hour compared to say twenty minutes. Twenty minutes is generally considered to be the maximum time scale for a learning object /task in order for full concentration to be maintained. It would therefore be important in a study for the learning task to last no longer than twenty minutes.

3. The third and final point is so important that there is a direct quote from the author's paper (2000, p.8):

> It is possible that while the students were studying parts of the instructions became redundant because students did not need to see and read or hear things for a second time. In the visual conditions, it would be easier to skip through texts and only study what's relevant than in the audio conditions. That would mean that in the audio conditions the mental resources were partly used for processing unnecessary information, leading to a higher extraneous load and undoing the benefits of the modality effect.

Blind learners always have to listen to the information online via a screen reader, they cannot visually scan. However, some expert assistive technology users will be able to scan aurally in that they can listen at high speed. They also have to listen to the screen reader giving navigational information. In both cases they have very limited opportunities for skipping information.

The authors conclude in this study that there may not be clear-cut rules for designers as described by CLT. However, the framework does guide designers particularly in respect of the combination of mental effort and performance scores.

Expertise reversal effect

This section ends with a brief examination of the expertise reversal effect. Kalyuga et al (2003) posit that instructional techniques that are highly effective with inexperienced learners can lose their effectiveness and even have negative consequence when used with more experienced learners. In the paper there is a review of empirical literature on the interaction between instructional techniques and levels of learner's experience that led to the identification of the expertise reversal effect. This aspect of CLT is considered to be important as the impact of cognitive load may be that it is dynamic and there may be a need for at least different, if not increased, guidance for learners who are blind compared to sighted learners. Moreover if a learning object is designed to address the needs of a range of learners of varying abilities and disability then the guidance may become so complex as to have a detrimental effect and increase the cognitive load, and therefore reduce the quality of the learning experience for all those concerned. In a nutshell, explanatory notes may reduce the cognitive load of inexperienced learners, but increase the cognitive load of experienced learners.

Conclusion

CLT was introduced as the underpinning theoretical framework to be used in the main study to analyse the data and to begin to identify and measure the quality of the e-learning experience. Working memory is the foundation of cognitive load theory in that working memory is finite and that it is used as a platform on which to problem solve, with additional information being retrieved from the long-term memory. Learners who are blind may be at a disadvantage in an e-learning environment in that they are using up some of the working memory operating the assistive technology which the sighted learners do not have to do. In connection with this there was consideration of visual and auditory channels and blindness. There is the possibility that there may be additional capacity for learners who are blind to process schemas and to store information in the long-term memory to enhance problem solving.

Types of cognitive load were examined, and extraneous and germane loads both have implications for learners who are blind in that they can both be influenced by the designer. This would apply to learners who are blind in that the designer can affect navigational aids, for example, or reduce cognitive load by not including content that is not essential to the learning.

Measurement of cognitive load was considered and, linked to the conceptual framework of accessing, using and doing, it was decided to focus for the main study on ‘time on task’ along with 'rating of difficulty of task/perception of mental effort’ and ‘performance outcome’.

The concepts of split-attention and modality were found to be of importance in that studies such as those carried out by Tabber et al (2000) had examined combinations of text, audio and graphics in order to ascertain which combinations were most effective for learning. Three key points for the main study arose from this and related studies:

1. Listening to audio may be tiresome for sighted learners. Learners who are blind are already at a disadvantage in that they only receive information aurally (except sometimes when there is a tactile alternative available, but this is the exception).

2. The learning task should be no longer than twenty minutes to ensure full concentration by the participants.

3. Sighted learners have the opportunity to visually scan content and skip what is redundant. Learners who are blind do not have this opportunity. However some very experienced learners are able to scan aurally.

In summary CLT is of great relevance to the main study and in the light of this it was decided to develop a method which incorporated CLT to get a richer picture of learners who are blind and their experiences of using online materials. The key aspect of this being the quality of the learning experience. The main study design and method are set out in Chapter 8 which follows.

CHAPTER 7

MAIN STUDY DESIGN AND METHOD

Introduction

Two chapters relate directly to the main study. This chapter describes the design and method of the main study and Chapter 9 analyses and discusses the results.

This study builds upon the methods used in the exploratory and pilot studies as set out in Chapters 4, 5 and 6. The key question or stepping stone to be addressed is in respect of the quality of the learning experience and the extent to which learners who are blind experience the same quality of learning as sighted learners. It compares the experiences of ten participants who are blind and ten participants who are sighted in working through an online learning object. The learning object was in the form of a 20 minute piece of learning content delivered over the internet. A range of quantitative and qualitative data was collected and included relating that to the conceptual framework as described above. The results of performance tests, a satisfaction survey and perception of mental effort were also collected. A satisfaction survey has been used for the main study largely in terms of the learner’s satisfaction of using the learning object and their preference in respects of working media.

The Chapter commences with a consideration of the links with the methodology as set out in Chapter 6. This is followed by an overview of the method; the participants involved; a description of the interview schedules and the overall procedure. The learning object task to be performed, which was used as a focus for the task to be performed by the learner, is then set out. The rest of the chapter is then structured to reflect the stages of the data collection and this structure is also used to present the results in Chapter 9 to aid clarity. These areas of data collection are:

- observations of learners carrying out the task
- learning performance including quiz-style questions and a post-task test
- perception of mental effort
- satisfaction survey.

Links with the Methodology

This section examines the conclusions from Chapter 7, the methodology and literature revisited, and describes how this affected the requirements of the main study. This is connected directly to the research methods developed for the pilot study. In essence the key aspects that arose as being useful in terms of addressing the research question at this stage (whether the quality of the e-learning experience is the same for a learner who is blind as for a sighted learner, that is, is there a level playing field?) were:

- recording of time taken to carry out the task;
- observation of the activities participants were engaged in, that is accessing, using and doing;
- the need for participants to carry out real learning activities;
- the extent of satisfaction in engaging with the learning activity;
- comparison between blind and sighted participants.

These aspects were to be the basis of the next stage. In order to take this further the following aspects needed to be developed:

- The introduction of measures of cognitive load in terms of learning performance, perception of mental effort and time taken to complete tasks.
- The engagement of participants in a more focused learning activity with clear learning goals.
- An increase in the scale of the study in terms of numbers of participants. In the pilot study there had been a small group of participants, two of whom were sighted, three who were blind and one who was partially

sighted. It was found that a comparison between experiences was of use in that there was evidence to demonstrate that there is a difference and an indication of the difference.

- A more in-depth and focused satisfaction survey.

How this was achieved is described briefly in the section below and more fully in the rest of the Chapter.

Overview of Method

The following is a summary of the method used in the main study. This is described in more detail below.

Participants: The 20 participants in the study were all young men aged 16–27. In order to reduce the number of potential variables that could influence how the learners experience e-learning it was decided to eliminate gender as a potential confounding variable by creating a single gendered sample. Males were not specifically chosen over females. 10 of the participants were sighted and the other 10 were blind (the latter group used a screen reader, JAWS for Windows, to access information on a computer). The participants were all competent users of computers, and the two groups had similar experience using computers, the internet, email and chat rooms. All were studying at similar educational levels.

Design: A between-subjects design (comparing a group of sighted participants to a group of participants who were blind) was used in the research because the comparison of the experiences of the two groups was central to the research question.

Learning material: The main part of the activities revolved around the participants working through an online learning object on sports injuries. The information in the learning object is displayed in the form of words, graphics, and audio in a linear format covering 24 pages or screens. The learning object was primarily designed for sighted persons, but was adapted to be used by persons who are blind in that everything was accessible through direct speech from the software or using screen reading software. The participants were videotaped working through the materials, with the video lens focus being on the screen.

Procedure: Each participant worked on a single computer in a room with the author. The participant worked through the learning material (which took approximately 10 to 35 minutes).

Mental effort: At nine points during this work, each was asked questions about the amount of 'mental effort' required to understand the materials and navigate through the materials.

Satisfaction: At the end of the session, the participants were also asked about the general enjoyment/satisfaction of using the material.

Learning performance 1: Also, throughout the learning materials, the participants were required to complete some 'quiz-style' questions that were recorded. As a result, a learning performance score at the time of learning (maximum score of 12) was acquired.

Learning Performance 2: Finally, two days after they completed the activity, the participants completed a recall test to give a learning-performance score (maximum score of 27).

Observation: The video of the activity was summarised using three observation schedules. Each schedule was based on a momentary time sampling (or 'point' sampling) method, in which observations were made every 10 seconds from the video recording. The schedules related to what page of the material the participant was using, what type of action was being taken (such as listening, reading, answering, checking or navigating, or a JAWS-related activity) and what main activity they were engaged in (accessing, using or doing).

Participants

In the main study the key variable was task performance and how well learners were able to engage/learn within a learning object. This may be affected by:

- experience and expertise with ICT including assistive technology;
- literacy and numeracy levels (otherwise known as Skills for Life or functional Skills alongside ICT);
- levels of study in terms of vocational or academic courses followed;
- disability/Level of vision;
- age;
- gender.

All participants/learners were male and aged between 16 and 27. In respect of the recruitment methodology, for the learners the author approached tutors for recommendations of suitable participants who met the criteria below. In order to minimise the variables, participants were to be all of the same sex and there was no specific preference as to male of female. A majority of names put forward were male and in addition there was a very limited number of potential participants who met the criteria. All participants were to be engaged in a programme at Level 2 or 3 which was not sports related (see below for justification of this). They would need to be working at Level 2 in terms of literacy, numeracy and ICT related directly to this and to engage successfully in their main vocational programme. A questionnaire (see Appendix 3) was sent to all the learners to gain more detail as to the specifics of their ICT skills and knowledge. All participants considered themselves to be at least competent with ICT if not expert. For the blind learners, they needed to be competent or expert with the assistive technology too. It was important to ascertain their experience with e-learning as if they were familiar with the particular learning objects then this would greatly influence the results. The aim of the main study was to explore the question of whether the quality of e-learning is the same for sighted and blind learners. Therefore it was important to find a group of blind learners and a group of sighted learners with similar levels in terms of the variables above.

Set out below in Table 5 and **Error! Reference source not found.** is the aggregate information for each group of participants. This information can be found for each of the learners in Appendix 12.

Table 5 Summary of information for the learners who were blind

Age	18.4 years
Sighted?	All registered blind
Level of Study?	8 Level 3; 2 NVQ level 2
ICT Skills Level?	5 Intermediate; 5 expert
Assistive Technology Skills Level?	3 Intermediate; 7 Expert
No. of years computer use?	9.8 years
Preferred method of learning?	All used PC, 6 named braille, 2 named tape
No. of years internet use?	5.55 years
Purpose of internet use?	9 = study; 7 = hobbies; 5 = shopping; 1 = communication; 1 = entertainment; 1 = business
Email use?	All on a daily basis
Chat use?	7 used chat on a daily basis; 3 did not use it
Discussion board use?	2 used discussion board – both for hobbies
VLE use?	1 used VLE
Learning object use?	1 used online materials in accessibility trial
Multiple-choice question (MCQ) use?	5 used MCQs – 2 for forms, 1 for tests, 1 for quiz and 1 for maths
Games use?	4 used games – 1 each for Commando; cards; tennis; mortal combat. 1 had tried but failed.

Table 6 Summary of information for the learners who were sighted

Age	19.4
Sighted?	All fully sighted
Level of Study?	All level 3
ICT Skills Level?	All stated they were intermediate
Assistive Technology Skills Level?	N/A
No. of years computer use?	7.2 years
Preferred method of learning?	All said PC, 2 said audio and 1 said books
No. of years internet use?	5.2 years
Purpose of internet use?	7 = study; 7 = hobbies; 8 = shopping; 1 = business; 1 = communication
Email use?	7 daily, 2 monthly and 1 weekly
Chat use?	5 used chat – 3 daily, 1 weekly and 1 monthly
Discussion board use?	2 had used a discussion board for hobbies
VLE use?	None
Learning object use?	2 for revision
Multiple-choice question (MCQ) use?	6 – 3 for revision, 1 for Key Skills, 1 for Webwise and 1 for forms
Games	4 – 1 for allsorts, 1 for chess, 1 for poker and betting, 1 for pool

In summary all participants described themselves as competent users of computers. The participants who were blind all used a screen reader, JAWS for Windows, to access information on a computer. Participants were asked to rate themselves as either 'beginner, intermediate' or 'expert'. Five of the learners who were blind rated themselves as expert and five as intermediate, and all of the sighted learners rated themselves as intermediate. The two groups had similar experience of using computers, the internet, email and chat rooms, although the learners who were blind tended to use email and chat more regularly. One learner who was blind had used a VLE and no sighted learners had used a VLE. One blind learner had used a learning object in an accessibility trial and two sighted learners had used a learning object for revision. Five learners who were blind had experience of MCQs as opposed to seven of the sighted learners. Four learners who were blind and four sighted learners played online games, but an additional learner who was blind had tried and failed.

It is recognised that there may be an issue regarding the use of a small sample of 20 participants, but it would be impractical to conduct a study of this nature using a larger group. However, as is discussed here, it is believed that the sample yielded useful data and information that could influence policy and practice.

Procedure and Interview Schedules

The participants worked on a single computer in a room on a one-to-one basis with the researcher. These sessions were pre-booked to fit in with participants' timetables. They were first told about the task and the broad purpose of the study. When they were ready, the participants worked through the learning material (which took between approximately 10 to 35 minutes), although the expected time was twenty minutes and is described in the following section.

Information on navigation was limited to the need to use a play button to move to the next page, a menu button, a back button and the option to switch the audio on or off. Audio was provided for some of the commentary by the 'sports instructor' (online narrator) in introducing the learning materials. The audio commentary was supported by on-screen text, which could be accessed by the screen reader. The participants were videotaped working through the materials, with the video lens focus being on the screen.

The Learning Object

In the pilot study the learners carried out various tasks in a VLE. In this study learning object rather than a VLE was used in order to focus and contain the activity. Certain aspects of the VLE were very difficult for the learners who were blind to use, and a significant amount of time was spent on accessing. It was therefore decided to shorten and constrain the learning experience. The learning object was carefully selected in respect of accessibility, variety of features, content and intended duration.

The main part of the activities revolved around the participants working through an online learning object on sports injuries. This learning object is part of the National Learning Network (NLN) materials, funded by the UK Learning and Skills Council (technical and accessibility information is described further in NLN (2007)). The information in the learning object is displayed in the form of words, graphics and audio in a linear format covering 24 pages or screens. The learning object was primarily designed for sighted people, but was adapted to be used by people who are blind in that everything was accessible through direct speech from the software or using screen reading software. It should also be noted that the materials were intended to be a support for other practical-based learning opportunities, so that users would not usually come to them without any prior knowledge.

The learning object had a targeted delivery time of 20 minutes. This was important in that it was sufficient time for the participants to become engaged but not too long if, for example, there were extreme difficulties and a participant took an inordinate amount of time or they lost interest and/or concentration. There would be less wasted effort for learners in having training on how to use a VLE that they may never use again and this was explained in the pilot study. In addition the focus would be on the amount and quality of learning that had taken place.

In terms of content it was important that a self-contained piece of learning was used so that no or limited prior knowledge was required (none of the participants were studying this topic which was related to sports injuries). It was also important that the subject matter was potentially interesting and relevant to the participants and sporting opportunities were built into their educational programmes.

According to the NLN website (NLN, 2007) the materials are intended to be used in the following way:

> In class, materials may be used:
> – to visually demonstrate concepts that can be difficult or expensive to teach in other ways
> – to facilitate small-group work using case-study or problem solving exercises
> For individual study, materials may be used:
> – as preparation for a class
> – as a refresher or to help students catch up
> – as a revision tool
> The materials come with tutor guidance documentation which includes technical data, an overview of the learning objects and further support information.

In essence the materials were not intended to be used as a primary method of delivering the content but rather as support materials.

It was important for the study that the learning object was very accessible in order that the learners who were blind or sighted could work through with minimal training and intervention. This was to ensure that, as far as possible, each of the participants received the same amount of input before they started on the learning object and during the learning experience. The learning object had screen reader functionality built in (see the opening screen Figure 8 below) in that a button was available on the first page which if activated would enable a screen reader to read hidden text. The learning object had also been tested for accessibility. The author was involved with the testing process and had worked on a range of materials developed by different designers and with a range of learners/end users so she was very familiar with them. This testing involved learners who were blind trialling specific learning objects by working through the materials whilst being observed. General accessibility solutions had been applied by the designers of the content across the range of learning objects. This would be such features as tabbing around links in a logical order, logical labelling of links and the ability to change colour contrasts.

Figure 8 The opening screen of the learning object

The learning object had a range of features which included an audio on/off facility, multiple-choice/quiz-style questions, audio commentary with text alternative, diagrams, a flow chart and illustrations. In addition there was a screen (Figure 9) showing additional navigation keys which the learners could have used if they had found the page, but they were not directed to it as the intention was that they use their usual navigation keys.

Figure 9 Page displaying additional navigation keys

Appendix 5 sets out a schedule of the content on each of the 24 pages. This schedule shows the page number; the media involved (for example text and audio or graphics and text) and a brief description of the content, for example a multiple-choice question or a mnemonic.

Observations of learners carrying out the task

The method of recording the number of observations on each page as utilised in Chapter 6, the Pilot Study, was used again here as it was found to be a useful way of identifying what a learner was engaged in at any one time. The time factor would be revisited alongside further exploration and elaboration of the accessing, using and doing analytical framework as described in Chapter 6. In addition it was decided to record the number of observations per page. This would be useful evidence for demonstrating which sub-tasks took more time. The number of observations per page could also be linked to the nine points where perception of mental effort was assessed (see below).

Observation schedules and inter-rater reliability

The video of the activity was summarised using three observation schedules. Each schedule was based on a momentary time sampling (or 'point' sampling) method, in which observations were made every ten seconds from the video recording. The observation and analysis schedule is set out in Appendix 9. The schedules related to what page of the material the participant was using, what type of action was being taken (such as listening, reading, answering, checking or navigating, or a JAWS-related activity) and what main activity they were engaged in, that is accessing, using, or doing.

Confidence in the schedule was based on the inter-rater reliability demonstrated in the pilot study. In the Pilot Study (Chapter 6) two researchers had conducted inter-rater reliability tests of the schedule. Of the 274 observations, there were only 2 differences between the two observers' scores. However, on consultation it was found that these differences were errors, and agreement was reached.

Learning Performance

The possible impact on learning in terms of quality was further explored by measuring the extent to which learning may have taken place. There were two types of performance tests employed. The first were the quiz-style questions that the learners engaged in as part of working through the learning object and the second was a performance test two days after participating in the task.

Quiz-style questions

Throughout the learning materials, the participants were required to complete seven 'quiz-style' questions, the responses to which were recorded in the learning object. As a result, a learning-performance score at the time of learning (maximum score of 12 was acquired. There were four varieties of questions. The questions are set out in Appendix 4.

Performance was measured in terms of scores for each question; however, these would be no indication as to whether any of the learning had been taken into the long-term memory as schemas since this learning would most likely be stored in the working memory.

The first question was a true/false multiple-choice question (see Figure 10) which required the learner to select whether four statements were true or false based on their study in the previous pages of types of injuries.

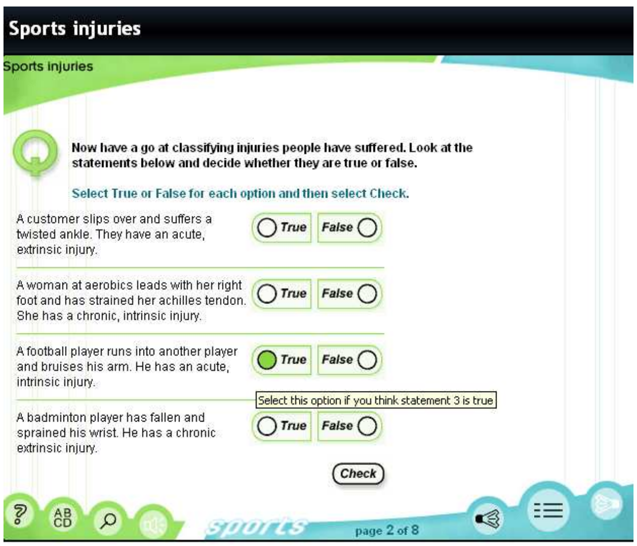

Figure 10 True/false sports injuries question

The second question, which is an odd-one-out style multiple-choice question (see Figure 11) required the learners to select three answers from a choice of five.

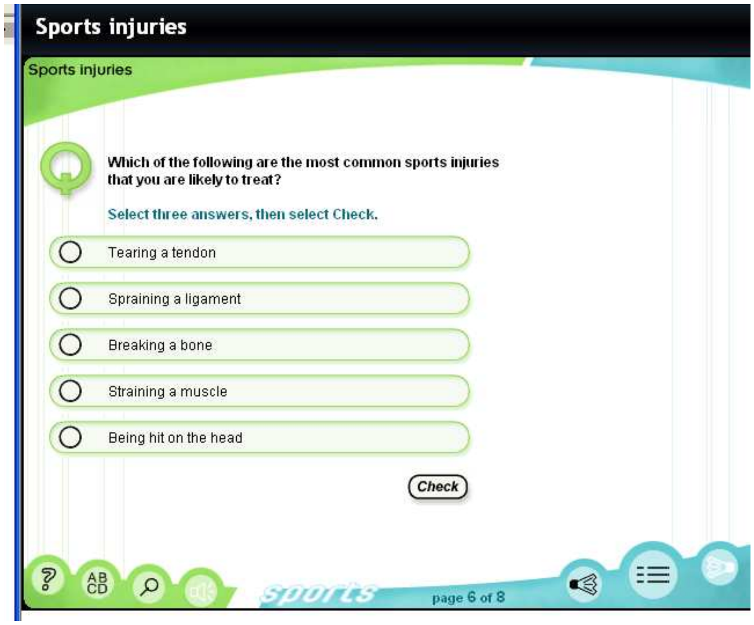

Figure 11 Odd-one-out style multiple-choice question

The third type of question (see Figure 12 below) known as the 'most-accurate' style of question was a series of four questions where the learner was required to select the correct answer from a list of three or four alternatives.

Figure 12 Most-accurate style question

The final quiz question (Figure 13 below), known as an either/or type of question, required the learner to select an option of either 'yes' or 'no' based on a statement relating to a flowchart on the previous page.

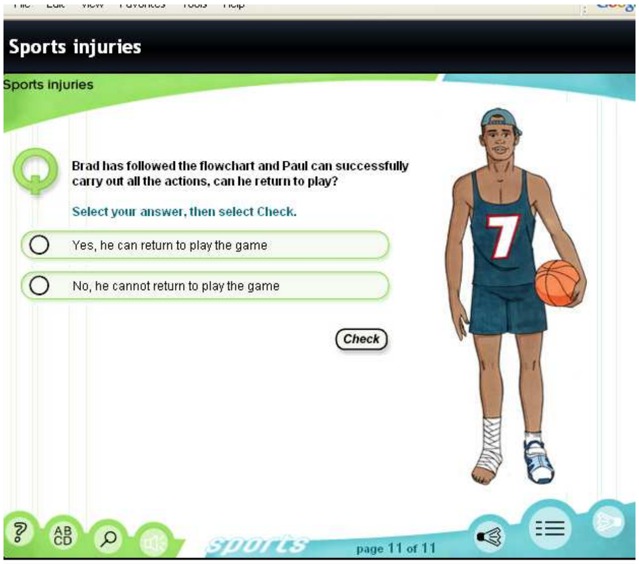

Figure 13 Either/or type of question

Performance test

A performance test at a set time after the learning activity was one of the proposed measures of cognitive load set out in Chapter 7, the Literature Review Revisited. A possibility would be to test at the end of the learning experience and then again after a period of time to ascertain whether the learning has been absorbed into the long-term memory. It was decided to test only once, two days after the learning experience. As stated previously the study materials were in an area which is not familiar to any of the participants as this would affect the performance results. The questions were based directly on the learning materials to ascertain understanding and were set in an order relating to the sequence of the learning content. The questions were also composed to elicit answers that should be based on the learning materials alone and not on prior knowledge. Learners were asked not to revisit any of the materials in between the end of the task and the test two days later.

A table setting out the schedule of questions can be found at Appendix 8. The table sets out the question, the answer, the page number in the learning material the question relates to, whether the question media is text, audio or graphic or a combination and finally true/false, closed or open. The questions related directly to the learning object and were asked in sequence relating to their position in the learning object. The questions were designed to be unambiguous and learners were asked to base their responses directly on what they had learned from working through the content. The first seven questions were about types of injuries and learners had a choice of two options, true or false, relating to a statement. Questions 8 to 17 were closed questions whereby a one/two word answer would be required. Question 18 required a short sentence to describe a situation as a response. Question 19 was a short scenario which required the learner to respond with the key mnemonic of RICEM (rest, ice, compress, elevation and mobility). The final question, question 20, required the learner to set out four key learning points/objectives that they learned from working through the learning object.

Perception of Mental Effort and Satisfaction Survey

Perception of mental effort

This is one of the proposed methods of measuring cognitive load as discussed in Chapter 7 (Literature Review Revisited). A scale of 1 to 7 was used, 1 being low perception of effort and 7 being high. This was not broken down into further descriptors but a diagram showing a scale from 1 to 7 was used to represent this. Learners could then judge their perception of mental effort either in terms of a number or by touch on the scale. For the learners who were blind a tactile version was used. Learners were asked about their perception of mental effort at nine key places where there had been a particular type of activity and/or a natural break. They were asked to judge the effort involved in terms of using, doing and for the learners who were blind, in terms of accessing; the responses were set out in the example Table 7. This would then link in with the conceptual framework of accessing, using and doing. This was an average of one key place every three pages. It was felt that if participants were interrupted more frequently then this would affect the learning experience. If learners were interrupted less frequently then insufficient key points would be addressed.

It was important that there was a ‘natural’ point at which to ask the question so as not to impact on concentration. For example, the first question was asked after the three introductory pages. At this point learners had been introduced to the learning object and had audio and reading material to deal with, and the third question was asked after the first, fairly complex, multiple-choice question. The participants who were blind were also asked a similar question about accessibility.

Table 7 Table used for recording perception of mental effort

Point	**Page in learning object**	**Activity**	**Perception of mental effort learning**	**Perception of mental effort using**	**Perception of mental effort accessing**
1	3	Introduction			
2	5	Classification of injuries			
3	6	Multiple-choice			
4	8	Muscles, tendons, ligaments			
5	10	RICEM and then multiple-choice			
6	12	Health and safety			
7	15	Intro to case study, MCQ and solution			
8	22	End of RICEM – MCQs and solutions			
9	24	Table and summary			

Satisfaction survey

At the end of the session, the participants were also asked individually by the researcher about their general enjoyment of using the material. Responses were combined to give a measure of satisfaction. This was measured on a 7 point Likert scale with 1 being strongly disagree and 7 being strongly agree as set out below:

1 = Strongly disagree
2 = Disagree a lot
3 = Disagree a little
4 = Neither agree nor disagree
5 = Agree a little
6 = Agree a lot
7 = Strongly agree.

The table below sets out the schedule of questions:

Table 8 Schedule of satisfaction survey questions

1. I enjoyed using the learning materials. 2. I learned more than I would using my usual method. 3. I preferred using these materials to my usual method. 4. I would use this method of learning again. 5. I will remember the materials more easily than with my usual method. 6. I found the material easy to navigate around. 7. I found the technology worked well. 8. The technology did not affect my ability to learn. 9. The audio content helped my learning. 10. The graphic/animation content helped my learning.

The questions covered satisfaction ratings relating to enjoyment; preference in comparison to usual methods of learning; how much was learned and remembered; ease of navigation; impact of the technology and the extent to which the various media affected the learning experience. Question 10 could only be answered by the sighted learners as this related to graphics and animations which could not be seen by the learners who are blind. For each question learners were asked to explain/elaborate on their answers.

It was decided that a different satisfaction survey from the pilot study should be used. In the pilot study learners were asked to rate their satisfaction in terms of confidence with the technology, not being frustrated and the way they carried out the task. This was rated on a Likert scale of 1 to 7, 1 being not at all satisfied and 7 being very satisfied. In this study the aim was to find out how much the learners enjoyed using the material and how the technologies involved affected their learning, how this might compare with their usual method of learning and most importantly was there any significant difference between the two groups of learners.

Measurement of Cognitive Load

As stated in Chapter 7, Literature and Methodology Revisited, there were three proposed measures of cognitive load identified (time taken to complete the task, perception of mental effort and performance score) to be used in this study. If the perception of cognitive load is low or poor then it would be expected that the satisfaction score would also be low. These results could be expected to relate to the time taken to complete the task, and in addition it is possible that they should relate to the satisfaction scores. For example, if the perception of cognitive load is high in terms of using, that is that navigation is difficult, then the satisfaction scores would be low.

Each of these four aspects has been coded as below in order to aid discussion of the relationship between them.

1. Time

10 to 15 minutes – low

16 to 25 minutes – average

26 to 30 minutes – above average

31 minutes and over – high

2. Perception of mental effort

Average 6 or 7 – high

Average 3, 4 and 5 – medium

Average 1 and 2 – low

3. Performance

15 or less – poor

16 to 20 – good (but must score min of 2/4 on Q 19)

20 to 27 – excellent (but must score min of 2/4 on Q 19)

4. Satisfaction

Average 6 or 7 – high

Average 3, 4 or 5 – medium

Average 1 or 2 – low

For the individual the best case scenario is that there would be a relatively short amount of time taken to complete the task with a minimum amount spent on navigating and accessing; a medium perception of mental effort on doing; an excellent performance outcome and a high level of satisfaction.

Conclusion

The increase in terms of quantitative methods of data capture in the pilot study has been further reinforced by the introduction of cognitive load theory and the particular methods of measuring this, that is time taken, perception of mental effort and performance tests. However, perception of mental effort although allocated a numerical rating is one person's perception of their own mental effort. This may not easily be compared to another person's perception of their own or anyone else's. In addition a satisfaction survey has been used and whilst this is given a numerical rating this is again an individual's subjective opinion. Compared to the pilot study, learners were asked to justify and/or elaborate on their satisfaction ratings. In the following chapter the data collected during the main study is set out and analysed and initial implications for learners who are blind evaluated.

CHAPTER 8

THE MAIN STUDY RESULTS AND DISCUSSION

Introduction

This chapter is the second of two chapters directly relating to the main study and is concerned with the results and analysis of the data from the methods described in Chapter 7. The chapter commences with an overview of the aggregate data for both groups of learners (blind and sighted) and which relates to:

1. Accessing, using and doing; that is, the time taken working in the learning object and how much time is spent on each of these three areas of activity. This is broken down further in terms of how much time is spent on each page and further analysis on time spent on doing.

2. The performance tests

    - Quiz-style questions answered while working in the learning object
    - The post-learning activity test carried out two days after the activity in the learning object.

3. Perception of mental effort (PME) applied to accessing, using and doing whilst carrying out the learning activity.

4. A satisfaction survey carried out immediately after completion of the learning activity.

Following analysis of the aggregate data there will be in-depth analysis of the following areas which link to the headings set out in Chapter 8 regarding the main study design and method:

- observations of learners carrying out the task;
- learning performance including quiz-style questions and post-task test;
- perception of mental effort;
- satisfaction survey;
- Measurement of cognitive load.

Results and Analysis

Analysis of Aggregate Data – Overview

In this section the aggregate data for each of the two groups, learners who are blind and learners who are sighted, is analysed (see Table 9 and Table 10 below). Further detail in terms of aggregate data can be found in Appendices 10 and 11 which collate the data from each of the 20 case studies. The data for each of the case studies can be found in Appendix 12 Case Studies 1 to 20. The background information (age, gender, academic level and ICT experience) in relation to these case studies has already been summarised in Chapter 8. All timings and percentages have in general been rounded up to the nearest minute or whole number except in relation to perception of mental effort and some averages. This section commences with a summary of each group's aggregate table and in all cases the figures are the average for each group.

Overview of Blind Learners' Experiences

Table 9 Overview of blind learners' experiences

Part. Number	**Time**				**Performance**		**Perception**	
	Access %	Using %	Doing %	Total mins	Quiz Max 12	Post-test Max 27	PME Average Out of 7	Satisfaction Out of 7
1	10	21	69	39	10	18	6	6.7
2	13	19	68	33	9	13	2.5	6.4
3	5	39	56	37	10	17	3.2	5.1
4	8	24	68	37	10	18	2.6	6.3
5	7	25	68	33	8	9	2.2	5.3
6	10	24	66	34	8	12	2	6.2
7	8	28	65	38	9	13	1.3	6
8	10	18	72	29	11	17	2.4	5.2
9	4	24	72	30	9	14	1.4	6
10	10	32	58	39	8	14	4.8	5.4
Average	9	25	66	31	8.9	14.7	2.9	5.8

The learners who were blind took an average (mean) of 31 minutes to complete the task (accessing 9% using 25% and doing 66%). Doing was broken down into 42% listening, 35% answering, 10% checking, 9% reinforcing and 3% other. Observations per page were generally evenly spread but slightly raised at pages 3 (introduction and learning objectives) and 7 to 10 (text and graphic and RICEM with a quiz-style question), each of the quiz-style questions and page 23.

In terms of PME this was accessing 2.4, using 2.8 and doing 3.5, with an average across the three areas of 2.9. They scored 8.9/12 for the quiz-style questions. They took 12.9 minutes to complete the performance test and scored 14.7/27.

Overview of Sighted Learners' Experiences

Table 10 Overview of sighted learners' experiences

Part Number	**Time**				**Performance**		**Perception**	
	Access %	Using %	Doing %	Total mins	Quiz Max 12	Post-test Max 27	PME Average Out of 7	Satisfaction Out of 7
1	N/A	10	90	15	12	21	3.2	6.4
2	N/A	9	91	13	11	21	1.4	6.4
3	N/A	8	92	11	12	10	1	4.9
4	N/A	10	90	12	9	20	1.6	5.4
5	N/A	10	90	15	9	11	3.7	4.4
6	N/A	15	85	19	11	17	1.9	5.7
7	N/A	5	95	19	10	21	2.2	7
8	N/A	13	87	20	11	18	3.8	5.2
9	N/A	9	91	12	11	17	1.7	5
10	N/A	13	87	21	12	19	1.8	5
Average	N/A	10	90	14	10.7	17.6	2.2	5.5

The sighted learners took an average (mean) of 14 minutes to complete the task (using 10% and doing 90%, accessing is not applicable for the sighted learners). Doing was broken down into 11% listening, 47% reading, 21% answering, 5% checking, 15% reinforcing and 1% other. Observations per page were generally evenly spread but slightly raised at pages 2 (objectives), 6 to 8a (quiz-style question and information on ligaments, tendons and capillaries) and 23 (quiz-style question).

In terms of PME the average for this was using 1.7, doing 2.7, with an average of 2.2 across the two areas. They scored 10.7/12 for the quiz-style questions. They took 9.7 minutes to complete the performance test and scored 17.6/27.

Overview: Comparison Between Blind and Sighted Learners' Experiences

The following section summarises the experiences of both groups relative to each other.

The learners who were blind took a relatively long time to complete the task, performed relatively poorly in the test and perceived the cognitive load to be medium for accessing, using and doing (doing being slightly higher), but they were very satisfied with the task.

The sighted learners took a relatively short time to complete the task, performed relatively well (good) in the test, perceived the cognitive load to be low for using and medium for doing and were very satisfied with the task, but not quite as much as the learners who were blind

There were clear differences between the two groups with the learners who were blind showing apparently poorer outcomes compared to the sighted learners in terms of time taken to complete the task, test results and perception of cognitive load, but they enjoyed the task more.

The above differences are explored furthering the following sections with the data being analysed in more depth.

Observations

The following data relates to the video analysis of the learners working through the learning object.

Time taken working through the learning activity

Overall, the participants who were blind took twice as long to complete the learning task as did the sighted participants (sighted participants: mean = 14.5

minutes, *SD* 20.5; blind participants: mean = 30.75 minutes, *SD* 20.4). This difference was found to be significant using a t-test (t = 10.9; *df* 1,18; p < .0005). Table 11 below presents the breakdown of how the different groups spent their time (both in terms of time taken and the percentage of time on different activities). Clearly, one reason why the participants who were blind spent a longer time on the task is that they had to spend time 'accessing' the materials using their screen reader (an average of more than 8% of their time). Nevertheless, even accounting for this overhead, they took longer to complete the task than did the sighted group (Add the mean / standard deviations). This difference was found to be significant using a t-test (t = 10.1; *df* 1,18; p < .0005).

Table 11 The number of observations (time taken) to carry out the different sub activities of the learning activity by the blind and sighted groups (percentage and number of observations in parentheses)

Activities	**Blind group (n = 10)**	**Sighted group (n = 10)**
Total mean number of 10 second observations	184.5 (30.75 mins)	84.3 (14.05 mins)
Broad activity % (minutes)		
Accessing	8.4% (15.5)	N/A
Using	25.5% (47.1)	10.4% (8.8)
Doing	66.1% (121.9)	89.6% (75.5)
Total	**100% (184.5)**	**100% (84.3)**
Specific 'doing' sub activities		
Listening	41.8% (50.4)	11.1% (8.4)
Reading	NA	47.0% (35.2)
Answering questions	35.4% (44.2)	21.4% (16.3)
Checking	10.4% (12.7)	4.6% (3.5)
Reinforcing	9.1% (11.4)	15.1% (11.5)
Other	3.2% (3.2)	0.8% (0.6)
Total	**100% (121.9)**	**100% (75.5)**

Note: N/A = not applicable.

Both groups tended to spend more time engaged in ‘doing’ than in other tasks ($F = 294$; df 1,18; $p < .0005$). Although the percentages suggest that the sighted participants spent proportionately more time ‘doing’ than did those who were blind, the interaction was not found to be significant when tested using an analysis of variance with repeated measures of ‘time using’ and ‘time doing’ ($F = 1.0$; df 1,18; $p > .05$).

Table 11 also presents a breakdown of the sub activities in respect of listening, reading, answering questions, checking, reinforcing and other (either asking questions or making a comment). The greatest amounts of time spent were observed to be listening for the participants who were blind (41.8%) and listening and reading for the sighted participants (58.1% split between 11.1% listening and 47% reading). Note that whereas the sighted participants were reading, those who were blind were listening using the built-in audio or the screen reading software. Also note that the participants who were blind spent much longer answering questions than did those who were sighted (35.4% versus 21.4%). This is analysed in more depth later in the chapter.

With regard to answering the multiple-choice questions contained within the learning object, it was not possible to differentiate between doing and navigating. Therefore, all the observations were counted as answering the question, but it is possible that more of the observations for the participants who were blind were for navigating. This may be because they had to keep revisiting the question to read them otherwise they have to carry the options in their head. For example, they are not able to glance quickly at options as a reminder and they would have had to navigate back to the relevant option and re-read it. This in itself would be an additional cognitive load as their working memory is being used up by having to remember the questions. Some types of question may be more difficult than others. A question that involves selecting one correct option from say four may be easier to complete than selecting two or three options from a range, particularly if the learner has to keep the options in their head.

It is vital that the navigation is easy to use, but it is also vital that the type of question and answer required is considered when implementing multiple-choice questions for learners who are blind. Cognitive load theory indicates that additional working memory may be being used and therefore there is less memory available to problem solve and to learn and create schemas from engaging in this type of activity.

Observations per page

In terms of the average number of observations per page of learning material, there were generally two to four times more observations for the participants who were blind. Some pages of the learning material (those with multiple-choice questions) appeared to be especially slow for this group. Appendix 13 sets out the page number, the learning content, the presentation of the content and the comparison of the average number of observations for both the learners who were blind and the learners who were sighted.

All the quiz-style questions took the learners who were blind at least three times longer than the sighted learners to answer. The true/false question and the odd-one-out question appeared to be particularly difficult and this may be because they both required a large amount of information to be held in the working memory. The 'most accurate' style question may be less demanding as it requires less information to be stored in the working memory, particularly as the correct answer is known. A question which is of an either/or type can be less demanding in terms of cognitive load in that there are only two options to retain in the working memory.

Pages 22 and 22a of the learning material related to an introduction to mobility and there was a link on this page that took the learners to a decision tree. A majority of the learners who were blind missed the link to the table (see Figure 16 below) whilst none of the sighted learners missed the link. This accounts for the amount of observations for both groups being similar. Even on the pages where there was no activity such as a quiz question or a link to follow, the learners who were blind took approximately two to three times the number of observations compared to the sighted learners.

Perception of Mental Effort and Satisfaction Survey

Perception of mental effort

Table 12 shows that the participants who were blind, on average, perceived that the learning activity required greater mental effort than did the sighted participants. The average is based upon the mean of the mental effort ratings on a seven-point scale given at nine instants during the learning task – see Appendix 6. This was true for both perceived mental effort using the materials (navigating the various pages) and learning from them. However, these trends were not found to be statistically significant ($F = 2.8$; df 1,18; $p > .05$). Nevertheless, it should be noted that the participants who were blind said that accessing the learning materials took some mental effort (using the screen reading software), and the sighted participants did not have this additional overhead.

Table 12 The mean perception of mental effort to carry out the learning activity and the mean satisfaction score (by the blind and sighted groups)

Perception and satisfaction	Blind group (n = 10)	Sighted group (n = 10)
Perceived mental effort		
Accessing	2.4 (SD = 1.82)	N/A
Using	2.8 (SD = 1.51)	1.7 (SD = 0.89)
Doing	3.5 (SD = 1.55)	2.7 (SD = 1.27)
Overall satisfaction score	5.8 (SD = 0.69)	5.5 (SD = 0.82)

Note: N/A = not applicable.

For both groups the trend for navigation/using (see Figure 14 below) was fairly constant and for the participants who were blind there was on average greater mental effort in terms of using at the start, possibly as they were becoming familiar with the navigation, and at the end when they would have been trying to navigate around the table, summary and returning to the menu.

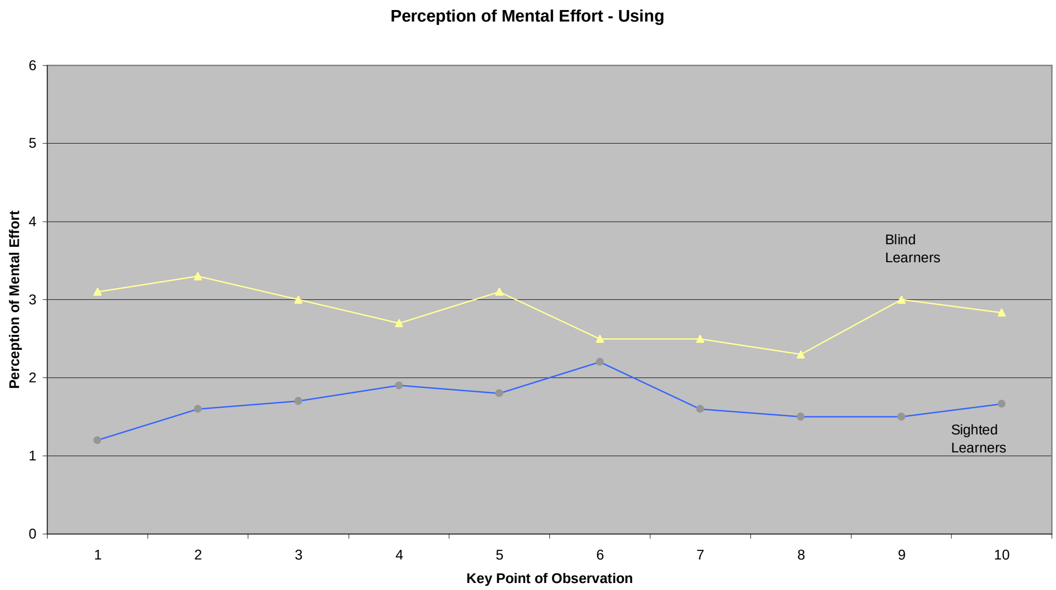

Figure 14 Line graph showing comparative perceptions of mental effort for using

Noticeably the learners who were blind did not have a high perception of mental effort in respect of navigating the pages relating to multiple-choice questions, where there was a high number of observations (over three times as many compared to the learners who were sighted). However, they did have an increased level of mental effort in terms of learning at this point and this is discussed further below. Another interesting point is that at point six the learners needed to navigate back to the menu to move on to the case study, and observation by the author at the time did indicate that a number of participants did find this difficult but this was not reflected in their scores. This could be addressed by having more observation points but this would have interrupted the flow of the learning experience.

It is noteworthy that overall the participants who were blind did not have a particularly high perception of mental effort compared with the sighted learners. This was indicated by the number of observations recorded against navigation showing that the navigation was at least time consuming if not potentially quite difficult. An explanation of this could be that navigation in an online learning environment can be generally difficult for people using a screen reader and this environment which has been adapted for use with a screen reader was less challenging. This aspect needs to be kept in mind when using perception of mental effort as a measure of cognitive load and is considered further in Chapter 10.

In terms of perception of mental effort of learning/doing, the trend in the line graph for both groups was similar (see Figure 15 below).

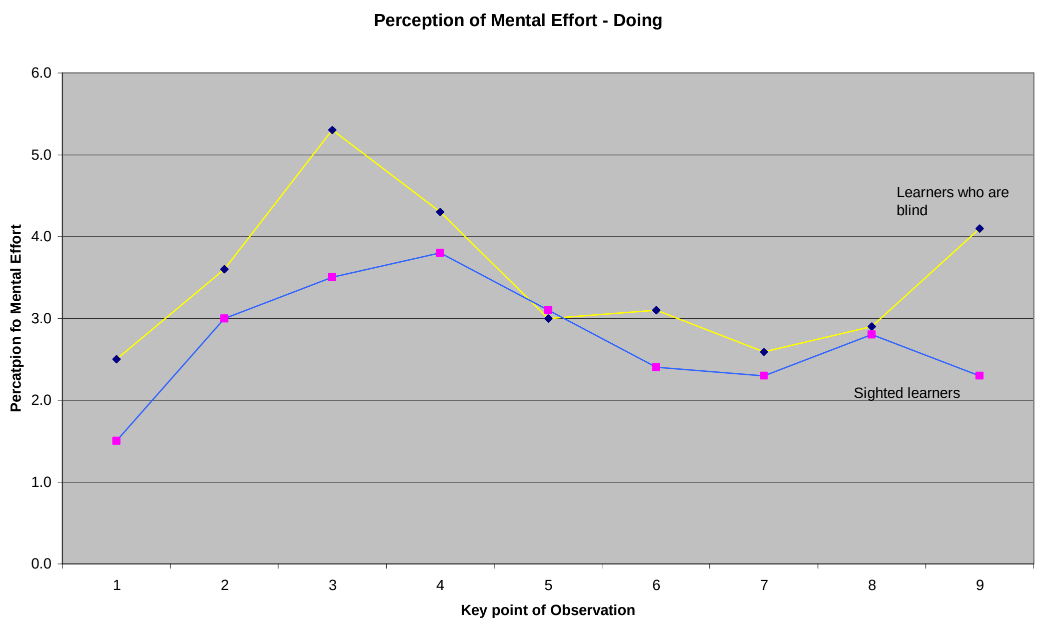

Figure 15 Line graph showing comparative perceptions of mental effort for doing

The trends started low and rose to a peak around observation point three which was the first multiple-choice question. The trend falls generally for both groups rising slightly at points seven and nine where they moved to the case study and related multiple-choice questions. At the final observation point nine, which relates to the table and summary, there was an increase in the perception of mental effort by the learners who were blind and a decrease by the sighted learners. It would be expected that perception of mental effort would increase although the navigation here was not straight forward. Therefore it is possible that there may have been confusion between perception of mental effort regarding doing and using.

Satisfaction survey

Both groups responded positively to the materials in the satisfaction questions (see Appendix 7) – a mean of 5.7 for the entire sample on a 7-point scale. The blind learners had an average of 5.8 which was marginally higher than the sighted learners although there was no statistical difference between the groups (t = 0.8; df 1,18; $p > .05$). Two participants who were blind thought that the learning materials were user-friendly and easy for them to use, and three referred to specific aspects, such as the speed at which pages refreshed. It should be noted that five participants who were blind specifically commented that the materials were accessible and usable.

In terms of the satisfaction survey the key question was the question regarding the enjoyment of the learning experience. On reflection, this may have been better asked at the end of the questionnaire, as it would have summarised the whole of the experience after the other questions had been asked and considered by the learners.

Table 13 below summarises the responses. Further analysis of the comments is set out below and is analysed under a sub-heading relating to each of the questions.

Table 13 Summary of responses to satisfaction survey

Question	Mean Blind learners	Mean Sighted learners	Total
1. I enjoyed using the learning materials	6.3	4.9	5.6
2. I learned more than I would using my usual method	5.1	5.3	5.2
3. I preferred using these materials to my usual method	5	4.7	4.8
4. I would use this method of learning again	6.2	5.7	6
5. I will remember the materials more easily than with my usual method	5	5.3	5.2
6. I found the material easy to navigate around	5.9	6.4	6.2
7. I found the technology worked well	6	6.2	6.1
8. The technology did not affect my ability to learn	6.4	6.5	6.5
9. The audio content helped my learning	6.4	5.3	5.9
10. The graphic/animation content helped my learning	0	5.1	2.6
Total Mean	**5.8**	**5.5**	**5.7**

1. I enjoyed using the learning materials

The learners who were blind really did seem to enjoy using the materials. Four gave a score of 7; five gave a score of 6 and one a score of 5. Comments from the learners who were blind were:

> It was accessible to JAWS. Audio made it interesting – kept concentration levels up.

I learned some things that I did not know.

Easy to access, good information and presentation.

Impressed as JAWs did well.

Gained insight into something new – how easy it is to pick up something I have no experience of.

Made it more easier getting around.

It was fun.

Helps you learn – good learning aid at own pace.

The sighted learners appeared to enjoy the learning experience less than the learners who were blind. One learner gave a score of 7, one of 6, four gave a score of 5 and the remaining four gave a score of 4. Comments from the sighted learners were:

Very visible; clear and concise. Audio good.

More interaction – easier than a book.

Easy – not too technical – easy to get into head.

Learned quite a lot – I will remember about RICEM (the mnemonic) which he did as reflected in the performance test.

It was the layout – it was not boring. Use of colour relevant to everyday life – contextualised.

2. I learned more than I would using my usual method

Of the learners who were blind six gave a score of 6. Comments were:

> I usually use Word on the PC or internet. I enjoyed the audio.
>
> I preferred it but not sure why.
>
> The voice helped – Brad the narrator.
>
> Have learned more letting the PC talk to me.

The remainder of the learners who were blind gave scores of 4 or 5.

Two of the sighted learners gave a score of 7; four gave a score of 6 and five a score of between 3 and 5. One commented that they liked the narration and would forget if they just read it.

3. I preferred using these materials to my usual method

The scores to these questions related directly to the score for the question above in terms of learning more with this method than their usual method. Two of the learners who were blind gave a score of 7 and two a score of 6 in respect of preferring this method of learning to their usual method which would generally be reading on the PC using a screen reader. One gave a score of 5, four gave a score of 4 and one a score of 3. It is difficult to interpret this answer and on reflection it may have been preferable to ask for a 'yes' or 'no' answer. However, when viewed in relation to the question above it would seem that in general they tended to prefer this method to their usual method, but this may have been because it was new and different.

Of the sighted learners, one gave a score of 7. One commented 'it was more interesting than using a book' and the other, 'this method sieves out the information you need'. Two gave a score of 6 and one a score of 5, four gave a score of 4 and one gave a score of 3 and one a score of 2 (commenting that, ‘You cannot ask questions’ – meaning that the content was not sufficiently interactive).

4. I would use this method of learning again

The learners who were blind were generally very positive with four giving a score of 7 and five giving a score of 6. There was only one comment, ‘It always helps more than one method – something to fall back on to look at.’ One gave a score of 4 and said that he would use this method again if navigation with JAWs was better; however, he did perform relatively well in both the MCQs and the performance tests.

Of the sighted learners three gave a score of 7 and three a score of 6 with one of them commenting that it was easier to follow than a book. Two gave a score of 5 and one gave a score of 1.

5. I will remember the materials more easily than with my usual method

Scores were relatively low for the learners who were blind compared to other questions. This may have relevance to cognitive load and the quality and/or retention of the information. One learner was very positive giving a score of 7 and saying that Brad, the online narrator/avatar, was like a person and that they were able to take all the information in (this learner did score well in both the MCQs and the performance test). Four gave a score of 6, all commenting positively including, ‘This is different from using Word – with this you can just listen’ and, ‘Yes I can learn at my own pace.’ Five gave a score of 5 or less.

Of the sighted learners, four gave a score of 7 and comments were, ‘Because of the pictures it is doing half of the work for you. You are focusing on what you need;’ ‘Better than to try and sit and learn from a person.’ The remaining six gave a score of 5 or less with two commenting that they were not sure at that stage whether they would remember the material more easily or not.

6. I found the material easy to navigate around

Of the learners who were blind one gave a score of 4, three a score of 5 and the remaining five gave a sore of 7. One found the screen slow to refresh which gave problems; one specifically commented on the difficulties with the flowchart and one said that the navigation got easier towards the end, but that the word ‘play’ (which was the button used to proceed to the next page) was confusing. Five of the sighted learners gave a score of 7, four gave a score of 6 and one gave a score of 5. There were not additional comments from this group.

7. I found the technology worked well

Two of the learners who were blind gave a score of 4 for this aspect, whilst one gave a score of 7 and said that the technology could work better; another commented that the multimedia worked well with JAWs. One gave a score of 5, two gave a score of 6 and the rest gave scores of 7. Two of the sighted learners gave scores of 5 whilst the remainder gave scores of 6 or 7.

8. The technology did not affect my ability to learn

One learner who was blind said that the technology could be improved and gave a score of 4. The rest of this group gave a score of 6 or 7 except for one who gave a score of 5. This is an interesting outcome as the technology, in terms of the multimedia, took them a lot longer to work through than the sighted learners and clearly caused them difficulties particularly with the quiz questions. However, it is possible they did not view these questions as a learning activity. In addition some of this group missed parts of the learning but they would not have actually known this. The sighted learners gave scores of 6 or 7 for this question in that the technology did not affect their ability to learn and no one gave any further comments on this.

9. The audio content helped my learning

Seven of the learners who were blind commented on how they liked having a different voice or that the voice of the online narrator/avatar, Brad, helped their understanding, whilst only one said that they were happy just listening to JAWs. ‘It was easy to take in the terminology, said in a way that could be understood.’ ‘It was nice to hear a different voice.’ Six of the sighted learners said that the audio helped their learning. Only one from this group did not like the audio. Comments were, ‘You can read and listen at the same time.’ ‘Helps concentration.’

10. The graphic/animation content helped my learning

The learners who were blind were not asked to comment on this aspect. Only one of the learners did not like this aspect and one preferred the audio to the visual content. One did not think there was any animation. The other seven liked the animation/graphic content and thought that it made the experience more interesting and/or that the ideas were clearer.

The results presented here could be argued both ways. It seems that the participants who were blind were as satisfied with the materials as were the sighted participants. Whether such satisfaction would be maintained over a longer period and if they understood how much longer they had to take on the material are other questions.

Learning Performance

Data in terms of learning performance was in the form of answer to the quiz-style questions in the learning object and the answers to the post-task performance test.

Quiz-style questions

The section commences with an overview of the results and each question is subsequently analysed in more depth.

Table 14 Mean learning performance scores at the time of the learning activity (maximum score = 12) and two days later (maximum score = 27) by the blind and sighted groups

Mean scores	Blind group (n = 10)	Sighted group (n = 10)
Mean test score (at the time of the activity)	9.5 (SD = 0.85)	11.8 (SD = 1.14)
Mean test score (two days later)	14.7 (SD = 2.98)	17.6 (SD = 3.84)
Mean time taken (two days later)	12.9 minutes (SD = 5.65)	9.7 minutes (SD = 3.65)

Table 14 shows the average learning scores for the blind and sighted groups at the time of working through the learning materials. The sighted group had a higher average score than the blind group, and this difference was statistically significant ($t = 5.1$; *df* 1,18; $p < .0005$). This finding may reflect the differences in the amounts that the two groups learned, a greater difficulty accessing the materials or both. For example, one question proved particularly difficult for the participants who were blind, not because of difficulty in recollecting the relevant material but because some salient information (a table) was missed by seven of the group. As a result the question that was based on this table was answered incorrectly by 7 of the learners who were blind and by only one of the sighted learners. Figure 16 below shows the link to the table which was missed by 7 of the learners who were blind and by only one of the sighted learners. This suggests that the poorer scores for the learners who were blind were almost entirely caused by them missing content and is therefore an issue of access. If the learners who were blind had answered this question correctly to the same extent as the sighted learners then this would have almost closed the gap between the overall scores. This link leads to the flow chart as shown in Figure 17. This page is very important to the learning experience and as such it should not be accessed via a link but should be integral to the learning pathway to ensure it is not missed.

Figure 16 Link (orange circle) missed by learners who were blind

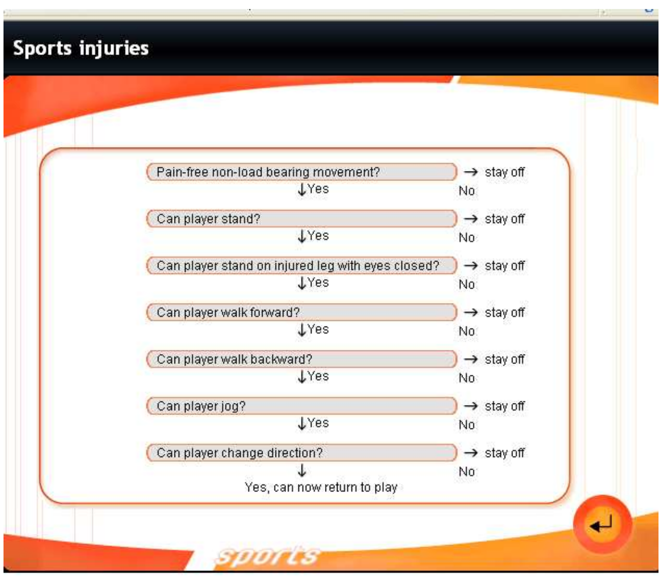

Figure 17 Flow chart which is difficult to access with a screen reader

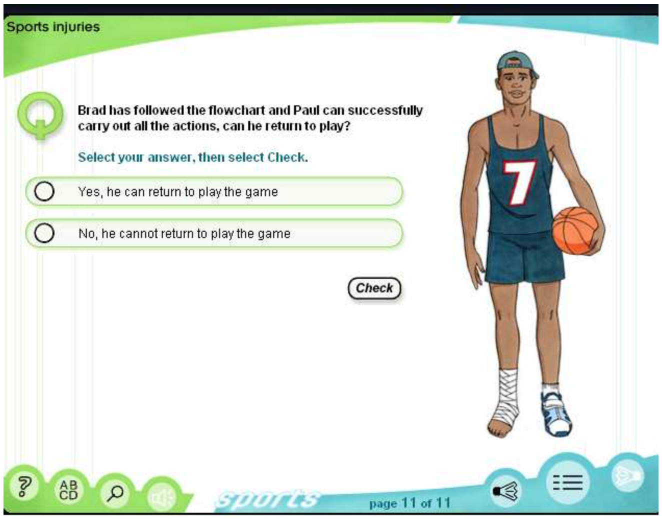

Figure 18 Yes/No question that is relatively accessible

Further analysis of the answers to the quiz-style questions shows that there was limited difference between the two groups except for questions 1 and 2. In each question there was one occurrence where only 4 of the blind learners answered part of the question correctly. This may be explained by the difficulties they had of navigating and retaining all the options in their head.

Post-task performance test

In this section there is an overview of the test results followed by and in-depth analysis of each group/type of question.

Table 14 (above) shows the average learning scores for the blind and sighted groups two days after they worked through the learning materials. Although the sighted group had a higher average score than the blind group, it was not a statistically significant difference (t = 1.89; *df* 1,18; $p > .05$). Similarly, the average time taken by the sighted group was shorter than that of the blind group, but the difference was not statistically significant (t = -1.5; *df* 1,18; $p >$ .05). Nevertheless, the general direction of the means indicated that, overall, the sighted group tended to recall more efficiently (a higher score in less time) than the blind group (a lower score in more time).

Further analysis shows some differences between the groups in relation to the type of question they were answering.

Table 15 below summarises the average number of correct responses for each question by each group of learners. These responses are considered in more detail below.

Table 15 Average number per learner group of correct answers to performance test

Question number	**Number of correct answers by learners who were blind**	**Number of correct answers by sighted learners**
1	8	9
2	8	8
3	5	9
4	7	10
5	6	8
6	6	9
7	6	9
8	8	6
9	0	2
10	3	1
11	7	10
12	3	8
13	8	9
14	10	8
15	6	7
16	7	9
17	7	4
18	5	9
19	2.6	2.9
20	1	1.2
Total number of correct answers	**113.6**	**139.1**

The first four questions required an either/or response and were based on the information on page 5 relating to types of injuries. There was the same average number of observations on this page for both groups; however, the learners who were blind performed less well; in particular with questions 3 and 4. This may be because they were having to retain the question in their head and by the time they had done questions 1 and 2 this may have caused confusion due to the similarity of the terminology, for example extrinsic and intrinsic.

Questions 5, 6 and 7 required a True/False response to a statement. On average six of the learners who were blind got each of these correct whereas of the sighted learners eight, nine and nine respectively got this set of questions correct. For the learners who were blind the average number of observations on this page was 23.5 and for the sighted learners this was only 7.5. The reason for this was that the learning was based on the first quiz-style question which was difficult to navigate. Again, there may have been difficulties in terms of retention of questions and similarity of terminology.

Questions 8 to 18 required a one or two word answer. Questions 9, 10 and 11 had a very low number of correct answers from both groups. These questions are analysed further below.

9. An injury to a ligament can often result in what? Answer – sprain
No learners who were blind and only two sighted learners answered this correctly. The answer is in the content but perhaps needed to be highlighted more. In addition it is likely that none of the learners knew this from any prior knowledge. People often mix up a sprain with a strain to the ankle.

10. Inflammation of the tendon is known as what? Answer – tendonitis
It was surprising that so few could give the answers sprain or tendonitis since this is clearly set out in the materials, and the condition tendonitis links so closely to the word ‘tendon’.

11. Name one key sign of an injury to a muscle tendon or ligament. Possible answers – pain, tenderness, redness, heat, swelling

This question links to Figure 19 below and ten sighted learners and seven learners who were blind got this wrong. This again is quite surprising as it is possibly an answer that could be guessed. However, the learners who were blind could be at a disadvantage in that they would not necessarily be aware that an injury can appear red or, if to another person, that there is swelling.

12. Inflammation occurs when an injury around it causes a capillary to ________ (fill in the blank word)? Answer – leak.

The learners who were blind did notably worse (3 correct answers compared to 8 for the sighted learners). The possible reason for this is that this effect is described on a separate page accessed by a link and via the use of a graphic (see Figure 20), so that even if the learner who is blind did follow the link they would not have benefited from the high visual impact of the learning content.

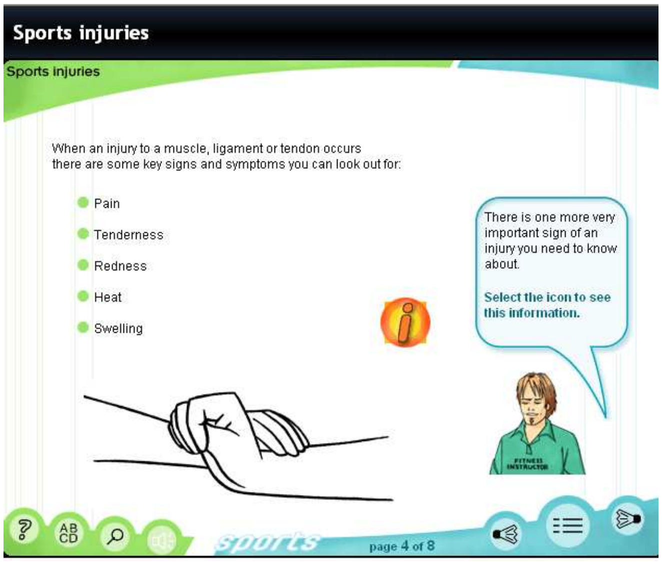

Figure 19 Orange link to illustration of capillary

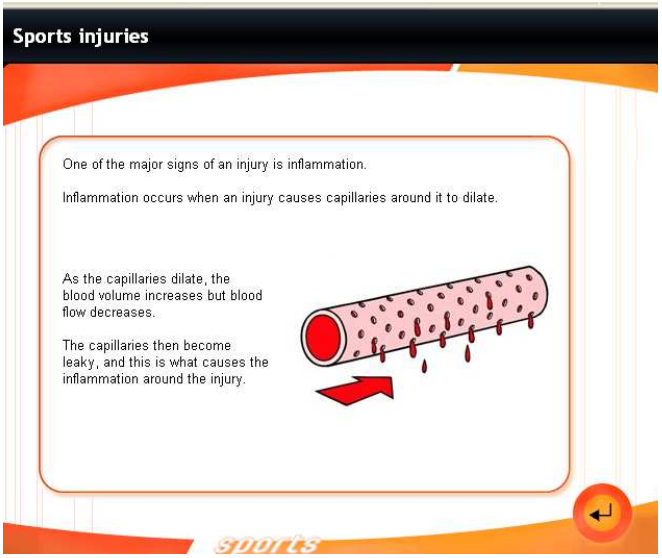

Figure 20 Illustration of a leaky capillary tube

Questions 13 to 17 and 19 required an answer based on the mnemonic of RICEM (see Figure 21 below).

Figure 21 RICEM mnemonic

The questions follow below and are then analysed as a group:

13. Rest will lower the heart rate and limit what to the injury?

14. When you treat an injury to a muscle, tendon or ligament for how long at a time should you apply ice

15. What would you apply to compress an injury?

16. Elevation means the injury should be placed above the person's what?

17. If the person is still feeling pain after how long should the injury be reassessed?

It should be noted that the mnemonic as shown in Figure 21 was very visual not just in terms of shape but in terms of colour, and even in the fact that it was displayed vertically rather than horizontally. The learners who were blind would only have received the information about it aurally so that it would just be delivered in the same medium as a majority of the rest of the content (except the online narrator Brad, who spoke in a different voice). The average in respect of the above 5 questions for the learners who were blind was 7.6, and 7.5 for the learners who were sighted. There was therefore virtually no difference between the groups so it is possible that the fact that the mnemonic was visual made no difference to the quality of the learning.

18. Name one situation when you should not give treatment? Possible answers – fallen from a height or suffered neck or back injuries.

Five learners who were blind and eight who were sighted got this question correct. A reason for this is possibly that the learning point was illustrated by a graphic of someone having fallen

19. *You are working in a gym and a female tennis player has turned her foot on a tennis ball. There is swelling, inflammation and the tennis player is in pain. What could you do to minimise the risk of further injury? Name as many points that you can. Possible answers – Rest, Ice, Compress, Elevate, Mobility, that is the answers are based on the mnemonic RICEM.*

However, this was not stated explicitly in the question but learners would have been led to this by the previous short answer questions – in fact four of the elements were specifically referred to in the questions. Only two (both sighted) learners got all 5 points. The average score out of 5 for the blind learners was 2.6 and for the sighted learners 2.9. If the question had been worded differently then there may have been more correct answers.

20. Name four main points relating to sports injuries that you learned from working through the materials.

Question 20 related to the learning objectives as set out on the summary page in Figure 22 below.

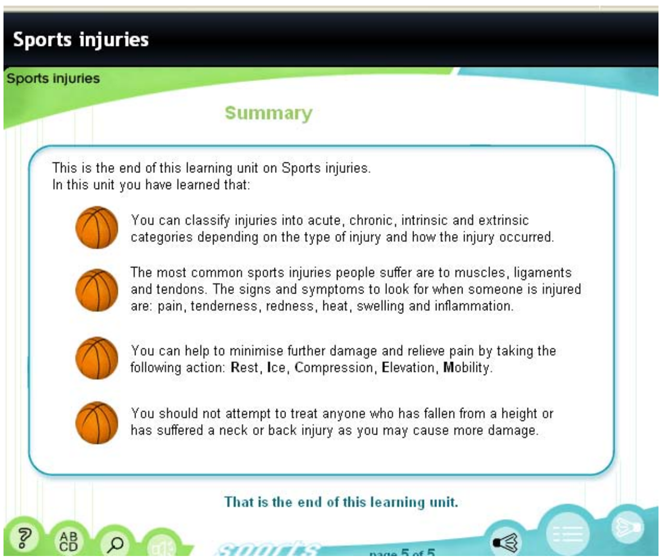

Figure 22 Learning outcomes relating to sports injuries

The average number of observations for this page was 5.3 for the learners who were blind and 3.8 for the sighted learners. The average score for the learners who were blind was 1.1 (four of them scoring 0) and for the sighted learners was 1.2 (two of them scoring 0). The highest score was 3. Learners could have based their answers on the previous questions and gained a good score. It may be concluded that the learners were not clear what answer was required and that the question could have been more clearly or differently worded and that this question was therefore not a clear indication of whether the learning objectives had been recognised.

Measurement of Cognitive Load

As described in Chapter 8, the three aspects of measurement of cognitive load used in this study (time; perception of mental effort and performance tests) together with satisfaction scores were coded in order to aid comparison between the learners and to aid discussion of the relationship between the aspects. The results for each learner are collated in Table 16 below.

Table 16 Perception of mental effort – average for each learner

Learners who were blind	**Accessing**	**Using**	**Doing**	**Average for each learner**
1	7	6	6.1	6.4
2	3.6	2.1	1.9	2.5
3	4.2	3.8	1.7	3.2
4	3.4	2.3	2.3	2.7.
5	2.7	2	2	2.2
6	2.9	2.1	1	2.0
7	1.6	1.4	1	1.3
8	2.4	3.2	1.6	2.4
9	2.3	1	1	1.4
10	4.7	4.3	5.3	4.8
Average for each type of activity	**3.5**	**2.8**	**2.4**	
Learners who were sighted				
11	N/A	3.1	3.3	3.2
12	N/A	1.2	1.6	1.4
13	N/A	1	1	1
14	N/A	1	2.2	1.6
15	N/A	2.3	5	3.6
16	N/A	1	2.7	1.8
17	N/A	1.4	3	2.2
18	N/A	3.3	4.3	3.8
19	N/A	1.6	1.7	1.6
20	N/A	1	2.5	1.7
Average for each type of activity	**N/A**	**1.7**	**2.7**	

In Chapter 8 it was stated that for the individual the best case scenario is that there would be a relatively short amount of time taken to complete the task with a minimum amount spent on navigating and accessing, a medium perception of mental effort (PME) on doing, an excellent performance outcome and a high level of satisfaction.

From the results in Appendix 10 it can be seen that none of the learners who were blind met this outcome. Only two performed the task in a good time, and only three, but not including the same two, performed well in the test. For those who performed well in the test they either had a PME that was medium or high. Both learners who had a low PME performed poorly in the test. Overall there was a medium level of PME with one instance of this being high and a medium to high level of satisfaction for this group.

For the sighted learners four met the model outcome. In general all the sighted learners took a relatively short time to carry out the task, PME was low to medium for all but two, the performance for four was good or excellent and the satisfaction scores were medium to high.

The performance test scores held the sighted group back from meeting the model outcome. The relatively low scores for both groups may be because the learning content is designed to be support material and not a primary learning/delivery medium. If this factor is taken into account then for the sighted learners in general there was a positive relationship between the measurements of cognitive load and the satisfaction score. For the learners who were blind this was not the case since in general they took a relatively long time to complete the task, performed poorly in the performance test, perceived the mental effort to be medium to high but were still very satisfied with the task.

Conclusion

CLT is useful for understanding that the additional cognitive load experienced by the participants who were blind may have been responsible for this group's slower and reduced quality performance. First, Wall and Brewster (2004) noted that people who are blind do not have access to external memory aids to mark points of interest and stated that such aids are powerful and can significantly reduce the requirements of working memory, that is reduce cognitive load. The reduction may lead to a vicious circle with people who are blind having to work harder to solve any problem and to repeat problem solving actions more often to build up the same understanding as sighted people. This may not mean that the quality of the learning experience is reduced, only that the experience may take longer. These difficulties will increase the time taken with the task and the complexity of the problem solving.

Secondly, the data demonstrates that people who are blind have to spend a significant amount of time using access software (in this case the JAWs screen reader) to access the learning object. Therefore, there is a cognitive load in terms of time (an average of approaching 10% of the time spent on the task). Some of this additional cognitive load experienced by the participants who were blind may reflect the best that can be achieved with current technology, an issue that is discussed later. It should be noted that the learning object used in the study was created as part of a U.K. government initiative, had been well resourced and designed and had been tested for accessibility. Even so, some strategies, such as those described below, would have immediately improved the experience of the participants who were blind in this study.

The analysis indicated that the participants who were blind took twice as long as the sighted participants on the task and performed less well on the learning-performance task. In terms of the additional time taken, some of it (although not all) could be explained by the additional time taken in using access technology. In spite of these apparent barriers to learning, the participants who were blind did not differ from the sighted participants in how difficult or enjoyable they perceived the task to be and, to some extent, how difficult they found the task to complete. The contrast between observed performance and subjectively perceived effort justifies the importance of using mixed methods when conducting studies of this kind.

Such results and debates enable us to reflect on our definition of *accessibility* in this context. In a technical sense, the learning materials that were used in this study were accessible in that the participants who were blind were able to access the information presented (with a few exceptions). In a broader sense, the learning materials were less accessible for the participants who were blind than for the sighted participants because it took them so much longer to access the materials.

The results and discussion have led to a range of conclusions being drawn. In a practical sense instructors and designers of learning resources must continue to think carefully about the technical accessibility of their materials and constantly seek ways of refining and updating them to optimise the learning experiences of users who are blind. Recommendations in respect of this are expanded upon in Chapter 10. The findings of this study support those of Coyne and Nielsen (2001) that the participants who were blind took longer to access materials than the sighted participants. However, the participants who were blind were at least as satisfied as the sighted participants with the experience of using the materials.

A more far-reaching conclusion is the need to consider the additional cognitive load that learning materials may demand of people who are blind and the implications that it may have. For example, if learning materials take impractical amounts of time for people who are blind to access (even if they pass various WAI guidelines on accessibility) people who are blind may simply choose not to access the materials and will be effectively excluded from learning.

There may be practical solutions; for example, when one designs suitable learning activities, it may be necessary to consider the length of time it would take for people who are blind to work through them. However, some have argued that it would be too costly and impracticable to address every learning object in this way (Sloan et al, 2006). Phipps and Kelly (2006) posit that it may be necessary in some cases to consider alternative methods and media of teaching. These alternatives should not necessarily result in reduced cost or effort in production, but there may be a tendency for designers and teachers to opt for an easy option of producing the alternative as straight text. This can be helpful in terms of accessibility and as noted in Chapter 2 the

Disability Rights Commission (2002) advocate production of all teaching materials in text format so that they can be easily converted into other formats, but it is then up to designers/teachers to convert the information into these formats. It is possible that they may not have time or the knowledge as to how best do this to address individual learning and teaching needs. This aspect is discussed further in the conclusion.

Chapter 10, which is the final chapter, follows and this summarises the findings and recommendations of all of the studies, evaluates the usefulness of the conceptual and theoretical frameworks and considers pathways for future research.

CHAPTER 9

CONCLUSION

Introduction

This final chapter is concerned with revisiting the overall aims of the thesis and the key questions and summarising the outcomes and implications of the studies. In this chapter the initial aims of the research are reviewed followed by general conclusions and a summary of findings in relation to the experiences of e-learners who are blind. There is then an evaluation of the conceptual and theoretical frameworks in terms of their effectiveness in addressing the aims and, to this extent, how the research has contributed to the methodological understanding. This is followed by an overview of the considerations to be taken into account when designing e-learning for learners who are blind and the implications for teaching. Implications for equality and diversity, and development of legislation and policy are then considered. This includes accessibility of content and equipment as well as staff development issues. The thesis ends with a reflection by the author on her journey and practice; an indication of future research pathways and a final word in the light of recent e-learning developments such as collaborative networks, and the extent to which e-learning may offer a level playing field between learners who are blind and those who are sighted.

Conclusions and Summary of Findings in Relation to Blind Learners’ Experiences of E-learning

This section revisits the aims of the research and key questions posed and summarises the extent to which they have been addressed. More detailed analysis is set out in the remainder of the conclusion.

The primary aim of this research was:

- To gain greater understanding of, and insight into, the issues that a blind e-learner might face. *Greater understanding was gained, in particular through the use of the conceptual framework of accessing, using and doing and the theoretical framework of CLT.*

The secondary aims, the outcomes of which are all addressed further below, were:

- To indicate general solutions for designers of e-learning materials.

- To help teachers to identify training needs and choose materials.

- To help education and training organisations address the Disability Discrimination Act (2005) and equality and diversity issues.

- To inform development of legislation and policy.

To address the aims the research questions that evolved during the writing of the thesis were:

1. Can a learner who is blind access e-learning? *The exploratory studies demonstrated that, with support, they could.*
2. Can a learner who is blind engage successfully with e-learning? *The pilot and main study evidenced that they could, and with limited support.*
3. Can a learner who is blind engage on the same basis as a sighted learner? *The pilot and the main study evidenced that they could not in that it took the learners who were blind up to three times as long and it was observed that they took greater effort. In addition they did not score so well in the performance tests.*
4. Will the quality of the e-learning experience be the same for a learner who is blind as for a sighted learner, that is, is there a level playing field? *The evidence as stated above is that it will not be so.*

The quote at the beginning of the thesis posits that technology can put people with disabilities ‘at the leading edge of educational innovation’ (O’Connor, 2000, p.11); that is, potentially ahead of the field. In terms of this study there would be a new stepping stone with learners with disabilities having an advantage. However, as far as can be seen learners who are blind are a long way off experiencing the same quality of e-learning as sighted learners, let alone a better one.

Conceptual Framework and Methodology

In this section the conceptual framework and methodology are evaluated in terms of their use in providing insight into the research questions.

Conceptual framework

The conceptual framework of accessing, using and doing was used twice: once in the pilot study and again in the main study. It was decided to use it a second time as it was found to be a useful way of identifying what a learner was engaged in at any one time. In the main study the time factor was re-visited alongside the introduction of recording the number of observations per page and more in-depth analyses of what was taking place under doing. This is explained more fully below.

In the pilot study, where there were low numbers involved, the learners who were blind spent approximately a third of their time accessing, a third of their time using and a third of their time doing. The learners who were sighted spent broadly speaking 20% of their time using and 80% of the time doing.

In the main study the learners who were blind spent approximately 9% of their time accessing, 66% of their time doing and 25% using. The sighted learners spent approximately 10% of their time using and 90% of their doing. There was relatively little variation between individual participants in each group. These results could be predicted up to a point, as the learning tasks in the pilot study were relatively complex and the interface was not very accessible; whereas, the learning task in the main study was constrained, was designed to last approximately twenty minutes and had had additional accessibility features built in. In addition all the participants were extremely competent with ICT.

The data in the main study was further analysed in terms of the number of observations per page. An increase in the number of observations per page appeared to be associated with an increase in perception of mental effort. This was particularly useful in identifying key areas of difficulty such as the quiz-style questions and navigation problems.

Using the conceptual framework as a vocabulary, one aim may be to reduce the proportion of time spent ‘accessing’ and ‘using' for blind learners and the proportion of time spent ‘using’ for the sighted learners. If the proportion of time spent ‘accessing’ and ‘using’ is reduced the proportion of time spent ‘doing’ (including learning) will increase, but there is no guarantee that the quality will increase. It may be necessary in some cases to increase the time spent using in order to improve navigation to ensure that all relevant content is covered, for example no links are missed and are followed in the required order. An example of this would be hidden text to describe what content is or a description of a diagram to aid understanding. That is, using the theoretical framework of CLT as a vocabulary, there will be a need to increase the proportion of germane cognitive load.

This method of analysing what a learner is doing at particular points can be useful when making decisions between different products. It may be less useful to carry out this type of observation when carrying out accessibility testing with Beta versions as if there were a high number of ‘snags’ then this would impact on the number of observations and there would be limited flow in terms of the learning experience.

Theoretical framework

In this section there is a consideration of the theoretical framework of cognitive load theory (CLT) in terms of demands on working memory and the types of cognitive load experienced (germane, extraneous and intrinsic as described in Chapter 7) and the implications for learners who are blind. CLT is based on the notion that working memory is limited and that effective design of instructional materials can reduce unwanted cognitive load to improve the learning experience.

Demands of working memory

Mayer and Moreno (2003, p.45) assert that ‘in multi-media learning, active processing (in the working memory) requires five active processes: selecting words, selecting images, organising words, organising images and integrating’. However, there may be a situation where the processing load may exceed the capacity of the working memory. In order to analyse this further Mayer and Moreno put forward three kinds of demands:

1. Essential processing which refers to the cognitive processes that are required for making sense of the material, for example selecting words and images, organising words and images, and integration.

2. Incidental processing which is concerned with cognitive processes which are not required for making sense of the learning content, such as additional background music to an animation. This is relevant here as the information regarding navigation provided by the screen reader is vital for the blind learner to participate but incidental to the learning experience in respect of the content.

3. Representational holding is concerned with the cognitive processes involved with holding a mental representation in the working memory, such as remembering a diagram on one page and reading about it on the next page. This again has significance for blind learners. There would be

a significant cognitive demand on virtually any type of online learning or learning per se.

A learner who is blind would, for example, need to hold each multiple-choice question in his/her head when reading through them. A sighted learner can glance at the options and constantly cross-reference and cross-check – i.e. vision has the capacity to *rapidly* cross-reference and make use of 'memory aids'. In the main study it was found that the learners who were blind took three times as long as the sighted learners to answer the multiple-choice questions. Use of text and graphics or auditory sources of information are of particular relevance here as a diagram alone can be more effective than a diagram plus text (Chandler and Sweller, 1991). In addition (Kalyuga, Chandler and Sweller, 2000) found that identical visual and auditory text was less effective than auditory text alone.

Extraneous cognitive load

Extraneous cognitive load relates to load that is irrelevant to the learning experience. Adding usability and accessibility features to an existing learning object may increase extraneous cognitive load for both sighted learners and learners who are blind, for example this may involve an increase in the number of option buttons. Adding usability/accessibility features to an existing learning object is unlikely to offer an equivalent learning experience and there is a possibility of an increase in cognitive load, both germane and extraneous.

One of the main problems which appears to occur for the blind learner using a screen reader may be the large amount of information that has to be stored in the working memory in order to navigate a web page. This may be exacerbated as there is usually no method of physically marking points of interest so this information must be stored in the working memory. These difficulties will make tasks take longer and make problem solving more complicated, since there will be fewer schemas (learning from previous experiences) created and stored in the long-term memory, (Paas, Renki et al, 2003). Again this was evidenced in the main study in respect of responding to the multiple-choice questions. This may lead to a vicious circle with the learner who is blind having to 'work harder' to solve any problem and to repeat problem solving actions more often to build up the same number of schemas as a sighted person. Therefore, as such, the learners who are blind start off with extraneous cognitive load which the sighted learners do not experience and in that respect the quality of the learning for learners who are blind is less than for sighted learners.

Intrinsic cognitive load

Intrinsic cognitive load relates to the subject material or content which cannot be directly changed by the designer. However, indirectly the designer does have control over the size or chunks of the content and how it is presented, and this could influence the type of cognitive load the learner experiences. It is possible that for the learner who is blind the content should be presented in smaller chunks than for the sighted learners, and that it may need to be more linear in structure both for mental processing and for navigation purposes. An example of this from the main study would be the content relating to the mnemonic ‘RICEM.’ This was presented on a single page with embedded links. An overview of the content on one page with each different aspects set out on a separate consecutive page would have aided accessing, using and doing and therefore reduced the cognitive load for the learners who were blind.

Germane cognitive load

Some learning materials (e.g. quiz-style questions) are specifically designed to aid the learning experience. That is, the material is designed to aid the acquisition of schemas and therefore may be associated with germane cognitive load (effective cognitive load which is concerned with the combination of elements of working memory to create schemas and thus enhance the learning experience). However, this may not be germane cognitive load for the learners who are blind. The perception of mental effort in respect of quiz-style questions increased, as did the time taken for learners who were blind. In terms of accessibility the designer has a choice to redesign the assessment of learning or to offer an alternative.

On the other hand there may be a reduction in cognitive load for learners who are blind in that they are not utilising visual aspects of the learning material and therefore may be able to use more of the working memory for auditory information as all the information a learner who is blind is receiving is auditory. This may be of benefit to their learning experience. The aspect of germane cognitive load may be the key in terms of quality when designing e-learning materials for learners who are blind. It should be noted that the introduction of such techniques is likely to increase the time taken with the learning. The recommendation given in respect of the RICEM content above would be an example whereby there may be an increase in time taken for the learning but that it may be better quality since the accessibility aspect, and therefore the cognitive load is reduced.

The question is whether it is meaningful to compare perception of mental effort for these two types of learners. If one group is used to working extra hard to achieve a task then their perception of mental effort/energy expended may be lower than might otherwise be expected. In the main study it was shown that for the learners who were blind the perception of mental effort was not significantly greater to that of the sighted learners. However, they took considerably more time to complete tasks and it was observed that they did experience considerable difficulties in some areas.

There is an additional cognitive load for learners who are blind using an online learning object which has been designed for sighted learners. Indeed it may not be possible to design a multimedia learning object that can offer an equal quality of learning experience for all. It may be necessary to provide the learning experience in a variety of formats and combinations of media. Until both accessibility and usability issues are resolved learners who are visually impaired will continue to be disadvantaged in terms of cognitive overload and time and energy resulting in a poorer learning experience. When designing multimedia content which is to be used by learners who are blind or sighted it is essential to consider accessibility at the outset. CLT is a useful tool to use as part of the design, and the teaching and learning processes.

Implications for Practice

This section examines the implications for practice from the evidence presented previously and the conclusions drawn. This relates to software, the design of content and teaching skills.

Implications for Designers of E-learning Materials

Gerber (2002) states that people who are blind or have low vision are willing to put up with frustration, high costs, imperfect technology and an additional amount of time because of the benefits of being able to be more independent. Some of these frustrations can be minimised by following good design principles, such as the guidelines of the Web Accessibility Initiative (WAI) (2008) which 'works with organizations around the world to develop strategies, guidelines, and resources to help make the web accessible to people with disabilities'. Nevertheless, Phipps and Kelly (2006) put forward a holistic approach to the design of e-learning and argued that simply following the WAI guidelines may not be sufficient and that an alternative but equivalent learning experience is required.

Induction

Induction, for the purposes of this study, relates to familiarisation with a learning object including understanding of the learning objectives, the layout of the learning materials and the associated navigation. This could be done by the teacher and this is discussed further below. However, with an increase in distance learning/self-study there is likely to be a decrease in face-to-face contact. It is vital that there is comprehensive information for learners on how to study materials, including the need to address accessibility and learning styles. It would not be practical to have extensive induction information for every 20 minute learning object, such as the one used in the main study. However, learners could be directed to a page at the start that they could skip if they were already familiar with the format, and which sets out key features in terms of usability (navigation) and accessibility. In the main study, for example, there were two pages where the sighted learners needed to click on buttons to get additional information. The learners who were blind did not need to do this as the screen reader would read all the related information. There would be hidden text at the top of the page with an announcement that the learner should ‘just sit back and listen’. This was confusing for some of the learners who were blind as they were not expecting this. The introduction of additional induction material may add to the time taken to work through the learning object but it may actually reduce the cognitive load during the learning experience thus improving the quality of the learning.

Quiz-style questions

Quiz-style and multiple-choice questions pose difficulties for people who are blind, particularly because they are not always set out consistently and can vary in style. They make demands on the working memory since all the options have to be ‘carried in the head’ or read repeatedly which involves additional effort with navigation. New and difficult terms may lead to further cognitive load. In this study the learners who were blind spent much more time with the questions which were:

- A list of statements each of which had a true/false answer.
- ‘Odd-one-out’ style questions – in this case the learners had to select 3 answers out of 5 which described a statement.

The ‘most accurate’ and ‘either/or’ questions were more manageable by the learners who were blind. The complexity of the terminology should be taken into account and in other cases where the answers are numerical or of a mathematical nature then this may add to the cognitive load and the need for repeated reading. The position of the select/radio button should be consistent and easy to navigate. If a learner who is blind fails to navigate to the relevant button then they could select the wrong answer or need to re-navigate and listen to the questions again thus increasing the cognitive load.

Single-word or two-word responses to straightforward questions may offer a more level playing field in that there is no need to read, re-read and retain information in the working memory; that is, they require all learners (not just blind learners) to *recall* rather than *recognise* answers. Therefore, there is more capacity in the working memory to solve problems and to retrieve information from the long-term memory. This may indicate a need to have an alternative test/assessment for those learners who are blind. This test/assessment must of course be a fair and equivalent test of the learning objective.

Links between pages

In two places in the main study there was a link to pages containing vital learning points that the majority of the participants who were blind missed and they did not know that they had missed them. There should at least be very clear indicators of such links within the text of the learning materials. However, if a learning point is of such importance then it may be preferable to include the information on the link in the main materials. There is then an issue of the materials being too linear and not encouraging exploratory learning. On the other hand it was observed in the study that all the learners did, in general, work through the content as quickly as possible; so if there is a great deal of content delivered in this manner there is the possibility that they would not visit additional links in any case.

Mnemonics

The first open question in the main study was based on a mnemonic which related to a key learning point which was not accessible visually to the participants who were blind. In this case, the mnemonic was set out as a word in a vertical format and in a range of colours so it was in effect presented in a different way to the sighted learners. Such a mnemonic may need to be repeated several times or presented in a different format or medium for participants who are blind. This is difficult in an online object as the only mode of delivery for learners who are blind is sound (although it is possible that touch could be incorporated, for example by learners being referred to a tactile diagram). The wording of the alternative or hidden text is very important in this case. Additional learning materials could be presented but these would be otherwise tactile which is not necessarily helpful with a mnemonic.

Graphics

In terms of graphics, simply adding alternative text does not necessarily make content or a web page accessible. Whilst it may indicate to a person who is blind that there is a graphic present and describe what the graphic represents, this will not necessarily add to their learning experience. This was demonstrated in the result of the main study where, for example, a graphic was used to demonstrate a leaky capillary tube. There was text associated with the graphic which fully described it but the learners who were blind clearly did not have access to this additional visual information. To enhance the learning experience for the learners who were blind a tactile model would be a very useful teaching aid. Significantly fewer learners who were blind (3) compared to learners who were sighted (8) answered the question to this correctly.

Time issues

Designers need to take into consideration the additional amount of time that a learner who is blind may take to work through a chunk of online learning. In the main study the content was only designed to last 20 minutes, but in a given course there may be a substantial amount of content delivered in this manner. If a sighted learner is engaging say two hours a day then, based on the outcomes of this study, the learners who are blind would have to engage for six hours a day given that the type of content is similar. It may be unrealistic to expect learners to do this. Nevertheless, it is extremely likely that both groups of learners would be faster once they were more familiar with the format and expectations of the learning object.

Consistency of layout

Consistency of layout will aid the learner and may help reduce cognitive load, particularly in respect of navigation and for those learners who are blind to access with assistive technology. In general the learning object in the main study was consistent in layout as far as can be expected in a short learning object given the variety of tasks and media involved. In a longer course consistency of approach would be of paramount importance for accessibility. The greater difficulty is where there is content provided by different designers/lecturers and/or the learners are engaged in a course not delivered by the same faculty or institution who have different ‘house styles’. The only way to address this would be through standards and/or legislation which are considered further below. The implication here for learners who are blind is the need for consistency of layout.

Quality and accessibility

It is very important for designers to note that the learning object used in this study was of very high quality in terms of content, layout and use of media. In addition, accessibility features were built in for those learners who would need to use a screen reader. This included the use of hidden text that would be read by a screen reader once the screen reader functionality was switched on. To produce such a learning object is very time consuming both in terms of design and user testing. Most e-content could not be produced to the standard of the learning object in the main study and therefore a different approach to accessibility may be needed. This could be in an alternative format, but should not be a lesser learning experience.

Where alternative materials are offered then these are frequently in the form of web pages with hyperlinks and simplified quiz-style questions. These may make the content more accessible to a wider range of learners who are blind. However, there is a possibility that those learners who have a high level of expertise may have a poorer quality learning experience and enjoy it less.

Implications for Teachers using E-learning Materials

This section sets out implications and recommendations, based on the studies within this thesis, for teachers working with learners who are blind in the area of ICT, and in particular e-learning. These implications and recommendations may be useful for those carrying out research with learners who are blind in an e-learning setting as well as for teachers.

Teaching skills

The teacher needs to understand how a person who is blind accesses and uses e-learning/ICT. The skills required to navigate in complex e-learning environments are considerable. Given the potential additional cognitive load of using the assistive technology the academic or skills level of the learning material and the study level (in terms of ability, prior knowledge and ICT skills) of the participant should be very carefully considered.

Douglas (2001) points out that new technologies are often complex and that teachers must have high levels of competence to exploit the technology's potential. Teachers and designers must have expert knowledge of both the learning environment and the content. For example, a VLE could be highly accessible but it would not be the most appropriate medium for delivering, for example, graphs to learners who are blind. However, it could be appropriate to deliver part of the content via the VLE, part face to face (i.e. blended learning) and another part using tactile technology, bearing in mind the time factor (increase) and the impact on the cognitive load. Due to the lack of existing accessible e-learning content teachers may also be required to produce their own materials. For such a scenario expert pedagogical and technological knowledge, specifically of blind and visually impaired learners, is required. Staff development needs are discussed further under legislation, standards and guidelines below.

Tasks

Tasks need to be achievable and it is felt that the learners should be able to complete tasks with minimum intervention in the use of the technology. However, where prompting is necessary then this should be carried out accordingly to minimise frustration and where research is being carried out, a note of this should be made and taken into consideration during analysis. A simple framework for assessing the skills of a learner who is blind engaging in e-learning is explored further below. In essence it assesses whether they were able to navigate effectively to operate in a linear, linear/exploratory or exploratory manner. It would be of no benefit to the individual learner if their skills enabled them to work in a linear way if they were engaging in an e-learning experience that demanded skills of an exploratory nature.

In relation to the above, the tasks should not be time limited (or if they are this needs to be done cautiously). Timing learners may lead to additional frustration, non-completion of tasks, additional cognitive load and may influence the quality of the learning and task performance. This is an important aspect in terms of e-assessment, for example functional skills (practical skills in English, information and communication technology (ICT) and mathematics) tests in the United Kingdom may be carried out online, but at the time of writing are not accessible to learners using a screen reader. However, it is hoped that in the near future they will be accessible in an electronic format and, if so, then careful consideration must be given to the time allocation for carrying out tests. At the time of publication the use of portable document format (pdf) files is being explored as an accessible means of accessing these tests.

In relation to time, in the Lexdis Project (Seale et al, 2008, p.8), it is stated,

> …all the disabled learners cited “TIME” as a real issue that influences their decisions about whether to use technology and whether to seek support to use technology. “Just-in-time” learning seems to be the most appreciated type of training. When students have a problem, is when they want to learn the solution. This needs to be taken into

account when thinking about library training, Blackboard and other technology training sessions.

This is clearly interrelated to the time issues identified in the pilot and main studies and highlights the difference between time taken acquiring the skills to use the technology and the additional amount of time it may take a learner who is blind to engage with the learning in any case.

As emphasised above, the e-learning experience should be very positive. The internet can offer opportunities for people who are blind to select and engage with written information completely independently. Information and communication technologies, and in this case specifically e-learning, offer opportunities to blind learners to engage in interaction with others and with learning materials enabling active communication, both on a social front and on a learning front, that was previously not available. It would be, at the very least, unfortunate if the learning experience deterred a learner who is blind from further participation in e-learning.

In the main study the learners who were blind clearly enjoyed using the materials and tended to prefer the e-learning experience to their usual method of learning. This may have been due to the experience being novel. The implication here is that due to the complexity of the e-learning materials and use of assistive technology, the required skills of both teacher and learner, and the demands of the classroom, learners who are blind may miss out on e-learning opportunities. This situation may be exacerbated when learners who are blind are being taught in mainstream institutions where in some cases there is a lack of specific expertise. A solution here could be for specialist e-learning practice to be focused in regional centres (within a mainstream or specialist college) where there is a body of specialist knowledge and for these institutions and departments to disseminate findings and share good practice via publication, workshops and help lines. These help lines could be in the form of telephone support, online and terminal services including remote access.

Assessment of learner competency

Competent navigation of the World Wide Web may not indicate that a learner can engage effectively in a virtual learning environment. Learner competencies may be overestimated in some cases both by the teachers and by the learners themselves.

It was observed by the researcher that some of the learners were not navigating as efficiently as they could have. For example they were not making use of links lists and in the main study they did not listen to the additional navigational information given on some pages. That is, they needed more training. This is in line with Luke (2002), referred to earlier in the literature review, who found that accessibility of online environments for people with disabilities depends on prior experience, the availability of assistance, the presence of clear help files and familiarity with the assistive technology. In general, from the main study it was identified that with a few adjustments navigation could be easily improved, and this would apply where there is a standard linear layout or repeated use of websites. Although in the main study the learning object had a fairly set pathway through it, in order to re-visit/review content and to engage with it to best effect then a more exploratory/less linear approach would be needed. In terms of the exploratory study and the pilot study to engage with the learning environment and content an exploratory approach was required. The learner would need to be very confident with the technology and able to problem-solve in terms of use of the technology. This may be true for any learner/user but may be especially true for learners who are blind.

Suggested categories of navigational expertise for learners using screen readers were developed and were set out in Chapter 4. The framework is a useful starting point when assessing the skills of a learner who is blind and has implications for staff development as it will not be only ICT specialists who will need to assess these. Teachers working with learners in a range of subjects will need to know whether their learners can access resources and use them to learn effectively.

Assessment, induction and support strategies need to be developed to address these issues. Failure to do so could result in a reduced quality of the learning experience to total despondency, loss of confidence and reluctance to engage in any further learning experiences. This would indeed be a tragedy since all the learners involved in this study enjoyed using the VLEs, and the results of the satisfaction ratings may indicate that although learners in general met many difficulties they felt confident in the technology, not frustrated and satisfied with their execution of the tasks. The potential for effective and innovative learning experiences are immense.

Implications for Policy

This section is concerned with the implications for policy, taking into account standards and guidelines, in the context of implications for design of e-learning and the issue of staff expertise and continuing professional development, as set out above. A range of recommendations have been put forward above relating to practice but the question considered here is which of these and in what ways could they be enforced.

Design of e-learning

As already described in Chapter 2, the Literature Review, there is a plethora of guidelines and a range of standards, some of which are generic and some of which are more application or technology specific and that there is confusion as to which guidelines or standards to apply and how. The most well known and perhaps influential are those developed by the Web Accessibility Initiative (WAI) of the World Wide Web Consortium (W3C). As Seale (2006) points out, organisations such as TechDis have drawn out key points on how to deal with specific applications, such as text and images, and that these are simple and user-friendly, but they may not be as authoritative as those of the WAI.

However, it needs to be pointed out that guidelines are, of course, only guidelines. Alongside standards which are concerned with consistency, they are not enforceable and are often applied or interpreted by people who have limited knowledge of the client group that they may be targeting in terms of accessible needs. To illustrate this, the learning object used in the main study had been designed following the WAI guidelines and had been further tested in terms of accessibility, but there were nonetheless a small number of key issues that had not been identified. For example the learners who were blind were not able to access a flow chart giving an overview of a decision making process used to problem solve.

In terms of standards and guidelines Seale et al (2008) summarise the situation succinctly: ‘To argue that adherence to accessibility standards and guidelines alone will empower disabled learners is to ignore the agility of learners and the real-life choices and decisions that they make when using technology**.’**

As stated above in the summary of the main findings, just because an e-learning environment is ‘accessible’ (for example it may conform to the web content accessibility guidelines and priorities such as W3C, 2007), it is not necessarily ‘usable’. It may be possible to navigate through the content and perform all the tasks but it may take an inordinate amount of time or there may be a high probability of user error. For example, complex navigation may be required or the additional time taken for a blind learner to engage may be so great as to render the learning experience meaningless. At worst the learner who is blind may just simply give up altogether.

Legislation should be concerned with enforcing accessibility and usability of e-learning materials. While some material is ‘accessible’ it is unusable because of the consequences of the effort it takes. Therefore it seems necessary to build in this bigger picture when assessing whether something is truly and meaningfully ‘accessible’. It is possible that the word ‘accessible’ is open to too wide an interpretation and that ‘usable’ may be less open to interpretation. With the meaning of accessible being so open it would be very difficult to enforce the law. The issue with the former point is that there is the possibility that learners who are blind may end up receiving all their course materials as straight forward text and they would not benefit from interactivity and multimedia aspects.

However it would ensure that materials were more easily convertible into another medium/format.

As discussed in Chapter 2, Legislation that applies in this context is the Disability Discrimination Act (DDA, 2005) whereby an institution must make reasonable adjustments to accommodate the needs of a person who is disabled, and discrimination has occurred if a person with a disability is treated less favourably. Unfortunately ‘reasonable adjustment’ is vague and open to wide interpretation and it is possible that it is so wide that designers and teachers could ignore it altogether.

In terms of the design of e-learning content, consistency of layout is a key component in making materials more accessible. That is, consistent within the learning object as well as between learning objects and virtual learning environments, and ideally with everyday software applications such as email, word-processing as well as websites. A learner who is blind should not have to be using different email interfaces; for example, if they use one as part of their software suite and another as part of a virtual learning environment, since navigation and layout will be different in each. This may be true for all users.

E-assessment, for example, in the form of quiz-style questions, should be set out in the same way with check boxes in the same place whichever e-learning environment a learner is in. Technology is advancing in this area and if all content had to be supplied in text format then it would be relatively straightforward to convert this into a suitably accessible format to address the needs of the individual. This could be automated particularly if the content is correctly tagged and relates to the discussion above regarding pdf files.

Expertise and staff development

Evidence from the Literature Review, the studies and from the author’s own experiences as a teacher of learners who are blind clearly indicates that this group can benefit from e-learning but in order for it to be effective a high level of expertise and experience is required. This expertise and experience needs to be kept up-to-date (ideally trail-blazing and not lagging behind or just keeping up) and learners need access to the latest assistive technology.

In the Literature Review regulations (LSC, 2006) state that by 2010 all teachers in Further Education of learners with disabilities must have a mainstream qualification. There is still no legal requirement for them to have a specialist qualification. The standards for teachers of learners with a visual impairment produced by the Visual Impairment Centre for Training and Research (VICTAR, 2007) are comprehensive and such standards could be a legally enforced. In addition it would be useful if they were linked to the annual CPD requirements of the Institute for Learning (IfL) of which all teachers in Further Education must be a member. Teachers of learners with special needs (including blindness) should be required to demonstrate annual professional updating in their field.

Whilst mainstream education may be the best option for some learners who are blind, for others a specialist college may be the best option in that there is a focus of expertise and the potential of a 24 hour curriculum. It should be noted that the number and location of specialist colleges is limited, usually residential (this means that learners are usually not in their home area), vocationally orientated for adults and provision is expensive to deliver. However any such provision can be expensive.

This situation could be addressed partly by the setting up of regional centres and/or by distance learning. It is possible, so long as the learner has a personal computer and access to broadband, to access assistive technologies remotely via the training provider's servers, and for the learner to be supported through remote access. However, the learner needs to have the equipment (personal computer or laptop and broadband), the trainer needs to have a very high level of expertise and sophisticated equipment and the whole process needs to be funded. Such provision would not be able to address independence skills such as mobility and daily living skills.

As found in the RNIB report (2001), support in many mainstream colleges and universities needs to improve to meet all the needs of blind and visually impaired learners. This report has informed the RNIB strategy for setting up centres of excellence in mainstream colleges on a regional basis. The full impact of these centres has yet to be evaluated; however, centres where staff expertise and resources are pooled may be a useful way forward. These could be hubs relating to a National Centre of Excellence/National Resource Centre based on the model of practice used in Sweden (National Agency for Special Needs Education and Schools, 2009). The four national resource centres, alongside specialist schools for up to year 9 have expert knowledge and provide advice and guidance and carry out assessments in respect of people with:

- visual impairment with or without additional disabilities;
- deafness or impaired hearing combined with learning disabilities;
- congenital deafblindness;
- severe speech and language disorders.

In order to meet the needs of most of these learners, it is argued that this should best be carried out in their home area in order to maximise independence skills and life and work opportunities. It is vital therefore that all teachers and those who support learners who are blind or visually impaired have up-to-date specialist qualifications monitored on an annual basis. In a nutshell legislation should demand that people who are blind need the best teachers with the best resources in the most appropriate place for them.

Reflections of the Author as a Practitioner

An overview of publications, conferences attended and external influence is set out in the Introduction. This section examines the more practical applications of lessons learned from the studies.

Prior to and during the early part of the course of the thesis the author had been a teaching practitioner teaching ICT and business studies in a specialist college for people who are blind or visually impaired. During this time she carried out the exploratory and pilot studies. She was then employed at the college in a non-teaching role. During this time she carried out the main study. During the duration of this time the author was an Associate Lecturer with the Open University supporting distance learning ICT related courses and students included a number who were blind or visually impaired.

The exploratory and pilot studies enabled an in-depth understanding of the problems that blind learners might encounter in an e-learning environment. As a result strategies could be devised in advance. For example on one Pen University course a range of tactile diagrams were developed to further illustrate computer systems. These were successful and enhanced the audio descriptions of existing diagrams. MCQs were converted into braille in advance. The author had close communication with the course team at the Open University and was able to advise of areas of potential difficulty and possible solutions for future design.

In terms of her remit to recommend a VLE for use at a specialist college the issue of take up in the college arose. Initially a licence for Blackboard was purchased but there was very limited take up of this in the college and due to the accessibility issues and the cost this was abandoned. Moodle (an open source VLE) was eventually adopted in 2006; the main reasons for this were that it was relatively accessible and very widely used. Again there was slow take up in the college at first in spite of there being a range of materials uploaded and staff development sessions held. However a clear e-learning strategy was developed by the author that included the implementation of Moodle.

Project funding was acquired in 2008 from Becta, the government agency leading the national drive to ensure the effective and innovative use of technology throughout learning, and with the help of a teaching practitioner Moodle was incorporated as part of the BTEC National ICT programme. The learners on this programme all had a high level of ICT and AT skills. The project had not been evaluated at the time of writing but early feedback from staff and learners evidenced that it was being used successfully.

As discussed previously an issue was implementing a learning technology that may exclude some learners due to accessibility and issues of complexity. However it was decided that by not implementing it for those who could access and use it successfully then this group was being disenfranchised.

Apart from accessibility issues slow take-up may be in part due to other activities taking a priority. In a specialist college there will be a focus on independent living skills with academic and vocational skills taking second place. An e-learning involvement is another layer or interface which takes up additional time and energy not just for the learner but from the teacher as well. On reflection this project was successful because there was clear buy-in from the teacher involved and she was given additional hours to work on this (given that there was funding available to do so); a need to use the VLE on the course and buy-in from senior management. It was planned to extend the VLE out across all curriculum areas.

E-learning in its many guises is changing rapidly. There is an increase in the use of Web 2.0 technology and social networks which have fundamentally user-generated content. This will include online facilities such as ‘blogs’ and ‘wikis’. A ‘blog’ (or web log) is basically an online dairy and is controlled and edited by one person. A ‘wiki’ is an online space where people can share, add and edit content. Digital photography sharing and publishing, and podcasting/vodcasting are other examples. Familiar user-generated content sites include Flickr (photo sharing library), YouTube (video sharing facility) and MySpace where users create their own online personal pages (Chillingworth, 2007).

Virtual immersive worlds are developing and are increasingly being used to deliver courses. One such virtual world is Second Life which is an advanced social network where people are represented in an online environment as avatars. It is a highly graphical interface and difficult to access with a screen reader, although there is a screen reader specifically designed to access it. Virtual immersive worlds are increasingly being used in universities as part of undergraduate programmes. They are also being used increasingly to deliver soft skills to people with disabilities, particular in the area of autism, (Smith, 2009). It is this aspect that is currently being pursued by the author, particularly in terms of reducing cognitive load and the exploration of equivalent but alternative activities.

Future Work

Potential areas of future work are (and explored further below):

- Varying the content, the assessment method and using CLT to ascertain changes in cognitive load and performance outcomes.
- Applying the conceptual and theoretical frameworks to other e-learning experience.
- Introducing additional modality such as kinaesthetics.
- Applying adaptations of the conceptual and theoretical frameworks to non-e-learning experiences.
- The measurement of cognitive load by means of monitoring brain activity.
- The application of the measurement of cognitive load theory to an individual using a range of learning methods.

1. Variations in cognitive load

It would be useful to measure variations in cognitive load when changes in e-learning content and assessment method are implemented. This would be difficult using the type of e-learning object used in the main study as it would not be possible to access the code to change the object. This could be carried out in a VLE where it would be relatively easy to change the type and presentation of the content as well as the style of assessment.

2. Applying the conceptual and theoretical frameworks in different contexts

The conceptual and theoretical frameworks could be applied to very different e-learning contexts. The e-learning explored in this study was relatively limited, and it would be interesting to expand the method of analysis and evaluation to broader e-learning initiatives. These approaches may be particularly challenging for blind students because they make use of such a variety of interfaces and applications within a VLE. The exploratory and pilot studies explored some of this usefully, but real-time interactions such as chat rooms may be hard to take part in because of the access issues, such as speed, highlighted by the research. Online problem-based learning (PBL) resources are used, for example, as part of a course for teachers studying for a specialist qualification (working with children who are visually impaired) through distance education (McLinden et al 2007). This type of PBL involves students being involved in online discussion groups and chat, and some groundwork has been done in this area in the pilot study (and published as in Evans and Sutherland, 2003).

3. Additional modal input (use of tactiles)

Linked to the above aspect of introducing additional modality, a study involving additional modal input in the form of tactile diagrams, relating to the learning object used in the main study would be beneficial. The results of this study would be compared to the results of the study relating to the learners who were blind. Tactile diagrams, which could be either with or without supporting commentary (talking tactiles), would be produced to support aspects of the online learning. For example, in the case of the learning material used in the main study this could be the diagram relating to capillaries, the mnemonic RICEM and the table. In addition the multiple-choice questions could be adjusted so that they were not so demanding in terms of cognitive load. The hypothesis is that the performance scores would increase, the number of observations on the pages relating to quiz-style questions would decrease, but there would be an increase in time taken to complete the task where the tactile diagrams were being used. In essence there is an increase in germane cognitive load.

According to Chandler and Sweller (1991) CLT is concerned with the manner in which cognitive resources are focused and used during learning and problem solving. Gerjets and Sheiter (2003, p.33) assert that, ‘The main goal of the theory is to guide instructional design decisions,’ and indeed most research that is carried out is in the area of hypermedia. However, it would suggest that since CLT can give insight into the additional cognitive load experienced by a learner who is blind in an e-learning environment this may be extended to non e-learning/ICT environments.

CLT was used successfully by the author to talk through daily living/independence issues and work-based issues with learners and staff. For example it was a framework to explore and understand the workload of a colleague who was blind. The framework provided a means to identify the impact of a range task as part of a whole job. This in turn enabled the formulation of a range of strategies to reduce the additional (cognitive) load and is an area that is being explored further.

4. Application of conceptual framework in a non-ICT environment

The conceptual framework used in the studies breaks up tasks into accessing, using and doing. This helps identify broad areas of task engagement which could be applied to a non e-learning/ICT environment. Note that in a lecture where there is a teacher and note-taking is required then there is a situation very similar to an e-learning environment, particularly for the learner who is blind. They will need to be listening and taking notes, probably on a personal computer, laptop or braille note taker, in which case they will need to be accessing with the assistive technology and there will be some need to navigate. In addition they will be listening to the speaker and to the screen reader. An example would be in mathematics whereby the learner who is blind may be listening to the teacher, using maths braille (embossed) and tactile diagrams. Written problem solving would either be on a brailler (electric or manual) or on a PC. This would be mainly a kinaesthetic and auditory experience. A sighted learner in this instance may not need the input of a teacher and using a textbook, diagrams and handwritten notes instead. A comparative study here may not be what is important but an examination of the cognitive load for the learner who is blind and how this may be reduced.

5. Measurement of brain activity

Another avenue of future research could be that of cognitive load and the measurement of this by means of monitoring brain activity. This links into the research described in Chapter 7 relating to supra-normal auditory abilities in people who are blind and the relevance of cross-modal plasticity. In short this is concerned with the use of the space allocated to visual senses in the working memory by learners who are blind. This would have relevance in further investigations into the quality of the e-learning experience for learners who are blind. The research could be taken forward by a repetition of the main study but using PET imaging, for example, to show which part of the brain is being used during a particular process; the hypothesis being that a learner who is blind is using part of the visual cortex when working in a multimedia environment to process learning content and to problem solve.

6. Using cognitive load theory to indicate optimum method of learning

Finally it may be useful to apply CLT to an individual who is blind using a range of learning methods. It would most likely need an automated method of measuring cognitive load (such as measuring brain activity) since the focus would be on one learner and they could become over burdened with giving their perception of the cognitive load. The outcome of this would be to identify the best method of learning for the individual; however, it should be borne in mind that this may not be their preferred method of learning.

Final Word

The fourth key question that was posed in the Introduction was whether the quality of the e-learning experience will be the same for a learner who is blind as for a sighted learner, that is, is there a level playing field? In the main study it was found that the two groups of learners did have a similar learning experience although it took the learners who were blind approximately twice as long to complete the task as the sighted learners. In this respect if there was not exactly a level playing field a great deal of effort had gone into addressing this.

Analysis of the way that the learners interacted with the learning object provided insight as to how the gap in the quality of that experience could be further addressed. For some there are small pockets of e-learning that offer a level playing field, but, at the time of writing, new learning environments and technologies are evolving and the majority of people who are blind are not even ‘in the game’. O’Connor’s (2000) vision of learners who are blind being advantaged in the e-learning field may be too far away for anyone to see. Additionally it should be noted that, with rapid technological advancement, legislation that is too prescriptive in terms of accessibility and e-learning may very soon become out of date; however, that is possibly a small price to pay.

As Corn and Wall (2002, p.211) conclude: 'Academic success, future employment, and opportunities for higher education may depend on how the field of visual impairment addresses how to level the playing field for students with visual impairment in a technological age.' However, it is not just the field of visual impairment that needs to do this, it is everyone involved with developing and delivering education and training for blind and partially sighted learners. It seems that until the implementation of guidelines and standards is legally enforceable and the best teachers with the best resources in the most appropriate place are funded it is unlikely that there will be a level playing field.

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APPENDIX 1 Pre-Soap Group Questionnaire

Please answer the following questions. The information may be used for research but participants will not be identified and confidentiality will be maintained in this respect. Press reply and then answer on the screen and return to se@College.ac.uk.

1. Age.

2. Gender.

3. Vocational/academic course of study.

4. Working medium e.g.

5. What assistive software do you use e.g. screen reader, magnification?

6. If you use assistive software, which make e.g. Supernova or Jaws?

7. How long have you been using a computer?

8. What do you use it for?

9. Do you use email frequently e.g. more than once a day?

10. Do you use the internet?

11. If yes to the above question what do you use it for e.g. shopping, sport, college work?

12. How long have you been using the internet?

13. Do you use it frequently e.g. more than once a day?

14. Do you use chat?

15. Have you ever used a virtual learning environment such as Blackboard before?

16. If yes to the above please give details.

17. Have you ever used a discussion board/bulletin board before?

18. If yes to the above please give details?

19. What do you expect to get out of the Electronic Soap Group?

Thank you for taking the time to answer these questions.

APPENDIX 2 Questionnaire for Electronic Soap Group

End of pilot questionnaire – to be used in conjunction with a forum on the discussion board.

This information may be used to inform academic research but you will not be identified and confidentiality of information will be maintained at all times. Please do set out any difficulties you had in using Blackboard – this is not a judgment on you but on the software and ways in which it may be improved to help you to learn. Please ask if you have any concerns.

1. Did you have any difficulties logging in? If yes could you describe what happened, approximately how many times and what did you do about it?

2. Did you experience any difficulties finding the relevant sections e.g. the discussion board, external links, assignments? If yes please describe any difficulties and what you did about them.

3. Were you able to move easily between the different areas of Blackboard? If not please can you describe any difficulties and what you did about them.

4. Do you get lost in Blackboard – if yes describe what you did to find your way again, or did you give up?

5. Did you like the way the discussion board was organised i.e. by weeks and then topics? Is there a better way it could be organised?

6. Did you find it easy to find threads, messages etc. if not how could it be improved?

7. Did you enjoy using the discussion board?

8. Do you prefer discussions on the discussion board to face-to-face discussions?

9. Do you prefer a mixture of face to face and discussion board to face-to-face discussion on its own?

10. Do you prefer a mixture of face to face and discussion board to discussion board on its own?

11. Note down what you have learned as being part of the electronic soap group.

12. Would you have preferred a longer introduction to Blackboard at the outset?

13. Were you happy with the amount of technical support/help you had face to face?

14. Were you happy with the amount of technical support/help you had in Blackboard or by email?

15. Were you happy with the amount of tutorial support you had face to face?

16. Were you happy with the amount of tutorial support you had in blackboard/by email?

17. Would you like to continue with ESG after half tem and if so please note down any ideas for topics you may have?

APPENDIX 3 Comparison of Pre-Study Computer Usage

Question	Overview of Responses – learners who were blind	Overview of Responses – learners who were sighted
Age	18.4 years – average	19.4 years – average
Sighted?	All registered blind	All fully sighted
Level of Study?	8 Level 3; 2 NVQ level 2	All level 3
ICT Skills Level?	5 Intermediate 5 Expert	All stated they were intermediate
Assistive Technology Skills Level?	3 Intermediate 7 Expert	N/A
No. of years computer use?	9.8 years	7.2 years
Preferred method of learning?	All used PC, 6 named braille, 2 named tape	All said PC; 2 said audio and one said books
No. of years internet use?	5.55 years	5.2 years
Purpose of internet use?	9 = study; 7 = hobbies; 5 = shopping; 1 = communication; 1 = entertainment; 1 = business	7 = study; 7 = hobbies; 8 = shopping; 1 = business; 1 = communication
Email use?	All on a daily basis	7 = daily; 2 monthly and 1 weekly
Chat use?	7 used Chat all on a daily basis; 3 did not use it	5 used chat – 3 daily; 1 weekly; 1 monthly
Discussion board use?	2 used discussion board both for hobbies	2 had used a discussion board for hobbies
VLE use?	1 used VLE	None
Learning object use?	1 used online materials in accessibility trial	2 for revision
MCQ use?	5 used MCQs – 2 for forms; 1 for tests, 1 for quiz and 1 for maths	7 – 3 for revision; 1 for Key Skills; 1 for Webwise and 1 for forms
Games use?	4 used games – 1 each for Commando, cards; tennis; mortal combat. 1 had tried but failed.	4 – 1 for allsorts; 1 for chess; 1 for poker and betting; 1 for pool

APPENDIX 4 Multiple-Choice Questions

Question No.	Type of question	Relates to content	Questions/Options	Answer
1	True/False	Classification of injuries	**Look at the statements below and decide whether they are true or false**	
			A customer slips over and suffers a twisted ankle. They have an acute/extrinsic injury.	True
			A woman at aerobics leads with her right foot and has strained her Achilles tendon. She has a chronic intrinsic injury.	True
			A football player runs into another player and bruises his arm. He has an acute intrinsic injury.	False
			A badminton player has fallen and sprained his wrist. He has a chronic extrinsic injury.	False
2	Odd-one-out style	Common sports injuries	Which of the following are the most common sports injuries that you are likely to treat? Choose 3 of the following:	
			Tearing a tendon	Correct
			Spraining a ligament	Correct
			Breaking a bone	Incorrect
			Straining a muscle	Correct
			Being hit on the head	Incorrect

APPENDIX 5 Summary of Content on Each Page

Page Number	Presentation Media	Type of Content
1	Text	First time user page
2	Text	Objectives
3	Text and Audio	Intro with learning objectives
4	Text and Audio	Menu
5	Text with assistive visual layout	Classification of injuries
6	Text with enhanced visual layout	MCQ – true/false
7	Buttons with enhanced visual layout followed by text and short animations	Links to further information on muscles, ligaments and tendons
8	Text with bullets and graphics plus key link to capillary graphic	Signs and symptoms of injuries
8a	Text and graphic	Capillaries
9	Text and button links to further information. Each link has additional text information	RICEM
10		MCQ – 3 correct answers from 5 – odd-one-out style
11	Text and graphic	When not to treat
12	Text and graphic	Health and safety
13	Text and graphic and audio	Intro to case study
14	Text with enhanced visual layout and graphic	MCQ – 'most accurate' style
15	Text and graphic and audio	Reinforcing rest
16	Text with enhanced visual layout and graphic	MCQ – 'most accurate' style
17	Text and graphic and audio	Reinforcing ice
18	Text with enhanced visual layout and graphic	MCQ – 'most accurate' style
19	Text and graphic and audio	Reinforcing compression
20	Text with enhanced visual layout and graphic	MCQ – 'most accurate' style
21	Text and graphic and audio	Reinforcing elevation
22	Text and graphic and audio plus important button link to table	Introducing mobility
22a	Table	Decision tree
23	Text and graphic with radio buttons	MCQ – either/or
24	Text with enhanced layout and animations	Summary – what has been learned?

APPENDIX 6 Perception of Mental Effort – data collection sheet

Name:

Date:

1 = low effort

7 = high effort

Page in learning object	**Activity**	**PME Learning**	**PME Using**	**PME Accessing**
3	Introduction			
5	Classification of injuries			
6	Multiple choice			
8	Muscles, tendons, ligaments			
10	RICEM and then multiple choice			
12	Health and safety			
15	Intro to case study, MCQ and solution			
22	End of RICEM – MCQs and solutions			
24	Table and summary			

APPENDIX 7 Satisfaction Survey Questions and Results

Reponses to questions

1 = Strongly disagree

2 = Disagree a lot

3 = Disagree a little

4 = Neither agree nor disagree

5 = Agree a little

6 = Agree a lot

7 = Strongly agree

		Blind Learners (n = 10)	Sighted Learners (n = 10)
Question	**Total average score**	5.8	5.5
		Average satisfaction score per question	
		Blind Learners	**Sighted Learners**
1. I enjoyed using the learning materials.		6.3	4.9
2. I learned more than I would using my usual method.		5.1	5.3
3. I preferred using these materials to my usual method.		5.0	4.7
4. I would use this method of learning again.		6.2	5.7
5. I will remember the materials more easily than with my usual method.		5.0	5.3
6. I found the material easy to navigate around.		5.9	6.4
7. I found the technology worked well.		6.0	6.2
8. The technology did not affect my ability to learn.		6.4	6.5
9. The audio content helped my learning.		6.4	5.2
10. The graphic/animation content helped my learning.		N/A	5.1

APPENDIX 8 Performance Test Question Analysis

Question	Answer	Relates to page nos.	Learning – audio or text or graphic	Type of question
1. An injury that builds up over time is known as a. An intrinsic injury b. A chronic injury	Chronic	5	Text in a block diagram arrangement	Either/or
2. An injury that builds up suddenly is known as a. An extrinsic injury b. An acute injury	Acute	5	Text in a block diagram arrangement	Either/or
3. An injury that is caused by a force inside the body is known as a. An intrinsic injury b. A chronic injury	Intrinsic	5	Text in a block diagram arrangement	Either/or

APPENDIX 9 Observation and Analysis Schedule

Student:

Researcher(s):

Date of Video Trial:

Assistive Technology and VLE used:

Date of Analysis:

10 second interval	Actual Activity	Accessing/Using/Doing	Comments/Notes including Errors

APPENDIX 10 Aggregate Data Table – Blind Learners

Background Information

Question	Overview of Responses
Age	18.4 years
Sighted?	All registered blind
Level of Study?	8 Level 3; 2 NVQ level 2
ICT Skills Level?	5 Intermediate 5 Expert
Assistive Technology Skills Level?	3 Intermediate 7 Expert
No. of years computer use?	9.8 years
Preferred method of learning?	All used PC, 6 named braille, 2 named tape
No. of years internet use?	5.55 years
Purpose of internet use?	9 = study; 7 = hobbies; 5 = shopping; 1 = communication; 1 = entertainment; 1 = business
Email use?	All on a daily basis
Chat use?	7 used Chat all on a daily bases; 3 did not use it
Discussion board use?	2 used discussion board both for hobbies
VLE use?	1 used VLE
Learning object use?	1 used online materials in accessibility trial
MCQ use?	5 used MCQs – 2 for forms; 1 for tests, 1 for quiz and 1 for maths
Games use?	4 used games – 1 each for Commando, cards; tennis; mortal combat. 1 had tried but failed.

1. Number of observations (average)

	Data	
Accessing	15.5	8.5%
Using	46.4	25.4%
Doing	121	66.2%
Total no. of observations	182.9	
Total time taken in learning object	30.48 mins	

2. Observations on each doing activity (average)

	Data	
Listening	50.8	41.7%
Reading	N/A	N/A
Answering	43.1	35.4%
Checking	12.7	10.4%
Reinforcing	11.1	9.1%
Other	3.9	3%

3. Observations on each page (average)

	Data
1	0.1
2	5.4
3	9.3
4	9.4
5	7
6	23.5
7	10.7
8	6.2
8a	3.1
9	12.7
10	16.7
11	4.1
12	4.2
13	6.2
14	7.4
15	4.8
16	5.7
17	5.7
18	7.8
19	4.4
20	7.3
21	4.3
22	4.5
22a	2.6
23	7.7
24	5.3

4. Perception of Mental Effort

	Data		
1 = Low Perception of Mental Effort 7 = High Perception of Mental Effort	**Accessing**	**Using**	**Doing**
Introduction	2.4	3.1	1.2
Classification	2.2	3.3	1.6
MCQ	2.4	3.0	1.7
Muscles, tendons, ligaments	2.2	2.7	1.9
RICEM	2.3	3.1	1.8
Health and Safety	2.7	2.5	2.2
Intro to case study and MCQ	2.3	2.5	1.6
Table and MCQ	2.3	2.3	1.5
Learning outcomes	2.8	3.0	1.5
Average Total	2.4	2.8	3.5

5. Satisfaction Questionnaire

	Data
	Reponses to questions 1 = Strongly disagree 2 = Disagree a lot 3 = Disagree a little 4 = Neither agree nor disagree 5 = Agree a little 6 = Agree a lot 7 = Strongly agree
1. I enjoyed using the learning materials	6.3
2. I learned more than I would using my usual method	5.1
3.I preferred using these materials to my normal method	5.0
4. I would use this method of learning again	6.2
5. I will remember the materials more easily than with my usual method	5.0
6. I found the material easy to navigate around	5.9
7. I found the technology worked well	6.0
8. The technology did not affect my ability to learn	6.4
9. The audio content helped my learning	6.4
10. The graphic/animation content helped my learning	N/A
Average satisfaction score out of 7	5.8

6.MCQs

Question Number	Type of question	No. of correct answers
1	4 x True/False statements	4 learners had 4 correct 2 learners had 3 correct 4 learners had 2 correct Total: 30
2	3 correct statements out of a choice of 4	3 learners had 3 correct 7 learners had 2 correct Total: 23
3	Multiple-choice	10
4	1 out of 4	9
5	1 out of 4	6
6	1 out of 4	9
7	A or B	3
Average score of out 12		8.9

7. Performance Test

Question No.	Type of question	Number of correct answers
1	A or B	8
2		8
3		5
4		7
	Total for Question Type	28
5	True or False	6
6		6
7		6
	Total for Question Type	18
8	Single/two word answer	8
9		0
10		3
11		7
12		3
13		8
14		10
15		6
16		7
17		7
	Total for Question Type	59
18	Short sentence	5
19	5 key points (RICEM)	None had 4 or 5 correct answers 1 had 3 correct 3 had 2 correct 2 had 1 correct 4 had None correct Total: 26
20	4 key points	None had 4 correct 1 had 3 correct 3 had 2 correct 2 had 1 correct 4 had none correct Total: 11
Average time to complete test		12.9 minutes
Average score out of 27		14.7

APPENDIX 11 Aggregate Data Table – Sighted Learners

1. Background Information

Age	19.4
Sighted?	All fully sighted
Level of Study?	All level 3
ICT Skills Level?	All stated they were intermediate
Assistive Technology Skills Level?	N/A
No. of years computer use?	7.2 years
Preferred method of learning?	All said PC; 2 said audio and one said books
No. of years internet use?	5.2 years
Purpose of internet use?	7 for study; 7 hobbies; 8 = shopping; 1 = business; 1 = communication
Email use?	7 = daily; 2 monthly and weekly
Chat use?	5 used chat – 3 daily; 1 weekly; 1 monthly
Discussion board use?	2 had used a discussion board for hobbies
VLE use?	None
Learning object use?	2 for revision
MCQ use?	7 – 3 for revision; 1 for Key Skills; 1 for Webwise and 1 for forms
Games	4 – 1 for allsorts; 1 for chess; 1 for poker and betting; 1 for pool

1. Number of observations (average)

	Data	
Accessing	N/A	N/A
Using	8.8	10.4%
Doing	75.9	89.7%
Average Total No of observations	84.6	
Average Total time taken in learning object	14.1 mins	

2. Observations on each doing activity (average)

	Data	
Listening	8.4	11 %
Reading	35.7	46.9 %
Answering	16.3	21.4 %
Checking	3.5	4.6 %
Reinforcing	11.5	15.3 %
Other	0.6	0.78%

3. Observations on each page (average)

	Data
1	0
2	0.9
3	3.4
4	2.6
5	6.2
6	7.5
7	7.0
8	2.4
8a	1.9
9	8.5
10	3.6
11	2.5
12	2.4
13	3.7
14	2.2
15	2.3
16	1.8
17	3.1
18	2.5
19	3
20	1.7
21	2.2
22	4.4
22a	2.2
23	1.9
24	3.8

4. Perception of Mental Effort

	Data		
1 = Low Perception of Mental Effort 7 = High Perception of Mental Effort	Accessing	Using	Doing
Introduction	N/A	1.2	1.5
Classification	N/A	1.6	3.0
MCQ	N/A	1.7	3.5
Muscles, tendons, ligaments	N/A	1.9	3.8
RICEM	N/A	1.8	3.1
Health and Safety	N/A	2.2	2.4
Intro to case study and MCQ	N/A	1.6	2.3
Table and MCQ	N/A	1.5	2.8
Learning outcomes	N/A	1.5	2.3
Average Total	N/A	1.7	2.7

5. Satisfaction Questionnaire

	Data
	Reponses to questions: 1 = Strongly disagree 2 = Disagree a lot 3 = Disagree a little 4 = Neither agree nor disagree 5 = Agree a little 6 = Agree a lot 7 = Strongly agree
1. I enjoyed using the learning materials	4.9
2. I learned more than I would using my usual method	5.3
3.I preferred using these materials to my normal method	4.7
4. I would use this method of learning again	5.7
5. I will remember the materials more easily than with my usual method	5.3
6. I found the material easy to navigate around	6.4
7. I found the technology worked well	6.2
8. The technology did not affect my ability to learn	6.5
9. The audio content helped my learning	5.2
10. The graphic/animation content helped my learning	5.1
Average satisfaction score out of 7	5.5

6.MCQs

Question Number	Type of question	No. of correct answers
1	4 x True/False statements	4 learners had 4 correct 4 learners had 3 correct 2 learners had 2 correct 32
2	3 correct statements out of choice of 4	8 learners had 3 correct 2 learners had 2 correct 28
3	Multiple-choice	10
4	1 out of 4	10
5	1 out of 4	9
6	1 out of 4	10
7	A or B	9
Average score of out 12		10.7

7. Performance Test

Question No.	Type of question	Number of correct answers
1	A or B	9
2		8
3		9
4		10
	Total for Question Type	36
5	True or False	8
6		9
7		9
	Total for Question Type	26
8	Single/two word answer	6
9		2
10		1
11		10
12		8
13		9
14		8
15		7
16		9
17		4
	Total for Question Type	64
18	Short sentence	9
19	5 key points (RICEM)	2 had 5 correct 2 had 4 correct 2 had 3 correct 2 had 2 correct 1 had 1 correct 1 had 0 correct Total: 29
20	4 key points	None had 4 correct None had 3 correct 4 had 2 correct 4 had 1 correct 2 had none correct Total: 12
Average time to complete test		9.7 minutes
Average score out of 27		17.6

APPENDIX 12 Case Studies (1 to 20)

Case Study 1

1. Background Information

Age	21
Sighted?	Not sighted
Level of Study?	2
ICT Skills Level?	Expert
Assistive Technology Skills Level?	Intermediate
No. of years computer use?	13 years
Preferred method of learning?	Computer
No. of years internet use?	11 years
Purpose of internet use?	Study and shopping
Email use?	Yes, daily
Chat use?	Yes, daily
Discussion board use?	Not used
VLE use?	Not used
Learning object use?	Tried to use LearnDirect but accessibility problems
MCQ use?	Not used
Games	Not used

2. Number of observations

Activity	**Data**		**Comments**
			Has limited experience with JAWs – uses Supernova.
Accessing	19	9.6%	
Using	42	21%	
Doing	137	69%	
Total No of observations	198		
Total time taken in learning object	38 mins 30 secs		

3. Perception of Mental Effort

Activity	Data			Comments
	L	U	A	
Introduction	7	6	6	High PME across the board – most effort in learning. Quickly grasped the navigation. Skipped answers 15 to 22.
Classification	7	6	6	
MCQ	7	6	6	
Muscles, tendons, ligaments	7	6	6	
RICEM	7	6	7	
Health and Safety	7	6	6	
Intro to case study and MCQ	7	6	6	
Rest of MCQs	7	6	6	
Table and summary	7	6	6	
Average	7	6	6.1	

4. Observations on each activity

Activity	Data		Comments
Listening	51	26%	Did not ignore the instruction to sit back and listen. Doing made up of 26% listening; 29.3% answering; 6.5% checking and 6.5% reinforcing. Commenting
Reading	N/A	N/A	
Answering	58	29.3%	
Checking	13	6.5%	
Reinforcing	13	6.5%	
Navigating	42	21%	
JAWs	19	9.6%	
Other	3	1.5%	

5. Observations on each page (summary)	Obs rise pp. 5,6,7,10, 18	
6. MCQs	10/12	Missed flowchart but got Q7 wrong
7. Performance Test	18/27	All either/or correct. All T/F correct. Single answer 6/11. 3/5 for RICEM and 2/4 for learning objectives
8. Time taken	8 minutes	

9. Satisfaction Questionnaire

Question	Score	Learner comments
I enjoyed using the learning materials	7	It was accessible to JAWs. Audio made it interesting – kept concentration levels up.
I learned more than I would using my usual method	6	Usually read on PC – would have to look at using it with Customer Service
I preferred using these materials to my normal method	6	Usually use Supernova. Would have to look again.
I would use this method of learning again	7	It always helps to have more than one method – something to fall back on to look at.
I will remember the materials more easily than with my usual method	6	I was able to take it in.
I found the material easy to navigate around	7	Very user friendly
I found the technology worked well	7	No conflict between macromedia and JAWs
The technology did not affect my ability to learn	7	No additional response
The audio content helped my learning	7	It was easy to take in terminology – said in a way that it could be understood.
The graphic/animation content helped my learning	N/A	
Average score	6.7	

Case Study 2

1. Background Information

Age	17
Sighted?	Not sighted
Level of Study?	3
ICT Skills Level?	Expert
Assistive Technology Skills Level?	Expert
No. of years computer use?	10 years
Preferred method of learning?	Computer
No. of years internet use?	2 years, weekly
Purpose of internet use?	Study, hobbies, shopping
Email use?	Yes, daily
Chat use?	Yes, daily
Discussion board use?	Not used
VLE use?	Not used
Learning object use?	Not used
MCQ use?	Not used
Games	Yes – tennis a long time ago

2. Number of observations

Activity	**Data**		**Comments**
			Approximately 70% obs related to doing and 30% to using and accessing.
Accessing	27	13.1%	
Using	38	18.5%	
Doing	141	68.4%	
Total No of observations	206		
Total time taken in learning object	33 mins 10 secs		

3. Perception of Mental Effort

Activity	Data			Comments
	L	U	A	
Introduction	4	3	1	Low PME with accessing but spent 13.1 % of the time on this – due to JAWs losing focus of LO. Nearly 20% of time using but relatively low PME. Medium PME on learning.
Classification	5	2	2	
MCQ	5	2	2	
Muscles, tendons, ligaments	3	2	2	
RICEM	3	2	2	
Health and Safety	3	2	2	
Intro to case study and MCQ	3	2	2	
Rest of MCQs	3	2	2	
Table and summary	3	2	2	
Average	3.6	2.1	1.9	

4. Observations on each activity

Activity	Data		Comments
Listening	58	28.2%	Obs related to doing made up of 28.4% listening; 23.5% answering; 7.9% checking and 4.9% reinforcing.
Reading	N/A	N/A	
Answering	50	24.3%	
Checking	16	7.8%	
Reinforcing	10	4.9%	
Navigating	38	18.5%	
JAWs	27	13.1%	Problems loading
Other	7	3.4%	

5. Observations on each page (summary)	Obs rise pp. 6, 7, 9, 10, 20 and second menu.	
6. MCQs	9/12	Got 8/12 but attempted Q1 again and got 1 more correct answer. Also Q5 A incorrect and Q7 – did not read the table.
7. Performance Test	13/27	2/4 for Qs 1 to 4; T/F correct; 7/11 for single word answers; 2/5 for RICEM and 0/4 for learning objectives.
8. Time taken	12 minutes	

9. Satisfaction Questionnaire

Question	Score	Learner comments
I enjoyed using the learning materials	6	Made it more easier – getting around
I learned more than I would using my usual method	6	Usually use notes in Word – as above
I preferred using these materials to my normal method	7	Because it made learning easier then reading everything
I would use this method of learning again	7	Definitely
I will remember the materials more easily than with my usual method	6	When you are listening in Word you have to navigate a lot – with this you just listen.
I found the material easy to navigate around	7	No additional response
I found the technology worked well	6	No additional response
The technology did not affect my ability to learn	7	No additional response
The audio content helped my learning	6	Brad broke it down into simple bits
The graphic/animation content helped my learning	N/A	N/A
Average score	6.4	

Case Study 3

1. Background Information

Age	19
Sighted?	Not sighted
Level of Study?	3
ICT Skills Level?	Intermediate
Assistive Technology Skills Level?	Intermediate
No. of years computer use?	11.5 years
Preferred method of learning?	Computer and braille
No. of years internet use?	4.5 years
Purpose of internet use?	Hobbies
Email use?	Yes, daily
Chat use?	Yes, daily
Discussion board use?	Yes
VLE use?	No
Learning object use?	Yes, testing NLN materials
MCQ use?	Yes, radio buttons on forms
Games?	No

2. Number of observations

Activity	**Data**		**Comments**
			Approximately 56% of obs related to doing and 43% to accessing and using. JAWs kept reading from the middle of the page so had to navigate to top.
Accessing	9	5%	
Using	71	38.8%	
Doing	103	56.3%	
Total No of observations	183		
Total time taken in learning object	36 mins 30 secs		

3. Perception of Mental Effort

Activity	Data			Comments
	L	U	A	
Introduction	4	5	1	Higher PME with accessing classifications and RICEM.
Classification	6	6	4	
MCQ	5	3	1	
Muscles, tendons, ligaments	6	6	1	Navigation easier at the end. Learning lowest around case study.
RICEM	4	7	4	
Health and Safety	4	3	1	
Intro to case study and MCQ	3	2	1	
Rest of MCQs	2	1	1	
Table and summary	4	1	1	
Average	4.2	3.8	1.7	

4. Observations on each activity

Activity	Data		Comments
Listening	51	29%	Doing is made up of 29% listening; 17% answering; 5% checking and 5.5% reinforcing.
Reading	N/A	N/A	
Answering	31	17%	
Checking	9	5%	
Reinforcing	10	5.5%	
Navigating	71	39%	
JAWs	9	5%	
Other	0	0%	

5. Observations on each page (summary)	Obs rise pp. 3,4,5,6 and 9, 10	
6. MCQs	10/12	Did read table and did get Q7 correct. Q2a incorrect.
7. Performance Test	17/27	1-4 all correct; 2 out of 3 for T/F; and 8,9,10, 11, 12 incorrect; 3/5 for RICEM and 2/4 for learning objectives.
8. Time taken	12 minutes	

9. Satisfaction Questionnaire

Question	**Score**	**Learner comments**
I enjoyed using the learning materials	6	Gained insight into something new How easy it is to pick up something I have no experience of
I learned more than I would using my usual method	4	Read on-screen
I preferred using these materials to my normal method	3	More familiar with normal method
I would use this method of learning again	4	If navigation with JAWs was better then I would
I will remember the materials more easily than with my usual method	4	Doing a task would help me remember
I found the material easy to navigate around	3	Towards the end it was easier Confusing use of word Play
I found the technology worked well	4	No additional response
The technology did not affect my ability to learn	6	No additional response
The audio content helped my learning	6	Did help – more interesting
The graphic/animation content helped my learning	N/A	N/A
Average score	5.1	

Case Study 4

1. Background Information

Age	18
Sighted?	Not sighted
Level of Study?	3
ICT Skills Level?	Intermediate
Assistive Technology Skills Level?	Expert
No. of years computer use?	8
Preferred method of learning?	Computer
No. of years internet use?	8 years, daily
Purpose of internet use?	Hobbies, shopping, study, communication
Email use?	Yes, daily
Chat use?	Yes, daily
Discussion board use?	Not used
VLE use?	Not used
Learning object use?	Not used
MCQ use?	Yes, questionnaires, quizzes
Games	Yes, Tank Commander and Doom

2. Number of observations

Activity	**Data**		**Comments**
			Approximately 32% obs related to accessing and using with 70% relating to doing.
Accessing	16	8.1%	
Using	47	23.7%	
Doing	135	68.2%	
Total No of observations	198		
Total time taken in learning object	37 minutes 10 secs		

3. Perception of Mental Effort

Activity	Data			Comments
	L	U	A	
Introduction	1	2	2	PME with learning was high with p.6 and 8 and also the flowchart p.22a. Using and accessing fairly low apart from with the flowchart.
Classification	1	2	2	
MCQ	7	2	2	
Muscles, tendons, ligaments	5	2	3	
RICEM	3	1	1	
Health and Safety	2	1	1	
Intro to case study and MCQ	2	3	2	
Rest of MCQs	3	2	2	
Table and summary	7	6	6	
Average	3.4	2.3	2.3	

4. Observations on each activity

Activity	Data		Comments
Listening	61	31%	Doing was made up of listening 31%; answering 24.7%; checking 7.1%; Reinforcing 5.6%.
Reading	N/A	N/A	
Answering	49	24.7%	
Checking	14	7.1%	
Reinforcing	11	5.6%	
Navigating	47	24%	
JAWs	16	8.1%	
Other	0	0%	

5. Observations on each page (summary)	Fairly even spread of between 3 and 7 rising on pp. 6, 7, 9, 10, 14, 19, 22a and 23.	
6. MCQs	10/12	Q5a incorrect. Did read table but got answer wrong.
7. Performance Test`	18/27	4/5 with RICEM and 2/4 for learning objectives.
8. Time taken	25 minutes	

9. Satisfaction Questionnaire

Question	Score	Learner comments
I enjoyed using the learning materials	7	Easy to access, good information and presentation
I learned more than I would using my usual method	6	Have learned more – letting the PC talk to me
I preferred using these materials to my normal method	7	As above
I would use this method of learning again	6	Definitely it is good
I will remember the materials more easily than with my usual method	7	Able to take it all in – Brad is like a person
I found the material easy to navigate around	5	Not all of it e.g. The flowchart
I found the technology worked well	6	It did have a little tantrum
The technology did not affect my ability to learn	6	It did help
The audio content helped my learning	7	It really did help
The graphic/animation content helped my learning	N/A	
Average score	6.3	Very satisfied – the only real glitch was the accessibility of the flowchart

Case Study 5

1. Background Information

Age	17
Sighted?	Not sighted
Level of Study?	3
ICT Skills Level?	Expert
Assistive Technology Skills Level?	Expert
No. of years computer use?	6
Preferred method of learning?	It depends – braille, computer, audio
No. of years internet use?	4 years, daily
Purpose of internet use?	Study, communication and shopping
Email use?	Daily
Chat use?	Daily
Discussion board use?	Not used
VLE use?	Not used
Learning object use?	Not used
MCQ use?	Yes – some quizzes
Games	Yes – card game

2. Number of observations

Activity	**Data**		**Comments**
Accessing	12	7.3%	
Using	41	24.8%	
Doing	112	67.9%	
Total No of observations	165		
Total time taken in learning object	33 mins 20 secs		

3. Perception of Mental Effort

Activity	Data			Comments
	L	U	A	
Introduction	2	2	2	PME with using and accessing was a constant 2. PME with learning rose to 4 with muscles tendons and ligaments and also with the MCQs at page p22.
Classification	3	2	2	
MCQ	2	2	2	
Muscles, tendons, ligaments	4	2	2	
RICEM	2	2	2	
Health and Safety	2	2	2	
Intro to case study and MCQ	2	2	2	
Rest of MCQs	4	2	2	
Table and summary	3	2	2	
Average	2.7	2	2	

4. Observations on each activity

Activity	Data		Comments
Listening	65	39.3%	Doing was made up of approximately 39.3% listening; 17.6 % answering; 6.7% checking; 5.5% reinforcing.
Reading	N/A	N/A	
Answering	29	17.6%	
Checking	11	6.7%	
Reinforcing	9	5.5%	
Navigating	41	24.8%	
JAWs	11	6.7%	Giving opinion on accessibility
Other	2	1.2%	

5. Observations on each page (summary)	Reasonable spread – 3 to 7 rising on pp. 6, 7, 9, 10, 13, 22a and 23.	
6. MCQs	8/12	Read table and got Q7 right. Q1 c and d incorrect – also Q5 a and Q 6 b
7. Performance Test	9/27	Qs 2 to 12 inclusive were incorrect. 3/5 for RICEM; 1 learning objective.
8. Time taken	7 minutes	

9. Satisfaction Questionnaire

Question	Score	Learner comments
I enjoyed using the learning materials	5	It was all right – not my main interest – this topic
I learned more than I would using my usual method	3	Usually Word/Internet
I preferred using these materials to my normal method	5	More interaction
I would use this method of learning again	6	Not additional response
I will remember the materials more easily than with my usual method	4	Don't know – yet
I found the material easy to navigate around	7	I found it easy; others would not
I found the technology worked well	7	It worked for me but it could be a lot better
The technology did not affect my ability to learn	7	Not additional response
The audio content helped my learning	4	It was OK – do not mind reading it in JAWs.
The graphic/animation content helped my learning	N/A	N/A
Average score	5.3	Preferred usual method of learning and is quite happy listening to JAWs

Case Study 6

1. Background Information

Age	19
Sighted?	Not sighted
Level of Study?	3
ICT Skills Level?	Intermediate
Assistive Technology Skills Level?	Intermediate
No. of years computer use?	7
Preferred method of learning?	Computers
No. of years internet use?	6
Purpose of internet use?	Study, hobbies, music
Email use?	Daily
Chat use?	Daily
Discussion board use?	Not used
VLE use?	Not used
Learning object use?	Note used
MCQ use?	Yes on Bikesite – maths
Games	Tried but failed

2. Number of observations

Activity	**Data**		**Comments**
Accessing	17	9.6%	
Using	43	24%	
Doing	122	66%	
Total No of observations	182		
Total time taken in learning object	33 mins 30 secs		

3. Perception of Mental Effort

Activity	Data			Comments
	L	U	A	
Introduction	2	3	1	Generally fairly low but rising around p.6 and p.7 as well as the table and summary. PME with accessing very low.
Classification	2	3	1	
MCQ	5	2	1	
Muscles, tendons, ligaments	5	2	1	
RICEM	3	2	1	
Health and Safety	3	2	1	
Intro to case study and MCQ	1	1	1	
Rest of MCQs	1	1	1	
Table and summary	4	3	1	
Average	2.9	2.1	1	

4. Observations on each activity

Activity	Data		Comments
Listening	34	18.7%	The doing was made up of 18.7% listening; 33.4% reading; 9.4% checking and 5.5% reinforcing.
Reading	N/A	N/A	
Answering	61	33.4%	
Checking	17	9.4%	
Reinforcing	10	5.5%	
Navigating	43	24%	
JAWs	17	9.4%	
Other	0	0%	

5. Observations on each page (summary)	P.2 audio not on caused a problem. Pp. 6 and 10 very high no. of obs due to difficulties accessing the information.	
6. MCQs	8/12	Missed the table and got Q7 wrong. Also 1 B and D and 2 D incorrect.
7. Performance Test	12/27	4/4 for either/or; 2/3 for t/f; 7/11 for single answer; 2/5 for RICEM and 0 for the learning objectives
8. Time taken	15 minutes	

9. Satisfaction Questionnaire

Question	Score	Learner Comments
I enjoyed using the learning materials	6	It was fun – I am connected with sport
I learned more than I would using my usual method	6	Voice helped (Brad the narrator)
I preferred using these materials to my normal method	6	Not additional response
I would use this method of learning again	7	Not additional response
I will remember the materials more easily than with my usual method	4	Don't know yet
I found the material easy to navigate around	6	Not additional response
I found the technology worked well	7	Not additional response
The technology did not affect my ability to learn	7	Not additional response
The audio content helped my learning	7	Not additional response
The graphic/animation content helped my learning	N/A	N/A Not additional response
Average score	6.2	High degree of satisfaction – only lowered by not knowing whether he would remember the materials more easily

Case Study 7

1. Background Information

Age	16
Sighted?	Not sighted
Level of Study?	3
ICT Skills Level?	Expert
Assistive Technology Skills Level?	Expert
No. of years computer use?	10 years
Preferred method of learning?	I can learn in any way and am a braillist
No. of years internet use?	5 years, daily
Purpose of internet use?	Study, hobbies, music
Email use?	Yes, daily
Chat use?	Can't log on but otherwise would use it daily
Discussion board use?	Not used
VLE use?	Not used
Learning object use?	Yes GCSE revision
MCQ use?	Don't know
Games	Yes mortal combat

2. Number of observations

Activity	**Data**		**Comments**
Accessing	15	7.6%	
Using	55	27.9%	
Doing	127	64.5%	
Total No of observations	197		
Total time taken in learning object	38 mins 20 secs		

3. Perception of Mental Effort

Activity	Data			Comments
	L	U	A	
Introduction	1	1	1	Had problems grasping scale. Generally low PME – rises slightly on MCQs p 6.
Classification	2	3	1	
MCQ	4	3	1	
Muscles, tendons, ligaments	1	1	1	
RICEM	1	1	1	
Health and Safety	1	1	1	
Intro to case study and MCQ	1	1	1	
Rest of MCQs	2	1	1	
Table and summary	1	1	1	
Average	1.6	1.4	1	

4. Observations on each activity

Activity	Data		Comments
Listening	59	30%	The doing is made up of approximately 30 % listening; 19.8% answering; 8.1% checking which is relatively high and 5.6 % reinforcing which is quite low.
Reading	N/A	N/A	
Answering	39	19.8%	
Checking	16	8.1%	
Reinforcing	11	5.6%	
Navigating	55	28%	
JAWs	15	7.6%	
Other	3	1.5%	

5. Observations on each page (summary)	Rose 6, 7, 8, 9, 16 and 23. Re-visited capillary page twice – 8a – had difficulties getting out of it.	
6. MCQs	9/12	2c and 5a incorrect. Did not read table and got Q7 wrong.
7. Performance Test	13/27	3/4 for Either/Or; 0/3 for T/F; 8/11 for short answers; 2/5 for RICEM and 0 on the learning objectives.
8. Time taken	11 minutes	

9. Satisfaction Questionnaire

Question	Score	Learner Comments
I enjoyed using the learning materials	7	Impressed because JAWs did well
I learned more than I would using my usual method	4	I can learn anyway
I preferred using these materials to my normal method	4	I can learn any way
I would use this method of learning again	7	No additional response
I will remember the materials more easily than with my usual method	4	No additional response
I found the material easy to navigate around	7	No additional response
I found the technology worked well	7	No additional response
The technology did not affect my ability to learn	7	No additional response
The audio content helped my learning	7	Not just reading stuff off of the screen – there is something to follow
The graphic/animation content helped my learning	N/A	N/A
Average score	6	

Case Study 8

1. Background Information

Age	21
Sighted?	Not sighted
Level of Study?	3
ICT Skills Level?	Expert
Assistive Technology Skills Level?	Expert
No. of years computer use?	15 years
Preferred method of learning?	Computer
No. of years internet use?	5 years, daily
Purpose of internet use?	Study, hobbies, shopping
Email use?	Yes, daily
Chat use?	Yes, daily
Discussion board use?	Yes, Atomic Kitten message board
VLE use?	Yes, previous study
Learning object use?	Yes, trialled NLN materials
MCQ use?	Yes, previous study
Games	Not used

2. Number of observations

Activity	**Data**		**Comments**
Accessing	14	9.6%	
Using	26	18%	
Doing	106	72.6%	
Total No of observations	146		
Total time spent on learning object	28 mins 50 secs		

3. Perception of Mental Effort

Activity	Data			Comments
	L	U	A	
Introduction	1	5	4	Higher perception of mental effort with using than learning – using JAWs being the lowest. Highest PME with p. 6 MCQs – learning and using and also table and summary pp. 22a and 24.
Classification	2	5	3	
MCQ	7	5	1	
Muscles, tendons, ligaments	1	1	1	
RICEM	1	3	1	
Health and Safety	3	1	1	
Intro to case study and MCQ	1	3	1	
Rest of MCQs	1	3	1	
Table and summary	5	3	1	
Average	2.4	3.2	1.6	

4. Observations on each activity

Activity	Data		Comments
Listening	43	29.5%	Approximately 70% of doing is made up of 29.5% listening 24% answering; 8.9 % checking and 7.5 % reinforcing.
Reading	N/A	N/A	
Answering	35	24%	
Checking	13	8.9%	
Reinforcing	11	7.5%	
Navigating	26	17.9%	
JAWs	14	9.6%	Commenting on accessibility
Other	4	2.7%	

5. Observations on each page (summary)	Fairly consistent apart from p.6	
6. MCQs	11/12	Q2 C incorrect. Did not read table but did get answer correct.
7. Performance Test`	17/27	3/ 4 for either/or; 2/3 for T/F; 9/11 for short answer; 2/5 for RICEM and 1 correct for learning objectives.
8. Time taken	7 minutes	

9. Satisfaction Questionnaire

Question	Score	Learner Comments
I enjoyed using the learning materials	6	Helps you learn – good learning aid at own pace.
I learned more than I would using my usual method	4	Same – I don't really mind how I learn
I preferred using these materials to my normal method	4	Same – I don't really mind how I learn
I would use this method of learning again	6	No response
I will remember the materials more easily than with my usual method	6	Yes as I can learn at my own pace.
I found the material easy to navigate around	5	It was slow refreshing.
I found the technology worked well	4	Could be improved
The technology did not affect my ability to learn	6	No response
The audio content helped my learning	6	You get the text as well.
The graphic/animation content helped my learning	N/A	N/A
Average score	5.2	Generally satisfied – thought the technology could be improved.

Case Study 9

1. Background Information

Age	20
Sighted?	No
Level of Study?	3
ICT Skills Level?	Intermediate
Assistive Technology Skills Level?	Intermediate
No. of years computer use?	10 years
Preferred method of learning?	Computer, braille and tape
No. of years internet use?	6 years, daily
Purpose of internet use?	Music, Information, Radio and research
Email use?	Daily
Chat use?	Yes, daily
Discussion board use?	Not used (difficult with JAWs)
VLE use?	Not used
Learning object use?	Yes – trialled materials for SQA
MCQ use?	Yes – trialled materials for SQA
Games	Not used

2. Number of observations

Activity	**Data**		**Comments**
Accessing	6	4%	
Using	37	24%	
Doing	112	72%	
Total No of observations	155		
Total time spent on learning object	30 minutes		

3. Perception of Mental Effort

Activity	Data			Comments
	L	U	A	
Introduction	1	1	1	Although PME of Using and Accessing was low he did have some difficulties navigating and missed the table and had problems around pp. 3 and 4. Did use JAWs at fast speed – 60%. Low PME of learning except around pp 6 and 7.
Classification	3	1	1	
MCQ	6	1	1	
Muscles, tendons, ligaments	6	1	1	
RICEM	1	1	1	
Health and Safety	1	1	1	
Intro to case study and MCQ	1	1	1	
Rest of MCQs	1	1	1	
Table and summary	1	1	1	
Average	2.3	1	1	

4. Observations on each activity

Activity	Data		Comments
Listening	38	24.5%	The doing is made up of approximately 24.5 % listening; 29.8% answering; 5.8% checking; 8.4% reinforcing.
Reading	N/A	N/A	
Answering	46	29.8%	
Checking	9	5.8%	
Reinforcing	13	8.4%	
Navigating	36	25%	
JAWs	6	4%	
Other	6	4%	Pause – answered the telephone!

5. Observations on each page (summary)	Generally even spread of 2 to 7. Rising slightly on p.3, 5 and 10 and significantly on p.6 where he did the MCQs twice – getting one wrong the first time and two wrong on the second occasion.	
6. MCQs	9/12	Missed table and got Q7 wrong. Q1 B incorrect – went back and got C and D wrong
7. Performance Test	14/27	2/4 on either/or; 2/3 on true/false; 8/11 on short answer; RICEM 4/5 but 0/4 on the learning objectives.
8. Time taken	21 minutes	

9. Satisfaction Questionnaire

Question	Score	Learner Comments
I enjoyed using the learning materials	7	I learned some things I did not know
I learned more than I would using my usual method	6	Usually use Word on PC or the Internet. I enjoyed the audio
I preferred using these materials to my normal method	4	As above
I would use this method of learning again	6	No response
I will remember the materials more easily than with my usual method	3	I am not going to work in a fitness studio
I found the material easy to navigate around	7	No response
I found the technology worked well	7	No response
The technology did not affect my ability to learn	7	No response
The audio content helped my learning	7	It was nice to hear a different voice
The graphic/animation content helped my learning	N/A	N/A
Average score	6	Largely satisfied

Case Study 10

1. Background Information

Age	16
Sighted?	No
Level of Study?	2
ICT Skills Level?	Expert
Assistive Technology Skills Level?	Expert
No. of years computer use?	5
Preferred method of learning?	Braille
No. of years internet use?	4
Purpose of internet use?	Study
Email use?	Daily
Chat use?	Not used
Discussion board use?	Not used
VLE use?	Not used
Learning object use?	Not used
MCQ use?	Not used
Games	Not used

2. Number of observations

Activity	**Data**		**Comments**
Accessing	20	9.9%	
Using	64	31.5%	
Doing	119	58.6%	
Total No of observations	203		
Total time spent on learning object	38 mins 30 secs		

3. Perception of Mental Effort

Activity	Data			Comments
	L	U	A	
Introduction	2	3	3	Generally found JAWs more effort than using or doing. Using less effort than doing. Particular effort around RICEM and H and S and also at the end with the table and summary.
Classification	5	3	2	
MCQ	5	4	5	
Muscles, tendons, ligaments	5	4	5	
RICEM	5	6	7	
Health and Safety	5	6	7	
Intro to case study and MCQ	5	4	6	
Rest of MCQs	5	4	6	
Table and summary	6	5	7	
Average	4.7	4.3	5.3	

4. Observations on each activity

Activity	Data		Comments
Listening	44	21.7%	The doing is made up of approximately 21.7 % listening; 21.7% answering; 5% checking; 7.9 % reinforcing.
Reading	N/A	N/A	
Answering	44	21.7%	
Checking	10	5%	
Reinforcing	16	7.9%	
Navigating	64	32%	
JAWs	20	10%	
Other	3	1.5%	Pause

5. Observations on each page (summary)	Generally a spread of 2 to 8 but rising on pp. 3, 6, 7, 9, 10, 14, 18 and 19	
6. MCQs	8/12	Did not read table and got q 12 wrong. Also Q1 c and D and Q2 C incorrect.
7. Performance Test	14/27	2/4 either/or; 1/3 either or; 6/11short answer; 2/5 out of RICEM correct and 2/4 for learning objectives.
8. Time taken	13 mins	

9. Satisfaction Questionnaire

Question	Score	Learner Comments
I enjoyed using the learning materials	6	I like the computer and JAWs
I learned more than I would using my usual method	6	Yes but not sure why
I preferred using these materials to my normal method	4	Not sure why
I would use this method of learning again	6	No response
I will remember the materials more easily than with my usual method	6	Different
I found the material easy to navigate around	5	No response
I found the technology worked well	5	No response
The technology did not affect my ability to learn	4	No response
The audio content helped my learning	7	Different voice
The graphic/animation content helped my learning	N/A	
Average score	5.4	Generally reasonably satisfied

Case Study 11

1. Background Information

Age	16
Sighted?	Yes
Level of Study?	3
ICT Skills Level?	Intermediate
Assistive Technology Skills Level?	N/A
No. of years computer use?	8 years
Preferred method of learning?	Computer
No. of years internet use?	6 years
Purpose of internet use?	Study, hobbies, shopping and communication
Email use?	Daily
Chat use?	Daily
Discussion board use?	Not used
VLE use?	Not used
Learning object use?	Yes – GCSE revision
MCQ use?	Yes – GCSE revision
Games	Not used

2. Number of observations

Activity	**Data**		**Comments**
Accessing	N/A	N/A	
Using	8	9.6%	
Doing	75	90.4%	
Total No of observations	83		
Total time spent on learning object	15 mins 10 secs		

3. Perception of Mental Effort

Activity	Data			Comments
	L	U	A	
Introduction	1	1	N/A	Increase around pp. 8 to 12 and also 22.
Classification	2	2	N/A	
MCQ	3	2	N/A	
Muscles, tendons, ligaments	4	4	N/A	
RICEM	4	5	N/A	
Health and Safety	4	5	N/A	
Intro to case study and MCQ	3	3	N/A	
Rest of MCQs	5	3	N/A	
Table and summary	3	3	N/A	
Average	3.3	3.1	N/A	

4. Observations on each activity

Activity	Data		Comments
Listening	13	15.7%	No significant observations here. The doing is made up of approximately 15.7 % listening; 33.7% reading; 24.1% answering; 1.2% checking; 15.7 % reinforcing.
Reading	28	33.7%	
Answering	20	24.1%	
Checking	1	1.2%	
Reinforcing	13	15.7%	
Navigating	8	9.6%	
JAWs	0	0%	
Other	0	0%	

5. Observations on each page (summary)	Generally an even spread throughout – slightly raised at 22 due to navigating.	
6. MCQs	12/12	Read table and got Q7 correct
7. Performance Test	21/27	4/4 for either/or; 3/3 true/false; 9/11 for short answers; 3/5 for RICEM; 2 out of 4 for objectives
8. Time taken	7 minutes	

9. Satisfaction Questionnaire

Question	Score	Learner Comments
I enjoyed using the learning materials	6	More interaction – easier than a book
I learned more than I would using my usual method	7	Never did this kind of stuff at school
I preferred using these materials to my normal method	7	As above
I would use this method of learning again	6	No answer
I will remember the materials more easily than with my usual method	7	Interaction
I found the material easy to navigate around	5	No answer
I found the technology worked well	6	No answer
The technology did not affect my ability to learn	6	No answer
The audio content helped my learning	7	It was a new thing – helped concentration
The graphic/animation content helped my learning	7	More interesting than normal
Average score	6.4	

Case Study 12

1. Background Information

Age	16
Sighted?	Yes
Level of Study?	3
ICT Skills Level?	Intermediate
Assistive Technology Skills Level?	N/A
No. of years computer use?	6
Preferred method of learning?	Computer – internet
No. of years internet use?	6 years
Purpose of internet use?	Study, hobbies, shopping
Email use?	Daily
Chat use?	Not used
Discussion board use?	Not used
VLE use?	Not used
Learning object use?	Not used
MCQ use?	Yes – bitesize revision questions
Games	Yes – pool on Yahoo

2. Number of observations

Activity	**Data**		**Comments**
Accessing	N/A	N/A	
Using	6	9.1%	
Doing	60	90.9%	
Total No of observations	66		
Total time spent on learning object	12 mins 30 secs		

3. Perception of Mental Effort

Activity	Data			Comments
	L	U	A	
Introduction	1	1	N/A	Low perception of mental effort in respect of learning – raised slightly around pp. 4 to 12. PME in respect of using raised around H and S – navigating where to go next.
Classification	2	1	N/A	
MCQ	2	1	N/A	
Muscles, tendons, ligaments	2	1	N/A	
RICEM	2	1	N/A	
Health and Safety	2	2	N/A	
Intro to case study and MCQ	1	1	N/A	
Rest of MCQs	1	1	N/A	
Table and summary	1	1	N/A	
Average	1.6	1.2	N/A	

4. Observations on each activity

Activity	Data		Comments
Listening	8	12.7%	The doing is made up of approximately 12.7% listening; 41.3% reading; 15.9% answering; 3.2% checking; 17.5% reinforcing.
Reading	26	41.3%	
Answering	10	15.9%	
Checking	2	3.2%	
Reinforcing	11	17.5%	
Navigating	6	9%	
JAWs	0	0%	
Other	0	0%	

5. Observations on each page (summary)	Generally 2 or 3 obs per page except pp.6, and 9. Also p.22 due to navigating – slightly unsure of where to go next.	
6. MCQs	11/12	1b incorrect
7. Performance Test	21/27	4/4 for either/or; 3/3 for true/false; 8/11 for short answers and he scored 5/5 for RICEM and 1 out of 4 for learning objectives.
8. Time taken	9 minutes	

9. Satisfaction Questionnaire

Question	Score	Learner Comments
I enjoyed using the learning materials	5	Learned – quite a lot – I will remember about RICEM (he did – see Performance Test!)
I learned more than I would using my usual method	7	I normally use a book
I preferred using these materials to my normal method	7	Easier – explained simply
I would use this method of learning again	7	No answer
I will remember the materials more easily than with my usual method	7	As in 1
I found the material easy to navigate around	7	No answer
I found the technology worked well	7	No answer
The technology did not affect my ability to learn	7	No answer
The audio content helped my learning	4	Would have been happy to just read but read and listened.
The graphic/animation content helped my learning	6	How to apply bandages.
Average score	6.4	

Case Study 13

1. Background Information

Age	20
Sighted?	Yes
Level of Study?	3
ICT Skills Level?	Intermediate
Assistive Technology Skills Level?	N/A
No. of years computer use?	15
Preferred method of learning?	Computer
No. of years internet use?	5
Purpose of internet use?	Shopping
Email use?	Daily
Chat use?	Daily
Discussion board use?	Not used
VLE use?	Not used
Learning object use?	Not used
MCQ use?	Not used
Games	Yes – all sorts

2. Number of observations

Activity	**Data**		**Comments**
Accessing	N/A	N/A	
Using	5	8.3%	
Doing	55	91.7%	
Total No of observations	60		
Total time spent on learning object	11 mins 20 secs		

3. Perception of Mental Effort

Activity	Data			Comments
	L	U	A	
Introduction	1	1	N/A	Did not really read the information – thought it was easy.
Classification	1	1	N/A	
MCQ	1	1	N/A	
Muscles, tendons, ligaments	1	1	N/A	
RICEM	1	1	N/A	
Health and Safety	1	1	N/A	
Intro to case study and MCQ	1	1	N/A	
Rest of MCQs	1	1	N/A	
Table and summary	1	1	N/A	
Average	1	1	N/A	

4. Observations on each activity

Activity	Data		Comments
Listening	9	15%	Switched audio off to speed it up – therefore less time spent listening. The doing is made up of approximately 15% listening; 43.3% reading; 16.7% answering; 8% checking; 8 % reinforcing.
Reading	26	43.3%	
Answering	10	16.7%	
Checking	5	8%	
Reinforcing	5	8%	
Navigating	5	8%	
JAWs	0	0%	
Other	0	0%	

5. Observations on each page (summary)	Mainly 1 to 3 obs per page except pp. 5,6 and 7	
6. MCQs	12/12	Missed table at first – went back.
7. Performance Test`	10/27	4/4 for either/or; 2 /3 for true/false; 4/11 for short answer questions. No marks for Qs 19 and 20
8. Time taken	5 minutes	

9. Satisfaction Questionnaire

Question	Score	Learner Comments
I enjoyed using the learning materials	4	Not particularly
I learned more than I would using my usual method	4	I don't really have a method
I preferred using these materials to my normal method	4	No answer
I would use this method of learning again	7	Easy way of learning
I will remember the materials more easily than with my usual method	7	Better than to sit and try and remember from a person
I found the material easy to navigate around	7	No answer
I found the technology worked well	7	No answer
The technology did not affect my ability to learn	7	No answer
The audio content helped my learning	1	Not for me
The graphic/animation content helped my learning	1	Not really – prefer to learn from a person. Found them pointless and a distraction.
Average score	4.9	

Case Study 14

1. Background Information

Age	18
Sighted?	Yes
Level of Study?	3
ICT Skills Level?	Intermediate
Assistive Technology Skills Level?	N/A
No. of years computer use?	8 years
Preferred method of learning?	Computer
No. of years internet use?	8
Purpose of internet use?	Study, shopping
Email use?	Daily
Chat use?	Not used
Discussion board use?	Not used
VLE use?	Not used
Learning object use?	Not used
MCQ use?	Yes – Key Skills
Games	Not used

2. Number of observations

Activity	**Data**		**Comments**
Accessing	N/A	N/A	
Using	7	10.3%	
Doing	61	89.7%	
Total No of observations	68		
Total time spent on learning object	12 mins 20 secs		

3. Perception of Mental Effort

Activity	Data			Comments
	L	U	A	
Introduction	1	1	N/A	Low perception of mental effort with learning rising around pp. 9 and 10 and at the end. Consistently low PME with navigating.
Classification	2	1	N/A	
MCQ	2	1	N/A	
Muscles, tendons, ligaments	3	1	N/A	
RICEM	3	1	N/A	
Health and Safety	1	1	N/A	
Intro to case study and MCQ	2	1	N/A	
Rest of MCQs	3	1	N/A	
Table and summary	3	1	N/A	
Average	2.2	1	N/A	

4. Observations on each activity

Activity	Data		Comments
Listening	10	15%	Nothing untoward highlighted here and in-line with observations per page. The doing is made up of approximately 15% listening; reading 34.3%; 19.4 % answering; 3% checking; 17.9% reinforcing.
Reading	23	34.3%	
Answering	13	19.4%	
Checking	2	3%	
Reinforcing	12	17.9%	
Navigating	7	10%	
JAWs	0	0%	
Other	0	0%	

5. Observations on each page (summary)	Generally consistent 1 to 4 obs per page. Rises pp. 6, 7, 9 and 22.	
6. MCQs	9/12	Q1 a and d incorrect but repeated and got it right. Q5 incorrect. Read table and got answer correct.
7. Performance Test	20/27	4/4 for either/or; 3/3 for true/false; 9/11 for short answers; 3 out of 5 for RICEM and 1 out of 4 for learning objectives.
8. Time taken	10 minutes	

9. Satisfaction Questionnaire

Question	Score	Learner Comments
I enjoyed using the learning materials	5	Learned a bit more about sports injuries
I learned more than I would using my usual method	5	Use a book – more details
I preferred using these materials to my normal method	4	Book – depends on the topic
I would use this method of learning again	5	No answer
I will remember the materials more easily than with my usual method	5	Somebody talking to you helps my understanding
I found the material easy to navigate around	6	No answer
I found the technology worked well	6	No answer
The technology did not affect my ability to learn	6	No answer
The audio content helped my learning	6	Explains – you can read and listen
The graphic/animation content helped my learning	6	Good clear diagrams
Average score	5.4	Generally fairly satisfied. Topic would affect use of this method.

Case Study 15

1. Background Information

Age	8
Sighted?	Yes
Level of Study?	3
ICT Skills Level?	Intermediate
Assistive Technology Skills Level?	N/A
No. of years computer use?	10
Preferred method of learning?	Computer
No. of years internet use?	6 years; weekly
Purpose of internet use?	Shopping, hobbies
Email use?	Monthly
Chat use?	Not used
Discussion board use?	Not used
VLE use?	Not used
Learning object use?	Not used
MCQ use?	Yes – buying things from web sites
Games	Not used

2. Number of observations

Activity	**Data**		**Comments**
Accessing	N/A	N/A	
Using	8	10.7%	
Doing	67	89.3%	
Total No of observations	75		
Total time spent on learning object	14 mins 30 secs		

3. Perception of Mental Effort

Activity	Data			Comments
	L	U	A	
Introduction	4	2	N/A	Consistent fairly high level of PME with learning. Got lost after H and S – hence 4 there – otherwise low level of PME with navigating. Questioned the term ‘navigating’. Questioned whether he was learning when doing MCQ.
Classification	4	2	N/A	
MCQ	6	3	N/A	
Muscles, tendons, ligaments	6	2	N/A	
RICEM	6	2	N/A	
Health and Safety	5	4	N/A	
Intro to case study and MCQ	5	2	N/A	
Rest of MCQs	5	2	N/A	
Table and summary	4	2	N/A	
Average	5	2.3	N/A	

4. Observations on each activity

Activity	Data		Comments
Listening	8	10.9%	Nothing out of the ordinary and in line with obs per sheet. The doing is made up of approximately 10.9% listening; reading 35%; 21.6% answering; 8.1% checking; 13.5 % reinforcing.
Reading	26	35%	
Answering	16	21.6%	
Checking	6	8.1%	
Reinforcing	10	13.5%	
Navigating	8	10%	
JAWs	0	0%	
Other	0	0%	

5. Observations on each page (summary)	Even spread – slightly higher around 6, 7, and 9, 12 and 13 (as above)	
6. MCQs	9/12	Missed table and got Q7 wrong. Q1 c and d incorrect.
7. Performance Test	11/27	2/4 for either/or; 2/3 for true/false; 4/11 for the short answers; 2/5 RICEM and 2/4 for the learning objectives.
8. Time taken for performance test	10 mins	

9. Satisfaction Questionnaire

Question	Score	Learner Comments
I enjoyed using the learning materials	4	No answer
I learned more than I would using my usual method	4	Learns by doing – practical
I preferred using these materials to my normal method	2	Boring compared to using a PC
I would use this method of learning again	3	No answer
I will remember the materials more easily than with my usual method	3	No answer
I found the material easy to navigate around	6	No answer
I found the technology worked well	6	No answer
The technology did not affect my ability to learn	6	No answer
The audio content helped my learning	5	It is easier to take in with audio
The graphic/animation content helped my learning	5	Makes it slightly more interesting
Average score	4.4	Did appear to like some aspects of it – may have been that the content did not interest him.

Case Study 16

1. Background Information

Age	19
Sighted?	Yes
Level of Study?	3
ICT Skills Level?	Intermediate
Assistive Technology Skills Level?	N/A
No. of years computer use?	12
Preferred method of learning?	Audio
No. of years internet use?	5
Purpose of internet use?	Study, shopping, hobbies
Email use?	Less than once a month
Chat use?	Monthly
Discussion board use?	Not used
VLE use?	Not used
Learning object use?	Not used
MCQ use?	Yes
Games	Yes – RPG and chess

2. Number of observations

Activity	**Data**		**Comments**
Accessing	N/A	N/A	
Using	15	15%	
Doing	85	85%	
Total No of observations	100		
Total time spent on learning object	19 mins 20 secs		

3. Perception of Mental Effort

Activity	Data			Comments
	L	U	A	
Introduction	1	1	N/A	Consistent low perception with navigating. Varied with learning – highest on pp. 4, 5, 6 and7. Consistent with obs per page – except spent a long time on p.9.
Classification	6	1	N/A	
MCQ	5	1	N/A	
Muscles, tendons, ligaments	4	1	N/A	
RICEM	1	1	N/A	
Health and Safety	1	1	N/A	
Intro to case study and MCQ	2	1	N/A	
Rest of MCQs	2	1	N/A	
Table and summary	2	1	N/A	
Average	2.7	1	N/A	

4. Observations on each activity

Activity	Data		Comments
Listening	7	7 %	Nothing out of the ordinary observed. The doing is made up of approximately 7 % listening; reading 39%; 18% answering; 5 % checking; 16 % reinforcing.
Reading	39	39%	
Answering	18	18%	
Checking	5	5%	
Reinforcing	16	14.9%	
Navigating	15	14%	
JAWs	0	0%	
Other	0	0%	

5. Observations on each page (summary)	1 to 4 obs per page except pp. 5, 6, 7, 10	
6. MCQs	11/12`	1b incorrect. Read table and answered Q7 correctly.
7. Performance Test`	17/27	4/4 for either/or; 3/3 for true/false; 8/11 for the short answers. He scored 1/5 for RICEM and 1 /4 for the learning objectives. Scored 1 mark each on 19 and 20 – the open questions.
8. Time taken	9 minutes	

9. Satisfaction Questionnaire

Question	Score	Learner Comments
I enjoyed using the learning materials	4	No answer
I learned more than I would using my usual method	6	Prefers books. Liked narration – I forget if I read it
I preferred using these materials to my normal method	5	As above
I would use this method of learning again	6	No answer
I will remember the materials more easily than with my usual method	4	Don't know we will see.
I found the material easy to navigate around	7	No answer
I found the technology worked well	6	Except for the links that went backwards
The technology did not affect my ability to learn	7	No answer
The audio content helped my learning	7	No answer
The graphic/animation content helped my learning	5	Not as much as the audio
Average score	5.7	Generally a high score

Case Study 17

1. Background Information

Age	27
Sighted?	Yes
Level of Study?	3
ICT Skills Level?	Intermediate
Assistive Technology Skills Level?	N/A
No. of years computer use?	2
Preferred method of learning?	Computer and audiotape
No. of years internet use?	2
Purpose of internet use?	Study and general reference
Email use?	Twice a week
Chat use?	Not used
Discussion board use?	Not used
VLE use?	Not used
Learning object use?	Webwise – word processing
MCQ use?	Webwise
Games	Not used

2. Number of observations

Activity	**Data**		**Comments**
Accessing	N/A	N/A	
Using	5	4.5%	
Doing	107	95.5%	
Total No of observations	112		
Total time spent on learning object	40 mins but on task 19 mins		21 mins deducted due to loading problems

3. Perception of Mental Effort

Activity	Data			Comments
	L	U	A	
Introduction	1	1	N/A	Generally medium perception of effort on learning and very low perception of effort on navigating.
Classification	4	3	N/A	
MCQ	4	1	N/A	
Muscles, tendons, ligaments	4	1	N/A	
RICEM	4	1	N/A	
Health and Safety	4	3	N/A	
Intro to case study and MCQ	2	1	N/A	
Rest of MCQs	3	1	N/A	
Table and summary	3	1	N/A	
Average	3	1.4	N/A	

4. Observations on each activity

Activity	Data		Comments
Listening	7	6%	There was a problem with loading and these observations have been extracted. Most of the time was spent on doing. The doing is made up of approximately 6% listening; reading 52.7%; 19.6% answering; 7.1% checking; 9.8% reinforcing.
Reading	59	52.7%	
Answering	22	19.6%	
Checking	8	7.1%	
Reinforcing	11	9.8%	
Navigating	5	4.5%	
JAWs	N/A	N/A	
Other	127	Not counted	

5. Observations on each page (summary)	Generally 2 to 5 observations per page except pp.5, 6, 7 and 9.	
6. MCQs	10/12	1b and 2d incorrect. Read table and answered correctly.
7. Performance Test`	21/27	4/4 for either/or; 3/3 for true/false; 7/11 for short answers with 5/5 for RICEM and 2/4 for the learning objectives.5/5 for RICEM and 2/4 for learning points
8. Time taken	19 minutes	

9. Satisfaction Questionnaire

Question	Score	Learner Comments
I enjoyed using the learning materials	7	Very visible; clear and concise. Audio good
I learned more than I would using my usual method	7	Usually books – this is good as it sieves out info I don't need
I preferred using these materials to my normal method	7	As above - not having to wade through information
I would use this method of learning again	7	No answer
I will remember the materials more easily than with my usual method	7	Because of the pictures it is doing half of the work for you. You are focusing on what you need
I found the material easy to navigate around	7	No answer
I found the technology worked well	7	No answer
The technology did not affect my ability to learn	7	
The audio content helped my learning	7	Reasons as above – helps a lot. You shut your eyes and listen rather than look
The graphic/animation content helped my learning	7	Makes it very clear
Average score	7	Note that for part of the time he had to use online version which was very slow. He was asked to discount this section for the satisfaction survey

Case Study 18

1. Background Information

Age	20
Sighted?	Yes
Level of Study?	3
ICT Skills Level?	Intermediate
Assistive Technology Skills Level?	N/A
No. of years computer use?	8
Preferred method of learning?	Computer
No. of years internet use?	8
Purpose of internet use?	Work/hobbies/shopping
Email use?	Daily
Chat use?	Daily
Discussion board use?	Yes – the lock-up; dogsonacid
VLE use?	No
Learning object use?	No
MCQ use?	Yes – BBC; Bitesize; GCSE
Games	No

2. Number of observations

Activity	**Data**		**Comments**
Accessing	N/A	N/A	
Using	14	13%	
Doing	94	87%	
Total No of observations	108		
Total time spent on learning object	20 minutes		

3. Perception of Mental Effort

Activity	Data			Comments
	L	U	A	
Introduction	3	2	N/A	Perception of mental effort about half way along the scale – so medium difficulty perceived.
Classification	5	3	N/A	
MCQ	5	4	N/A	
Muscles, tendons, ligaments	5	4	N/A	
RICEM	5	4	N/A	
Health and Safety	4	3	N/A	
Intro to case study and MCQ	4	4	N/A	
Rest of MCQs	4	3	N/A	
Table and summary	4	3	N/A	
Average	4.3	3.3	N/A	

4. Observations on each activity

Activity	Data		Comments
Listening	8	7.5%	Read each page quite thoroughly. The doing is made up of approximately 7.5% listening; reading 50%; 17.8 % answering; 1.9 % checking; 10.3 % reinforcing.
Reading	54	50%	
Answering	19	17.8%	
Checking	2	1.9%	
Reinforcing	11	10.3%	
Navigating	14	13 %	
JAWs	0	0%	
Other	0	0%	

5. Observations on each page (summary)	Generally evenly spread out – pp. 5, 6 and 7 slightly higher – 7 and 8 observations per page. P.9 had 20 observations – spent a long time reading RICEM and navigating between them – was stuck after mobility and had to be prompted.	
6. MCQs	11/12	Q1B incorrect. Read table and answered correctly.
7. Performance Test	18/27	4/4 for either/or; 3/3 for true/false; 8/11 for short answers; 2/5 for RICEM and 1 /4 for learning objectives. Only 1 point as to learning objectives. 2 points out of RICEM.
8. Time taken	10 mins	

9. Satisfaction Questionnaire

Question	Score	Learner Comments
I enjoyed using the learning materials	5	It was the layout, it was not boring. Use of colour, relevant to everyday life (contextualised).
I learned more than I would using my usual method	5	I would normally use a book.
I preferred using these materials to my normal method	6	More interesting (than a book)
I would use this method of learning again	6	As above
I will remember the materials more easily than with my usual method	5	As above. Text can slip in one ear and out the other.
I found the material easy to navigate around	6	
I found the technology worked well	5	
The technology did not affect my ability to learn	6	
The audio content helped my learning	3	Could just as easily read it.
The graphic/animation content helped my learning	5	Demonstration – layout and colour
Average score	5.2	

Case Study 19

1. Background Information

Age	25
Sighted?	Yes
Level of Study?	3
ICT Skills Level?	Intermediate
Assistive Technology Skills Level?	No
No. of years computer use?	5
Preferred method of learning?	Computer
No. of years internet use?	5
Purpose of internet use?	Study, hobbies
Email use?	Yes, daily
Chat use?	Yes, weekly
Discussion board use?	Yes, lock-up forum
VLE use?	No
Learning object use?	No
MCQ use?	No
Games	Poker, card games, online betting

2. Number of observations

Activity	**Data**		**Comments**
Accessing	N/A	N/A	
Using	6	9.4%	
Doing	58	90.6%	
Total No of observations	64		
Total time spent on learning object	11 mins 50 secs		

3. Perception of Mental Effort

Activity	Data			Comments
	L	U	A	
Introduction	1	1	0	PME was low and evenly spread – the highest being on muscles, tendons and ligaments.
Classification	1	1	0	
MCQ	2	2	0	
Muscles, tendons, ligaments	4	3	0	
RICEM	2	2	0	
Health and Safety	1	1	0	
Intro to case study and MCQ	1	1	0	
Rest of MCQs	2	1	0	
Table and summary	1	1	0	
Average	1.7	1.6	N/A	

4. Observations on each activity

Activity	Data		Comments
Listening	6	9%	The doing is made up of approximately 9 % listening; reading 34.4%; 23.4 % answering; 0% checking; 23.4 % reinforcing.
Reading	22	34.4%	
Answering	15	23.4%	
Checking	0	0	
Reinforcing	15	23.4%	
Navigating	6	9.3%	
JAWs	0	0%	
Other	0	0%	

5. Observations on each page (summary)	This was very evenly spread with the highest being 5 on p.9 and 4 on p.6, 13 and 22.	
6. MCQs	11/12	Q2 D was incorrect. Seemed keen to get the answers right.
7. Performance Test	17/27	Used RICE acronym 2/4 for either/or; 2/3 for true/false; 7/11 for short answers; 4/5 for RICEM and 2/4 for learning objectives. He was the only learner to use the RICEM acronym.
8. Time taken	10 minutes	

9. Satisfaction Questionnaire

Question	Score	Learner Comments
I enjoyed using the learning materials	4	Indifferent
I learned more than I would using my usual method	5	Book – or by asking – easer if shown
I preferred using these materials to my normal method	3	
I would use this method of learning again	5	
I will remember the materials more easily than with my usual method	4	No sure at this stage
I found the material easy to navigate around	6	
I found the technology worked well	5	
The technology did not affect my ability to learn	6	
The audio content helped my learning	7	Because I did not have to read it.
The graphic/animation content helped my learning	5	Because someone was showing me
Average score	5	

Case Study 20

Background Information

Age	25
Sighted?	Yes
Level of Study?	3
ICT Skills Level?	2
Assistive Technology Skills Level?	N/A
No. of years computer use?	10
Preferred method of learning?	Computer, books and lectures
No. of years internet use?	9
Purpose of internet use?	Study, hobbies, shopping
Email use?	Once a week
Chat use?	Not used
Discussion board use?	Not used
VLE use?	Not used
Learning object use?	Not used
MCQ use?	Not used
Games	Not used

2. Number of observations

Activity	**Data**		**Comments**
Accessing	0	0%	
Using	14	13.1%	
Doing	93	86.9%	
Total No of observations	107		
Total time spent on learning object	21 mins 10 secs		

3. Perception of Mental Effort

Activity	Data			Comments
	L	U	A	
Introduction	1	1	0	Highest around p.6 MCQ and the muscles, tendons and ligaments – where he visibly put in a lot of effort. The only participant to flick back and forth between the pages here.
Classification	2	1	0	
MCQ	5	1	0	
Muscles, tendons, ligaments	5	1	0	
RICEM	3	1	0	
Health and Safety	1	1	0	
Intro to case study and MCQ	2	1	0	
Rest of MCQs	2	1	0	
Table and summary	1	1	0	
Average	2.5	1	0	

4. Observations on each activity

Activity	Data		Comments
Listening	8	7.5%	Other – related to asking the meaning of force. The doing is made up of approximately 7.5% listening; reading 41%; 18.7% answering; 4 % checking; 10.3% reinforcing.
Reading	44	41%	
Answering	20	18.7%	
Checking	4	4 %	
Reinforcing	11	10.3%	
Navigating	14	15.9%	
JAWs	0	0%	
Other	6	5.6%	

5. Observations on each page (summary)	Generally no issues except around pp. 5,6,7,9 and 22. This was answering the MCQ, flicking between muscles, tendons and ligaments and navigating at the end.	
6. MCQs	12/12	Missed table and was prompted to go and read it.
7. Performance Test	19/27	Did not name any of the main learning points
8. Time taken	9 minutes	

9. Satisfaction Questionnaire

Question	Score	Learner Comments
I enjoyed using the learning materials	5	Easy – not too technical. Easy to get into head.
I learned more than I would using my usual method	3	You can't ask questions
I preferred using these materials to my normal method	2	As above
I would use this method of learning again	5	Nothing to lose
I will remember the materials more easily than with my usual method	4	There was not that much detail – I can't apply it.
I found the material easy to navigate around	7	
I found the technology worked well	7	
The technology did not affect my ability to learn	7	
The audio content helped my learning	6	Because you can read and hear it at the same time
The graphic/animation content helped my learning	4	Not really any animation there
Average score	5	Generally agreed but preferred books and lectures

APPENDIX 13 Average Number of Observations per Page

Page Number	Type of Content	Average No. of Observations – Blind Learners	Average No. of Observations – Sighted Learners
1	First time user page	0.1	0
2	Objectives	5.4	0.9
3	Intro with learning objectives	9.3	3.4
4	Menu – 3 visits	9.4	2.6
5	Classification of injuries	7	6.2
6	MCQ	23.5	7.5
7	Links to further information on muscles, ligaments and tendons	10.7	7
8	Signs and symptoms of injuries	6.2	2.4
8a	Capillaries	3.1	1.9
9	RICEM	12.7	8.5
10	MCQ – 3 correct answers from 5	16.7	3.6
11	When not to treat	4.1	2.5
12	Health and safety	4.2	2.4
13	Intro to case study	6.2	3.7
14	MCQ	7.4	2.2
15	Reinforcing rest	4.8	2.3
16	MCQ	5.7	1.8
17	Reinforcing ice	5.7	3.1
18	MCQ	7.8	2.5
19	Reinforcing compression	4.4	3
20	MCQ	7.3	1.7
21	Reinforcing elevation	4.3	2.2
22	Introducing mobility	4.5	4.4
22a	Decision tree	2.6	2.2
23	MCQ	7.7	1.9
24	Summary – what has been learned?	5.3	3.8