Network of ICT supported Learning for Disabled People

Enable Network of ICT Supported Learning for Disabled People

Deliverable 3.4

ICT to Support Learning by Disabled Adults: Fundamental Principles of Good Practice, End-User Requirements, Methodological and Pedagogical Issues

Workpackage 3: Data Analysis and Evaluation: Principles for the Use of ICT to Support Lifelong Learning by Disabled People and the Future Research Agenda

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ICT to Support Learning by Disabled Adults: Fundamental Principles of Good Practice, End-User Requirements, Methodological and Pedagogical Issues

1. Introduction and Methodology

The use of ICT in education is becoming increasingly important. This has significant potential advantages for disabled learners in terms of increasing the accessibility of learning materials to them and making available new ways of studying. However, there are also issues of the accessibility and usability of these technologies (Hersh and Leporini, 2012) and their match to the particular needs and learning approaches of specific groups of disabled people. In addition, it is important that ICT is used to support making all types of learning accessible to disabled people rather than as an excuse not to make face to face learning accessible.

A small number of methodologies have been developed for matching assistive technology to the users, of which one of the best known is MPT (Scherer and Craddock, 2002). It is based on the Matching Person and Technology Model (Scherer, 2000; Scherer and Cushman, 2000), which is divided into the three main components of the person using the technology, the technology and the milieu or environment. Other approaches include the Assistive Technology Device Predisposition Assessment. Although this has been applied to matching students to assistive devices (Scherer and McGee, 1992) it is not designed specifically for learning technologies.

There are both a number of case studies of ICT learning technologies being used very effectively with disabled learners, some of which have been reported in deliverable 2.3 (Bothe, 2013) as well as numerous examples of inaccessible technologies, inappropriate use and other problems. This gives rise to a need for principles of good practice for developing, choosing and applying ICT learning technologies. These principles are presented in section 2.

The Effective Practice project specifications of the National Institute of Adult Continuing Education (NIACE) consider that education and training should ‘improve life chances, increase independence, reduce reliance on carers and other services, and increase the employability of learners" (NIACE, undated p.3). While practical outcomes of this type are valuable, it is equally important not to forget the value of education in itself in, for instance with regards to personal development and increasing knowledge and skills. JISC TechDis, the education advisory service for accessibility and inclusion considers that effective ICT should (i) try innovative new approaches which can lead to new opportunities even if they do not always work at first, (ii) make creative use of existing resources such as Word and PowerPoint in order to increase engagement and provide more inclusive learning experiences and (iii) enable learners to be active co-contributors to the learners process (NIACE, undated p.4).

1.1 Designing New Learning Technologies

Many otherwise good ICT learning tools have been developed without consideration of the needs of disabled learners and therefore may require possibly significant modifications to be used by them. Consideration of the needs of disabled and other minority group learners should be part of standard good practice rather than an add-on. In addition, modification of existing tools is generally less effective and/or more expensive than designing them to meet the needs to disabled users from the start (Hersh, 2010).

In designing learning technologies which can be used by disabled people a number of design choices will be required, some of which are the subject of these guidelines. In particular, a decision will be required as to whether to use design for all principles, design for a specific group of learners or modifications of existing technologies. Unfortunately, many design, IT and related courses have limited if any material on good practice with regards to design for all.

A design for all approach has a number of advantages. In particular, it enables all students to use the same learning technologies, avoiding stigmatisation and minimising difference between the experiences of different students. In addition, it increases the likelihood of all students having an equivalent learning experience and may reduce complexity in the classroom, as all students are using the same tools. However, in some cases there may be tradeoffs between tool complexity and the range of users. Design for specific groups can potentially ensure that a technology is well matched to the needs of disabled people with particular impairments. However, it may lead to students using this technology being less well integrated and/or stigmatised. Modification of existing learning technologies may be appropriate when the existing technologies used by an institution (or in general) are not fully accessible to all groups of disabled learners. However, the addition of additional features e.g. accessibility to some or all groups of disabled learners to an existing technology is not always successful.

1.2 Web Content Accessibility Guidelines

1.2.1. Accessibility guidelines

A number of different accessibility guidelines have been developed. The best known and most authoritative are those developed by the Worldwide Web Consortium (W3C), in particular the W3C Web Content Accessibility Guidelines (WCAG 2) (http://www.w3.org/TR/WCAG20/), (Seale, 2014). They have also been published as the international standard ISO/IEC 40500:2012.

Other W3C accessibility guidelines includes the Authoring Tool Accessibility Guidelines (ATAG2) (http://www.w3.org/WAI/intro/atag.php) which cover the accessibility of the software and services that web developers, designers, writers and others use to produce web content, including learning management systems and web pages for particular courses. W3C is also in the process of revising the User Agent Accessibility Guidelines (UUAG 1.0) (http://www.w3.org/TR/2002/REC-UAAG10-20021217/) for browsers, media players and other user agents.

The IMS Guidelines for Developing Accessible Learning Applications (IMS DALA) (http://www.imsglobal.org/accessibility/accessiblevers/) are specifically for educational technologies, referred to as applications. They are based on six principles which are mainly intended to address the needs of people with mobility or sensory impairments and may be less suitable for other groups of disabled people.

These guidelines provide useful checklists of issues to be taken account of. However, they are not able to cover all the issues that may affect disabled people and the issues covered may affect different groups of disabled people in different ways. In addition, most of the existing guidelines are for web-based technologies and not all learning technologies are web-based. However, the evaluation guidelines recently developed by the project (Hersh, 2014) include accessibility issues and are not restricted to web based learning technologies. For all these reasons and in accordance with good practice, it is important to involve

disabled end-users throughout the process of designing, developing and testing learning (and other) technologies.

1.2.2 Brief Overview of WCAG 2.0 and EN 301 549

The main accessibility guidelines of WCAG 2.0 are stated in 12 guidelines organised into four principles.

Principle 1: Perceivable Information and user interface components must be presentable to users in ways they can perceive.

1 Guideline 1.1 Text Alternatives: Provide text alternatives for any non-text content so that it can be changed into other forms people need, such as large print, braille, speech, symbols or simpler language.
2 Guideline 1.2 Time-based Media: Provide alternatives for time-based media.
3 Guideline 1.3 Adaptable: Create content that can be presented in different ways (for example simpler layout) without losing information or structure.
4 Guideline 1.4 Distinguishable: Make it easier for users to see and hear content including separating foreground from background.

Principle 2: Operable User interface components and navigation must be operable.

1 Guideline 2.1 Keyboard Accessible: Make all functionality available from a keyboard.
2 Guideline 2.2 Enough Time: Provide users enough time to read and use content.
3 Guideline 2.3 Seizures: Do not design content in a way that is known to cause seizures.
4 Guideline 2.4 Navigable: Provide ways to help users navigate, find content, and determine where they are.

Principle 3: Understandable Information and the operation of user interface must be understandable.

1 Guideline 3.1 Readable: Make text content readable and understandable.
2 Guideline 3.2 Predictable: Make Web pages appear and operate in predictable ways.
3 Guideline 3.3 Input Assistance: Help users avoid and correct mistakes.

Principle 4: Robust Content must be robust enough that it can be interpreted reliably by a wide variety of user agents, including assistive technologies.

1 Guideline 4.1 Compatible: Maximize compatibility with current and future user agents, including assistive technologies.

In addition hardware, web and non-web based software, documents and services should conform to the following eleven points of the European standard “EN 301 549: Chapter 4.2 Functional performance statements”:

1. Usage without vision: Some users need ICT to provide at least one mode of operation that does not require vision.
2. Usage with limited vision: Where ICT provides visual modes of operation, some users will need the ICT to provide features that enable users to make better use of their limited vision.
3. Usage without perception of colour: Where ICT provides visual modes of operation, some users will need the ICT to provide a visual mode of operation that does not require user perception of colour.
4. Usage without hearing: Some users need ICT to provide at least one mode of operation that does not require hearing.

5. Usage with limited hearing: Where ICT provides auditory modes of operation, some users will need the ICT to provide features that enable users to make better use of their limited hearing.
6. Usage without vocal capability: Where ICT requires vocal input from users, some users will need the ICT to provide at least one mode of operation that does not require them to generate vocal output.
7. Usage with limited manipulation or strength: Where ICT requires manual actions, some users will need the ICT to provide features that enable users to make use of the ICT with their limited manipulation abilities or hand strength.
8. Usage with limited reach: Where ICT products are free-standing or installed, some users will need the ICT to be operable with limited user reach.
9. Minimize photosensitive seizure triggers: Some users need ICT to provide at least one mode of operation that minimizes the potential for triggering photosensitive seizures.
10. Usage with limited cognition: Some users will need the ICT to provide features that enable them to make better use of their limited cognitive capabilities.
11. Privacy: Some users will need their privacy to be maintained when using those ICT features that are provided for accessibility.

It should be noted that the language in this standard is based on the medical rather than social model of disability. It does not cover users who require minimisation of sensory stimuli. In addition, it would have been advantageous to have presented this standard in terms of a design for all approach of making all technology accessible to as wide a range of people as possible.

1.2.3 Brief Overview of section 508

Section 508 is one of the two sections of the Rehabilitation Act of 1973 of US that affect accessible web design. This section discourages the Federal government from procuring electronic and information technology (E&IT) goods and services that are not fully accessible to disabled people (WebAIM, 2013). Paragraph 1194.1 of the Section requires Federal Agencies to develop, procure, maintain and use electronic and information technology which give disabled Federal employees the same access to and use of information and data and non-disabled employees, unlees this would put ‘an undue burden’ on the agency. It also requires disabled members of the public to have the same access to and use of information and data when looking for information or services as non-disabled people unless there would be ‘an undue burden’ on the agency (United States Access Board, undated).

It is considered to be an extremely influential piece of legislation as it provided the first US federal accessibility standard for the Internet (WebAIM, 2013). The first part of the Section 508 explains who needs to comply with this section and offers information about the circumstances that the compliance can be waived (WebAIM, 2013). The second part contains technical criteria and performance-based requirements which focus on functional capabilities of covered products (WebAIM , 2013). The Subpart C contains functional performance criteria and the subpart D contains information, Documentation, and Support (Section508.gov, undated).

The resources of the Section can be used by federal employees and the public in order to understand and implement the requirements as they apply to the development, maintenance, procurement, or use of information technology products and services, including operating systems and software applications, web-based internet and intranet information systems, video and multimedia products, telecommunications products, self-contained closed products and desktop and portable computers (Section508.gov, undated).

1.2.4. Accessibility Tools

There are a number of different web sites for checking compliance based on these guidelines. The WAVE Accessibility Tool (http://wave.webaim.org/) evaluates web pages through various tests, including any for compliance issues with the US Section 508 and the WCAG 2.0 guidelines (WAVE, undated). The Accessibility Valet Demonstrator (http://valet.webthing.com/access/url.html)) checks documents by URL for compliance with both Section 508 and WCAG 2.0.

Other tools check compliance for documents in particular formats. For instance, the PDF-Accessibility-Checker (PAC 2) (http://www.access-for-all.ch/en/pdf-lab/pdf-accessibility-checker-pac.html) tests the accessibility of PDF documents. The Accessibility Checker in Word Excel, and PowerPoint (http://office.microsoft.com/en-gb/word-help/check-for-accessibility-issues-HA010369192.aspx) checks the accessibility of Office files. The AccessODF (http://sourceforge.net/projects/accessodf/) supports the creation of word processing documents which are more accessible for disabled people and checks for compliance issues for conversion of files to DAISY format and Braille.

The Tingtun Accessibility Checker (http://accessibility.egovmon.no/en/pagecheck2.0/) which was developed as a part of the eGovMon project (eGovMon - eGovernment Monitor) checks the Accessibility of a web site (Site Checker), of a web page (Page Checker) and of PDF documents (PDF Checker).The Site checker checks a representative sample of a site's web pages and computes a score. The Page Checker checks a single web page based on the WCAG 2.0 and the results are: pass, fail, or to be verified. The PDF Checker is based on the WCAG 2.0 PDF Techniques (eGovMon - eGovernment Monitor). There are also tools available for checking components of the guidelines for ICT in general. These include the Contrast Analyser (http://www.paciellogroup.com/resources/contrastAnalyser) which is available for both Windows and Mac and evaluates the colour visibility and contrast of foreground/background colour combinations based on WCAG 2.0 colour contrast success criteria.

One of the earliest web sites for checking compliance is Bobby, which was established by the Center for Applied Special Technology (CAST) in 1995 and was originally available free of charge. It is still available but unfortunately no longer free of charge (CAST (1999-2013). Another commercialised website is the LIFT Machine (http://www.qbssoftware.com/products/Lift_Machine/overview/_prodliftmach) which centralises accessibility and usability management testing and monitoring for compliance with W3C and U.S. Section 508 accessibility guidelines and other usability guidelines. It is a server-based application which scans internal and external websites automatically for over 100 quality, usability and accessibility issues and then generates web-based reports for executives and individual content creators (qbs Software, 1987-2014).

A-Prompt (Accessibility Prompt) is another software tool which examines Web pages for barriers to accessibility. Apart from evaluating web documents it also repairs problems through a series of dialog boxes and some of its versions can be downloaded free of charge (Softpedia, 2001-2014) (http://www.softpedia.com/get/Internet/Other-Internet-Related/A-Prompt.shtml). The tools which are available free of charge include the Acc - an Accessibility Evaluator(http://appro.mit.jyu.fi/tools/acc/) which is designed to evaluate and report on compliance with some accessibility criteria; the Functional Accessibility Evaluator (http://fae.cita.uiuc.edu/) which analyses web pages for markup, consistent with the use of DRES/CITES HTML that translates the requirements of Section 508 and W3C into markup requirements for implementing web page features (iCITA, 2008); and the EvalAccess 2.0 (http://sipt07.si.ehu.es/evalaccess2/index.html) which is an on-line web accessibility

evaluation tool that is able to evaluate a web site, a single web page, and the HTML mark-up and provide a report consisting of a complete list of errors.

1.2.5 Accessibility requirements in Europe

In 2000 the eEurope Action Plan 2002 recommended that all member states should adopt the WCAG Guidelines for their public websites by the end of 2001. In September 2001, the European Commission formally issued Communication eEurope 2002: Accessibility of Public Web Sites and their Content and subsequently the Council Resolution of 25th March 2002 on the 'eEurope Action Plan 2002: accessibility of public websites and their content' was passed. It stressed the need for Web Accessibility in European Institutions. However, this fact seems to be a little known or much ignored.

In 2007 a study "Measuring progress of eAccessibility in Europe" was commissioned as a follow-up to the European Commission's Communication on eAccessibility of 2005 and it assessed the status of the eAccessibility situation in the member states (MeAC, undated). The study report stated that only a small proportion of EU wide public websites conform to WCAG 1.0. According to a joint publication of G3ict, the Centre for Internet and the Society and the Hans Foundation (2012) few countries have legislation policies and standards for implementing WCAG 1.0 (or 2.0). It should also be noted that compliance with guidelines should be seen as a first, though very important step. In addition, there is a need for accessibility checks by disabled people with a range of different accessibility requirements .

Indeed, in practice as shown by a number of research studies (Morten Goodwin Olsen, 2008; Kevin Cullen et al, 2009; Technosite, NOVA, CNIPA, 2011) few web sites fully meet these guidelines and serious accessibility problems are common. Typical examples include graphical links without text descriptions, which make sites totally or partially inaccessible to screen reader users and disabled people who access the internet with the graphics turned off.

To avoid further fragmentation of legislation and to cover a wider range of technologies and content than web content, the European Commission mandated the standards organisations European Committee for Standardisation (CEN), European Committee for Electrotechnical Standardisation (CENELEC) and European Telecommunications Standards Institute (ETSI) to "harmonise and facilitate the public procurement of accessible information and communication technologies (ICT) products and services" within Europe (Mandate 376 p.2, 2005). One outcome of this mandate was the standard EN 301 549 "Accessibility requirements suitable for public procurement of ICT products and services in Europe" (ETSI, CEN, CENELEC, 2014). This standard includes the WCAG 2.0 as well as parts of guidelines from the International Standards Organization (ISO) and ETSI standards related to accessibility and usability. It is intended to be used for conformity assessment of hardware, web-software, non-web-software, documents and service and new ICT should be developed in conformity with it.

1.2.6 Universal Design for Learning Principles and Guidelines

In addition to these more technical guidelines, the Center for Applied Special Technology (CAST) published the "Universal Design for Learning (UDL)" in the 90s. UDL is an educational framework aimed at providing support for teachers and others to help them develop curricula and plan individual lessons which reduce barriers and provide appropriate levels of support and challenge for all learners. (CAST 2011, Hall et a. 2012). There is considerable overlap between the UDL principles, guidelines and checkpoints and those of

WCAG 2.0 and EN 301 549. However, UDL also considers pedagogical issues, which are missing from WCAG 2.0 and EN 301 549, as they cover accessibility in general, rather than aimed specifically accessibility in the context of learning.

UDL consists of nine principles organised into three guidelines.

Principle I. Provide Multiple Means of Representation
1 Guideline 1: Provide options for perception
2 Guideline 2: Provide options for language, mathematical expressions, and symbols
3 Guideline 3: Provide options for comprehension

Principle II. Provide Multiple Means of Action and Expression
1 Guideline 4: Provide options for physical action
2 Guideline 5: Provide options for expression and communication
3 Guideline 6: Provide options for executive functions

III. Provide Multiple Means of Engagement
1 Guideline 7: Provide options for recruiting interest
2 Guideline 8: Provide options for sustaining effort and persistence
3 Guideline 9: Provide options for self-regulation

1.3 Methodology

The principles stated in section 2 have been obtained from two main sources. The first is a questionnaire circulated to the partners in the Enable Project. The most relevant questions are provided in the appendix. The partners used their experiences of working with ICT learning technologies and obtaining information about different technologies, as well as knowledge of the situation in their countries to make suggestions for 'good' and 'bad' practice and recommendations to be followed. The second was the results of a survey of accessibility and usability of ICT educational games carried out by the workpackage leader and partner P12 (Consiglio Nazionale delle Ricerche, Istituto di Scienza e Tecnologie dell' Informazione, CNR-ISTI). This lead to a number of recommendations (Hersh and Leporini, 2012) to be followed in designing ICT educational games for disabled learners. Some of these recommendations relate specifically to educational games, but many of them are relevant, possibly with slight modifications to all ICT learning technologies.

2. Principles of Good Practice

In this section a number of principles of good practice are presented. They are organised into the following sections.

2.1 Designing, Developing and Modifying ICT Learning Technologies
2.2 Accessibility and Usability
2.3 Pedagogical issues
2.4 Contexts which Support Learning
2.5 User Issues and Requirements
2.6 Evaluation of Learning Technologies

2.1 Designing, Developing and Modifying ICT Learning Technologies

2.1.1 General Design and Quality Issues

1. Clarity of aims i.e. what the learning technology is intended to do e.g. in terms of functionality, learning support and the type of desired learning outcomes
2. Clarity about intended users and contexts of use.
3. Awareness of the functionality, advantages and disadvantages of existing technologies and gaps in provision.
4. Design to meet the desired aims with regards to functionality, learning support and learning outcomes.
5. The provision of an enjoyable and high quality learning experience for all students that encourages the use of creativity and active learning.
6. Interdisciplinary focus for inclusive design taking into account end-user perspectives and different disciplinary approaches.
7. Consideration of user diversity, accessibility and usability requirements as an opportunity to use creative approaches rather than a problem.

2.1.2 Design Choices

1. Professionals and other involved in technology design, development and implementation should be aware of the (relative) advantages and disadvantages of design for all, design for specific groups of learners and the modification of existing technologies.
2. The use of design for all approaches should be considered good practice and generally used when developing new educational technologies.
3. In many cases it is appropriate to understand design for all as design for all learners in a particular age range or at a particular level of learning.
4. Design for specific groups of learners is generally appropriate when developing new (learning) assistive technologies, as they are intended to be used by specific groups of disabled people.
5. Modification of an existing technology is often appropriate when a learning technology which is not fully accessible has been used for an (extensive) period in a learning institution, resources have been developed to be used with it and staff are familiar with it. However, attempts at modification may not be successful in making the technology fully accessible to all disabled learners.

Note: The advantages of design for all include: (i) the ability of all students to use the same learning technologies, avoiding stigmatisation and facilitating discussion between students; (ii) increased likelihood of all students having an equivalent learning experience; and (iii) possible reduction in work load for teachers, who do not need to learn and plan classes for several different technologies. However, it is not always feasible or may result in excessive complexity. The main advantage of design for specific groups is that it can potentially ensure that the technology is well matched to the needs of disabled people with particular impairments (or other specific groups of learners). It has the potentially significant disadvantage that students using this technology may be less well integrated and/or stigmatised.

2.1.3 Design for all

1. The design should include a variety of user interfaces and compatibility with a wide range of assistive input/output devices as well as direct access.
2. The design should take account of pedagogical issues and the ability to use all functions and features of the technology, not just an accessible interface.

3. Support should be provided and all facilities available in a wide range of different languages.
4. Claims about accessibility and suitability for particular disabled learners should be based on evidence from user testing.

2.1.4 Accessibility and usability

1. Avoidance of features which make the technology unnecessarily restrictive or complicated.
2. ICT learning tools should be designed for easy transfer by the learner to other platforms.
3. Compatibility with appropriate AT e.g. screenreaders and switches is sometimes more appropriate than incorporating all accessibility features
4. Ease of use for all users.
5. Consideration of both general principles of accessibility and usability, and issues specific to the particular learning technology, the learning context it is intended to be used in and the target learners.
6. Consideration of the needs of users with multiple impairments e.g. technologies designed for learners with learning difficulties also need to be accessible and usable by blind and deaf learners with learning difficulties.

2.1.5 Respect

1. Involvement of disabled learners and teachers as experts on their own requirements with a role in decision making, in all stages of design, development and/or modification and implementation of learning technologies.
2. Philosophy based on the social model of disability, overcoming barriers and increasing choices and opportunities.
3. The use of design for all approaches which take account of the full diversity in user characteristics and preferences, while avoiding a high degree of complexity and taking account of the context in which the technology will be used.

2.1.6 Contextual Features

1. Within a design for all framework the design should take account of the context of the main groups of target users.
2. This should include factors such as individual learning or learning in educational organisations; educational background and motivation and self-perception of learners; and the availability of national and local support mechanisms.

2.1.7 Design trade-offs

1. There may be trade-offs between different factors e.g. complexity and diversity of the learner group.
2. In many cases both single and multi-function tools can be developed. The single function approach may give the learner the best performance on the current learning activity of interest, but the multi-function approach enables the same tools to be used for a wider range of learning activities.
3. There are often tradeoffs between ease and intuitiveness of use and the range and complexity, range and sophistication of the features provided.
4. It is often good practice to reduce apparent tool complexity where feasible, for instance by making only basic features available at the top menu layer, with more advance features available at lower levels.

2.2 Accessibility and Usability

2.2.1. Support for learners

1. Clearly written and well organised documentation in a variety of different accessible formats, including plain text of varying sizes and colours, HTML, simplified language, audio and sign language.
2. Clear statement of the available accessibility features.
3. For on-line systems a flexible on-line help system, with different options for accessing it.
4. The option for memory supports and regular prompts, with a choice of audio, visual or text cues.
5. Activities broken down into tasks with user choice of task size.
6. In more complex learning technologies warning and fail-safe features to minimise any negative consequences of errors and unintended or accidental actions.
7. Interesting tutorials in a variety of different accessible formats, particularly for more complex tools.

2.2.2. Navigation

1. Access to all functions and system components through a range of different input devices, including mouse, keyboard, joystick, game pad, binary switches, sip and puff device and head or eye tracker devices.
2. Full support for text-only navigation, including link shortcuts, hidden links and descriptive link texts.
3. Adaptive navigation facilities which allow users to go directly to the content, bypassing non-essential elements.
4. Simple menus which are easy to navigate and a quick start method.
5. Controls that can be remapped to allow users to tailor them to their needs and more than one control having the same action to reduce fatigue.

2.2.3. Accessibility of audio and visual elements

1. Choice of verbatim or summary closed subtitles (captions) for all dialogue and important sound effects.
2. Audio tags and support for sound location of all significant elements.
3. Choice of summary or detailed audio description for graphics and rich media.
4. Built-in screenreader with auditory access to the whole interface.
5. Options for reduced graphics versions of text, particularly for use with screenreaders.
6. Use of wrap lines for text.
7. Choice of visual representations of sounds e.g. sound balloons, sound visualisation and video clips.
8. Choice of high contrast modes, including black on white and white on black and scalable fonts and graphics.
9. Separate volume controls for music and sound effects.

2.2.4. Customisation

1. Where appropriate, the use of a user profile to support customisation. Users have control over the information in the profile and can choose whether or not it is automatically updated in response to user actions and game performance.
2. Options to turn a wide range of features on or off, including sound, graphics, blinking or flashing graphics, colour, prompts, memory cues, scrolling text, warnings, fail-safes and feedback. This provides all learners, particularly disabled ones, with the support and accessibility features they require, while avoiding accessibility barriers to

disabled learners with sensory sensibilities, and enhances the experiences of all learners.
3. Choice of different formats for feedback and other information e.g. audio, graphical, text, tactile, sign language or a combination.
4. Choice of a wide range of difficulty levels, to allow advanced users to be challenged and no user to find the game too difficult. This should include the size of the tasks into which activities are decomposed.
5. Choice of a wide range of speed options for all functions, allowing users to slow down games to take account of slow reaction times.
6. Other customisation options to meet specific user needs.

2.2.5. Interface

1. A non-intrusive interface, which is consistent in control, visual (colour, type style and size), audio (type and speed of voice) and dialogue design.
2. A number of alternative options for interacting with the learning technology.
3. Well organised and limited number of menu layers (if menu layers are required).
4. Convenient, flexible, customisable and intuitive controls, which are easy to learn and can be expanded for advanced options.
5. Network effects, such as disconnections and delays, are minimised.
6. Any relevant information should be readily available in clear, simple language and in alternative formats.

2.2.6. Learnability and challenge

1. Easy to learn without a manual, tutorials etc.
2. An appropriate degree of challenge – research indicates that the challenge associated with learning to use the technology can support learning.
3. The ability to use the basic or most commonly used functionality without needing to learn the full functionality of the system for more complicated, multi-function tools

Note: principles 2.2.2 – 2.2.5 are related to Web Content Accessibility Guidelines (WCAG 2) (http://www.w3.org/TR/WCAG20/) and EN 301 549 (http://www.etsi.org/deliver/etsi_en/301500_301599/301549/01.01.01_60/en_301549v010101p.pdf)

2.3 Pedagogical issues

2.3.1 Inclusive pedagogies

1. The use of inclusive pedagogies and the avoidance of any requirements, materials or technologies which are not fully accessible to all students, unless there are exceptionally good pedagogical reasons for using them.
2. Ensuring that all (disabled) students have access to equivalent learning materials and experiences, preferably by using the same learning technologies and other approaches as non-disabled students.
3. Flexibility with options for adaptation to the diverse needs of individual students.
4. Learner control of the technology and goals, with learning materials presented in meaningful units.

2.3.2 Support and encouragement

1. Support for cooperative learning, including discussing and negotiating different approaches to learning.

2. Encouragement to make meaningful use of existing knowledge and skills and familiar situations and experiences.
3. Meaningful and accurate feedback, giving real dialogue between the user and the technology.
4. Making learning enjoyable, while recognising that what is ‘fun’ for some students may be stressful for others.
5. Availability of buddy systems to support learners.

2.4 Contexts which Support Learning

2.4.1. Institution

Ethos

1. Motivation and genuine commitment rather than tokenism.
2. Attention to the needs of both disabled staff and students.
3. Coherent institutional policies.

Inclusiveness

4. Involvement of disabled learners and recognition of their expertise.
5. Disability equality, disability etiquette and other relevant training and information for everyone.
6. Relatively high percentage of disabled staff to help 'normalise disability' e.g. close to the approximately 15.7% of the population in Europe estimated to be disabled or have a long-term health condition (EUROSTAT, 2003).
7. Social as well as educational integration of disabled students.
8. Culture of inclusiveness.
9. An appropriate use of standards and checklists, with recognition that this is a minimum rather than sufficient to meet the needs of disabled learners.

2.4.2. Consultation and information

1. Regular consultation with organisations of disabled people, disabled staff and students, including on new technologies, but recognition that like non-disabled people, disabled people have varying needs and preferences.
2. Widespread availability of user evaluations of learning ICT by disabled people/organisations of disabled people.
3. Widely available of data bases of available learning technologies which include classification by their accessibility features.

2.4.3 National Context

Availability

1. Availability of free computers and internet access to prospective disabled and non-disabled learners in both formal and informal education
2. Availability of training in the use of ICT and available technologies to disabled people and organisations of disabled people
3. Availability of assistive and learning technologies and ICT to support learning in the home.
4. Ease of availability of learning technologies, e/audio books and other resources for disabled learners.

ICT and AT

5. Existence of national ICT and/or AT industries.
6. Standard accessibility features of computers in learning and training institutions.
7. Design for all, accessibility and usability are part of all design, engineering, IT etc courses.
8. Production of learning technologies in the local language or expertise and resources to convert technologies to local language.

Rights and Opportunities

9. Opportunities for disabled students to learn/practice e.g. Braille, sign language in mainstream classes.
10. Measures to ensure full social and academic integration of disabled students, as well as the organisation of regular events where disabled students can mix with disabled students with similar impairments.
11. A legal context which promotes the rights of disabled people, with implementation of the legislation monitored and sanctions for non-compliance.

2.4.4 Education System

Education for all

1. Education of all types is available free of charge to all learners throughout the lifespan
2. All learning materials are free to all students
3. Financial support e.g. bursaries to cover living expenses are available to all qualified full and (pro-ratio) to all qualified part-time students.

Inclusive education

4. Proactive rather than reactive approach with focus on overcoming barriers and making mainstream education accessible to all rather than additional/add-on measures to support particular groups of disabled learners.
5. Fully resourced properly designed mainstream education system with e.g. opportunities to mix with students from the same disability group and provision of high quality education disability related education e.g. sign language, Braille, orientation and mobility training
6. Recognition that an education system which is fully accessible to disabled learners can benefit all learners.
7. Availability of the same wide range of learning and assistive ICT throughout the education system, so learners can use the same technologies when moving to another level of education or another institution.

Teaching, IT and Support staff

8. Sufficient teaching staff, IT technicians and other support staff
9. Availability of a specialist unit for disabled students which evaluates their requirements and ensures they are met.
10. Availability of a specialist accessibility unit with a clearly defined remit which can e.g. produce materials in a range of formats and provide expertise on accessibility and pedagogical issues.
11. Disabled friendly training for teachers.
12. Teaching and other staff have moderate work loads, so that working with disabled students does not become yet another burden for overworked staff.
13. Teaching and other staff have regular access to training and opportunities to discuss teaching and accessibility issues with colleagues both within and outside their institutions.

14. Data bases of accessible teaching content and other resources which can be accessed by all teaching and educational IT and support staff.

2.5 User issues/ requirements

2.5.1 Accessibility, Usability and Practicality

1. Accessibility requirements, including the need for particularly clear, precise language and instructions.
2. Availability of learning materials in user's primary or preferred language, as well as options for bilingual education.
3. Cost effective learning technologies.
4. Time saving learning technologies.
5. Transferable learning technologies.

2.5.2 Respect for individual requirements

1. Learning technologies should take account of requirements related to personal characteristics, including gender and cultural factors.
2. Learning technologies should be designed to be used on their own without requiring assistance, though assistance should be available.
3. Learning technologies should be designed to enable users to use them in their preferred learning situations e.g. on their own, with teacher support, as part of a class or with peer group support.
4. Learning technologies and educational content should draw on existing skills and allows users to develop them.
5. All learning technologies and learning content should be designed to facilitate learning, while providing an appropriate level of challenge.

2.5.3 Choosing the Best ICT Learning System for a Particular Application

General

1. Significant involvement of disabled learner(s) and teachers
2. Consideration of both recent developments and established technologies.
3. Obtaining specialist advice if appropriate
4. Taking account of the context in which the technology will be used, user characteristics and requirements and intended learning activity/ies
5. Users should be given the opportunity to try out different tools/technologies for an extended period. This will be more difficult to do effectively for more complicated technologies where training and/or experience is required to use them (most) effectively.
6. Some proportionality between the effort involved in decision making and the importance of the tool/frequency with which it is used

Factors to be considered

7. Consideration of the platform(s) the technology is to be used on. There are generally advantages in technologies which are portable between different platforms.
8. Consideration of the context(s) in which the technology will be used including formal/institutional and informal learning; and whether in mainstream or segregated learning institutions.
9. There may be trade-offs between different factors e.g. ease of learning and satisfaction of other criteria.

10. Decisions may be required between single and multi-function tools. The single function approach may give learners the best performance on the current learning activity of interest, but the multi-function approach would enable them to participate in a wider range of learning activities.
11. Attitudinal and learner related factors of the main target group(s) of learners may affect technology choice. They includes (i) degree of motivation, (ii) self perception as a learner and a disabled person, (iii) education background, experience and confidence in using ICT learning technologies; (iv) conflicting demands and prioritisation of learning.

2.6 Evaluation of Learning Technologies

It is useful to have approaches for evaluating learning technologies, for instance to determine whether they meet their specified aims and the requirements of users. Other evaluation aims are presented in Hersh (2014) and a slightly earlier version was presented in deliverable 3.3 (http://i-enable.eu/sites/default/files/D3.3.pdf). The following principles are also taken from Hersh (2014), with a slightly earlier version presented in deliverable 3.3.

1. The aims of the evaluation
   - 1.1 Clarity about the aims, including any learning outcomes being assessed.
   - 1.2 Design of the evaluation to meet these aims.
   - 1.3 Trade-offs between evaluating everything and available resources, including the time and cognitive demands on evaluators, including disabled learners.

2. The underlying philosophy
   - 2.1 Evaluation approaches based on the social rather than the medical model of disability i.e. disability is considered the result of social, infrastructural, attitudinal and other barriers rather than an individual limitation arising from the person's impairment(s).
   - 2.2 Respect for all participants.
   - 2.3 Awareness of the four factors of the disabled learner or end-user, the context, the activities and the technology, though it is not necessary to always consider all of them.
   - 2.4 The importance of ethical issues, including provision of full information on the aims and process of evaluation and use of the results, the right not to participate or to withdraw, confidentiality and safeguarding of personal data.
   - 2.5 Following good practice in all aspects of evaluation, including confidentiality, ethical issues and health and safety.

3. The evaluation process
   - 3.1 Choice of appropriate (combinations of) methods to take account of the aims, available resources and deadlines.
   - 3.2 Use of a combination of quantitative and qualitative indicators and, where feasible, both formative and summative evaluation.
   - 3.3 Realistic expectations of the evaluation process and the associated difficulties.
   - 3.4 Recognition of the role of both simple quick and in-depth evaluations and the different types of results likely to be obtained.
   - 3.5 The use of simple, clear unambiguous language, which is appropriate for the particular individuals involved in the evaluation.
   - 3.6 Familiarisation with good practice and effective techniques for carrying out evaluations. There are a number of sources of information, including the Evaluation Cookbook (Harvey, 1998).

3.7 Where appropriate, repeated evaluation or evaluation throughout the life cycle, for instance in the case of learning technology development or procurement.
3.8 Where feasible, evaluation of both the technology in itself and in comparison to similar technologies.

4. Accessibility and participation of disabled evaluators
   4.1 Full accessibility and appropriateness of all aspects of the evaluation process, including evaluation of learning outcomes, for all participants.
   4.2 Asking all participants for their requirements in advance, ensuring they are met, and 'normalising' the concept of having accessibility requirements.
   4.3 Avoidance of restrictive pedagogical or other assumptions or requirements which lead to demands which some disabled learners cannot meet by reason of their impairment(s).
   4.4 Evaluation room: on ground level or choice of lift or stairs; close to wheelchair accessible toilet; any pictures, mirrors or clocks can be removed; windows with heavy blinds or curtains; away from sources of noise such as road, lift, stairs, coffee machines, boilers and machinery; calm décor.
   4.5 Communication: facing the person to allow lipreading, but not forcing eye contact; interpreters may be necessary and should be briefed in advance on the topics and any special vocabulary; use of direct, unambiguous language; level of language used should be tailored to the participants.
   4.6 Documents: availability in alternative formats, which could include electronic, large print, black and white, easy read, and sign language. The particular formats required will depend on the participants.
   4.7 Length and breaks: the evaluation should be kept as short as possible. Longer evaluations should be divided into sections with short breaks between them. Shorter sessions and longer breaks or evaluation over more than one day may be necessary. .
   4.8 Reducing anxiety: all evaluators should have full information and know exactly what is expected; short breaks; Investigators need to be alert to signs of anxiety and to provide support or end the session if necessary.
   4.9 Assessment procedure: if at all possible making the assessment procedure for all learners accessible to disabled learners rather than having separate procedures.

5. The evaluators
   5.1 The number and types of evaluators should depend on the aims of the evaluation.
   5.2 Where feasible, the involvement of several different evaluators and, if appropriate, evaluators from different stakeholder groups and with different perspectives and experience.
   5.3 The use of techniques such as convergent participation (Vargo et al, 2003) to obtain evaluator consensus or comparison of the evaluations produced by different evaluators.
   5.4 In the case of comparison of evaluations by different evaluators, it is useful to relate similarities and differences to personal and demographic data such as role (e.g. learner, teacher, expert, therapist), age, gender, disability status, accessibility requirements and years of experience and to obtain this data from the evaluators in order to do this.
   5.5 Where the focus is on the impact on particular learners, the evaluation should involve them and possibly also teachers and others working with or supporting them.

6. Ethical issues
   6.1 Good practice with regards to participation, informed consent, confidentiality and data privacy.
   6.2 Evaluation results will only be seen by the investigators and not by teachers, parents or social workers.

6.3 Learners need to know that are not being evaluated or assessed and that there will be no negative consequences for learners due to particular answers, or performing badly in a test using the learning technology.

7. Evaluation of learning outcomes
   7.1 Separate analysis of the learning outcomes of different groups of learners, based on personal and performance factors, such as gender, attitude to learning, 'successful' learning and type of impairment or reasonable adjustments required.
   7.2 Recognition and ethical resolution of potential conflicts of interest between the demands of rigorous evaluation e.g. based on controlled experiments and the requirements of learners for the best tools to support learning.
   7.3 Recognition that learning takes place in a context and it is rarely possible to separate the impact of the technology from other factors.
   7.4 Some of the impacts of the technology will be as a result of its influence on motivation and time spent learning. New technologies may be more successful initially when they are seen as exciting than when they become mainstream.

3. Case Study Examples of the Use of Learning Technologies

In this section a number of case study examples illustrating the use of Information and Communication Technology (ICT) with disabled adults in different educational contexts and settings are presented.

3.1 Examples of the Use of a Combination of Hardware and Software

Some of the earliest examples of disabled adults using ICT to support learning can be found in descriptions of ICT use in post-formal education, such as day centres and adult training centres (Parson et al., 2006). For instance. Clay et al (1988) presented a small series of case studies showing the effective use of ICT by disabled adult learners. This included a case study of the use of learning technologies by Elsie, a 47 year old woman born with athetoid cerebral palsy. She was a wheelchair user with unintentional repeated writhing movements of her head and feet (Clay et al., 1988). Her previous education had been restricted by the lack of technological and other forms of support. However, she was now using an Ergopad system consisting of a switch operated by a hand-held puffer, to control a Possum typewriter and a BCC computer via an Elfin keyboard emulator. This device was connected to the computer keyboard and she used a switch to select the key indicated by a light on the control panel. As a result she was making good progress in her basic education, such as learning to read and write (Clay et al., 1988). Thus the availability of technology was contributing to enabling Elsie to access the education she had previously been denied.

More recent examples have been provided by the ACE centre which specialises in Augmentative and Alternative Communication (AAC) and Assistive Technology (AT), and has helped many people to use technology to access education. For instance, Claire, who has cerebral palsy, is studying physics at Imperial College. She uses a ruggedised tablet computer that she accesses with a joystick and switch and which enables her to send and receive text messages (ACE Centre, 2014). In addition, although she relies upon her own speech, she uses synthesised speech when she is giving talks or presentations or as a backup. She also uses a DigiMemo, which is a digital notepad, during tutorials. Claire's study assistant writes notes onto it which can be shared with other students (ACE Centre, 2014). According to Claire's tutor, students engage much more with Claire's assistive technology than with the conventional whiteboard (ACE Centre, 2014), as it meets many

accessibility and usability principles. It is a very easy device to use and notes can be stored and uploaded to a computer.

Darren, who is on the autistic spectrum, attends a specialist college and uses a voice output communication aid called *Proxtalker* as part of his communication strategy (ACE Centre, 2014). He had used many communication systems in the past and has found the *Proxtalker* to be an effective communication method for him (ACE Centre, 2014). *Proxtalker* stores vocabulary on sound tags and retrieves it with of the device's radio frequency identification (RFID) technology.

Sandip is 40 years old and has cerebral palsy. As part of his communication strategy he uses a *Lightwriter*, which is a portable voice output communication device, as well as onscreen keyboards which he accesses with a sliding hand switch (ACE Centre, 2014). He uses a joystick to navigate the desktop. Sandip has taken a career break to study for a Masters degree in International Relations and his assistive technology is essential for him (ACE Centre, 2014).

3.2 Examples of the Use of Software

Printed material is not directly accessible to many groups of disabled people, including blind people, people with learning difficulties and people with impairments which affect muscle strength and/or cause pain (Ryba and Selby, 2004). Fortunately, a number of generally software based systems are now available to support access to printed materials and consequently to a wide range of information. At least some of the software can be used on mobile devices as well as PCs and laptops. Software systems include screen magnification and screenreaders with a range of features aimed at supporting visually impaired people or people with learning difficulties, and word prediction software. There are also onscreen keyboards, as well as hardware systems, such as overlay keyboards. Most word processing programs have spell and grammar check programs, though these are not necessarily optimised for use by disabled learners, such as those with learning difficulties.

Martin is visually impaired and is studying Social Policy at the University of Central Lancashire, which has been making supernova available on their computing network since 2000. It provides screen magnification, as well as speech output for use with headphones and loudspeakers and Braille output for use with a Braille display. The availability of Supernova means he can use any machine on campus which has a sound card in order to enable the Orpheus speech synthesiser output (Supernova, 2014). This gives Martin the flexibility to study where he wants without needing to carry his laptop around (unless he wants to do this). It also means that he does not need to recreate his settings files when he logs on to a new computer and has automatic access to the many applications available to other students.

Steven, who has been partially sighted for the past fifteen years and registered blind for the past ten years, is currently studying for a Doctorate in Counselling Psychology with the help of *Read&Write Gold*, which is a flexible toolbar with support features. This technology offers spellchecking and supports him in accessing reference books and journal articles. He uses the reading functions to read WORD, Excel, WordWeb pages, Help files and PDF documents. He also scans documents and uses the text-to-speech conversion program which offers him speech feedback by reading the content aloud with dual highlighting (Texthelp, undated).

Sean, who has cerebral palsy, has been using *Penfriend*'s word prediction, lexicon editing, screen reading and on-screen keyboard for about five years to enable him to write faster

(Penfiend, 1999-2014). It has enabled him to increase his typing speed by a factor of three from three to nine words a minute (Penfiend, 1999-2014). The synthesiser clipboard reader enables him to read his emails and articles on the web. He selects the text he wants to read, copies it and pastes it in the clipboard reader, which then reads the text back to him in his preferred voice (Penfiend, 1999-2014).

A tutor with Devon Adult and Community Learning describes the way she used technology (Microsoft's PhotoStory) to support and enhance the engagement of one of her learners:

> *"I had a learner with ADHD in my group. He was hard to engage at times. We were painting on glass, decorating items to sell on a market stall. He chose not to do the activity. Instead I gave him a digital camera and my laptop and asked him to produce a Photostory of the others' work for my records and evidence for their qualification. For nearly two hours he was either taking pictures or working on the Photostory. He has some computer skills but hadn't used Photostory before. He needed little support once I had explained the process of getting the photographs into the programme. He enjoyed using ICT to produce a record of their work and doing this provided evidence for his own portfolio."* (NIACE, undated p.9).

3.3 Case Studies of Courses and E-Learning for Disabled Adult Learners

Kent Libraries and Archives working with Kent Adult Education Services has developed and delivered a course on using the library specifically for adults with learning disabilities (NIACE, undated). People who have taken this course have become confident and independent users of the library's various facilities, including its ICT services. This has had significant potential benefits for both their quality of life and their access to a wide range of learning materials.

The work of the Estonian e-Learning Development Centre (ELDC), which is part of the Estonian Information Technology Foundation, began in 2000 and focuses on the development of flexible and accessible ways for learning and teaching by increasing the ICT competence of students and teachers (UNESCO, 2011). It promotes e-learning in vocational and higher education in Estonia (Innovation Centre for Digital Education, undated) supporting the selection of e-courses and coordinating web-based teaching and e-learning resources (UNESCO, 2011). It also offers the following e-learning environments:

1. Blackboard Vista, which is used by most of the universities, with more than 39,000 users and 1,800 courses. Approximately 55% of university level e-courses are on Blackboard.
2. Moodle, which is used by two universities and half of the vocational colleges, giving more than 30,000 users and 1,700 courses. Some vocational colleges have installed Moodle on their servers.
3. The Interactive Virtual Academy, developed by Tallinn University, and which is used by this university and the other 50% of vocational colleges, giving about 10,000 users and 1,800 courses (UNESCO, 2011).

The best approach to ensure that different learners can benefit from the use of ICT is universal access in terms of hardware and software and e-learning environments (UNESCO, 2011). The above learning environments have improved the inclusion of students with disabilities as they have enabled a wide range of adult learners to participate in learning (UNESCO, 2011).

In addition, ELDC allows access to a lecture recording system ECHO 360 (http://echo360.com) which creates a recording in suitable formats for students with visual or

hearing impairments (UNESCO, 2011). More specifically, Echo 360 is a Lecture Capture service which enables recording of the audio of a lecture, the content on the computer and video of the instructor at the podium simultaneously during meetings, speeches and other events. It works with webcams and internal microphones, as well as external peripherals (microphones, digital video recorders, webcams, etc.). The captures are published as Rich Media Flash files, as an MP3 podcast and M4V Video podcast.

The ELDC works alongside Primus, a programme on higher education quality development supported by European Social Fund and implemented in 2008 – 2013 by the Foundation Archimedes (www.archimedes.ee) (UNESCO, 2011). One activity of Primus was to develop and run a support system for students with special needs, developing different support services (e.g. creating training courses, digitalising and recording teaching material for students with visual impairments); improving learning environments (assessing physical accessibility of buildings) and running a scholarship scheme for students with disabilities in order to support their full participation in studies (UNESCO, 2011).

The pilot project "Informatics for the Blind Studies for Visually impaired People in Informatics and Economic Engineering" (Karlsruhe Institute of Technology, 2012) was set up in 1986 to use ICT to provide educational and professional opportunities to visually impaired students in mathematics, sciences, informatics, engineering and economics. It resulted in the establishment of the Study Centre for Blind and Partially Sighted Students (SZS) in southern Germany. This Centre carries out research and provides support to partially sighted and blind students in all courses offered at Karlsruhe Institute of Technology (http://www.kit.edu/english/) (UNESCO, 2011). It offers special support, counselling and guidance in both pedagogical and technical fields to blind and partially sighted students at the start of their courses, during their studies and when seeking employment (UNESCO, 2011). Due to the strong support for ICT, blind and partially sighted graduates obtain experience of the latest ICT and many of them obtain excellent grades (UNESCO, 2011).

The Centre on Deafness (GUIMC), which is based in the Bauman Moscow State Technical University in Russia, has developed and implemented training programmes that include the use of ICT for hard of hearing and deaf students. The Centre offers specialist Bachelors and Masters programmes in Computer science and engineering, standardization, certification and metrology, material science and technology of materials, and automation of technological processes and production (GUIMC, undated). These programmes are offered as a tool for improving learners' access to knowledge and information in formal and non-formal learning situations as well as a tool for alternative communication aiming to eliminate communication barriers in classroom settings (UNESCO, 2011). The technologies and support materials provided include a smart board with associated software, internet resources, powerpoint presentations, student presentations, scanners and printers.

First year's curriculum is universal and all students, entered GUIMC, work on it (GUIMC, undated). At the end of the first year, students are distributed to the fields of study based on vocational guidance and professional diagnostics or it is also possible for the most adapted and successful in studies students to be transferred into groups of the first course at chosen by them profession (GUIMC, undated). The second and third years' curricula of study include some disciplines of the future profession's curricula. Hence, the University's two-year course for GUIMC's students is timed for three years of study (GUIMC, undated). Then students can follow the below learning path:

- «bachelor», with the defense of a Bachelor's degree work, receipt of the Bachelor's Diploma and graduation with the following job placement;

- «bachelor-master», with the defense of a Bachelor's degree work, entrance to the Magistracy (on the assumption of the graduating sub department's

recommendations), continuation of study on it (2 years) and defense of a Master's degree;

- «transfer to the specialist's program» (if it is specified in the curriculum of the graduating sub department), with the corresponding increase in the period of study and the defense of a graduation work.

(GUIMC, undated).

An individual package of resources is developed for each GUIMC student based on evaluation of their needs. This includes individual and group hardware as well as additional support, communication and rehabilitation services such as special devices, special software, assistive listening devices and sign language translation (GUIMC, undated).

4. Discussion of the Application of the Principles

As indicated in the previous section, the technologies in deliverable D2.2 and the examples in deliverable D3.3, a number of good learning technologies for disabled learners are already available. The principles will now be illustrated by a brief discussion of the extent to which two technologies comply with them.

Read*&Write Gold* is designed for a wide range of disabled and non-disabled learners of different ages and abilities, including students with learning difficulties, struggling readers and writers and learners whose first language is not English. It enables them to access the tools they need to learn at school, college, university, work, or home (Texthelp, 2014). This enables them to have an equivalent learning experience to other learners (2.3.1.2). Clear statements explain the available accessibility features. Clearly written and well organised information in simplified language (2.5.1.1) is provided in different accessible formats such as plain text and audio (2.2.1.1, 2.2.1.2.).

Support is provided through built-in help videos which present and explain each feature in detail (2.1.4.6.), an online help feature on the toolbar (2.2.1.3) and a free one-hour webinar on the software website which provides a basic overview of Read*&Write 11 Gold* for PC (2.2.1.7). Users can access the tool using different input devices such as keyboard, alternative keyboard mouse or alternative mouse and camera (2.1.3.1., 2.2.2.1). There are several pre-set toolbars which provide a number of options to users and allow personalisation to meet the user's specific needs (2.2.4.6). The toolbars are simple, easy to navigate and enable learners to set their feature preferences from just a few features to the full suite of tools (2.2.2.4). The My Features toolbar can be customised to enable users to determine the position of the toolbar on the screen.

Several multi-function tools enable users to easily select any digital text, which can be highlighted, edited and converted to a sound file with the use of the speech maker (2.2.3.4). Other toolbar options include the picture dictionary and choice of the speed of the speech produced by the speech maker (2.2.3.2, 2.2.4.6). Other functions to support users include options for reading, scanning and converting documents. There are therefore a number of alternative options for interacting with the learning technology (2.1.3.1).

Only a small number of the principles have been discussed. However, *Read & Write Gold* meets most of those considered. In particular it is flexible and customisable (2.2.4.6), simple to use and easy to learn (2.1.4.4., 2.5.2.2) and a documentation and support materials are

available in several different formats (2.2.1.1.). It provides a high quality and potentially enjoyable learning experience for all learners who use it (2.1.1.5.).

The other technology that will be discussed in this section is *Twitter*. This is an ICT technology which is very widely used by both disabled and non-disabled adult learners as well as younger learners. *Twitter* is a social network which enables users to connect with people and send short text messages of up to 140 characters, as well as links to videos and pictures, which can be opened without leaving twitter. Users can also share documents. It is free (2.5.1.3.) and suitable for all users who can input text using a keyboard, mouse, jaws, keypad or voice recognition, independently of their age, gender, learning style and educational background (2.1.1.7, 2.1.3.1). It is used widely in a range of different locations, including schools, colleges, universities, workplaces and at home and enables people to share ideas and real-time information.

Twitter can be easily accessed through a website or downloaded and it is easy for all users (2.1.4.4.). The Help Centre provides information using the software, frequently asked questions and troubleshooting articles (2.2.1.3.). However, the principle 2.2.1.1. is not fully satisfied as this information is not provided in a variety of different accessible formats such as simplified language, audio or sign language. It is a simple software, easy to learn without a manual or tutorials (2.2.6.1) and previous knowledge is not required. Users can choose their preferred language from the more than 35 languages that are supported (2.1.3.3.), and customisation options permit a range of colours, sizes and speeds of operation to be chosen. However, customisation options, such as prompts, memory cues and feedback and turning off scrolling text, are not available. Therefore principle (2.2.4.2) is only partially satisfied, as only some, but not all learners receive the support and accessibility features they require.

The menus are simple and easy to navigate (2.2.2.4), keyboard shortcuts are available and the users can edit their profiles and change their settings. However, there are no facilities for providing text descriptions of transmitted videos and pictures for blind learners. This software is not ideal for visual learners, as it is mostly text based with no option to provide graphics or picture dictionaries. Twitter can be used with screen readers (2.1.4.3.). However, there is not a built-in screenreader and therefore, the principle 2.2.3.4. is not met. Thus, most disabled learners are able to use the main function of sending and receiving short text messages, but not the full functionality.

From a pedagogical perspective, it is available to all students (disabled and non-disabled) but only some features are fully accessible. Therefore the technology does not fully satisfy the principles 2.1.4.1. It is useful for learners as they can share news and exchange views instantly and it is considered to be a quick and fun way of communicating and makes learning enjoyable. However, the principle 2.1.1.5 is not fully satisfied, as lack of full accessibility of some features may reduce enjoyment or the quality of the learning experience for some learners.

These examples have illustrated the application of the principles and also shown that different learning technologies comply with them to different extents. However, the violations of the principles are not particularly serious ones and both technologies can be used by disabled learners.

5. Discussion and Conclusions

The use of ICT in education has important potential advantages for disabled learners in terms of increasing the accessibility of learning materials to them and making available new ways of studying. However, there are issues of the accessibility and usability of these technologies (Hersh and Leporini, 2012) and their match to the particular needs and learning approaches of specific groups of disabled people. In addition, there are examples of ICT learning tools which have been developed without consideration of the needs of disabled learners, resulting in technologies which are inaccessible or otherwise inappropriate for disabled learners. Several different accessibility guidelines have been developed but these guidelines do not cover all the issues that may affect disabled people. Furthermore, most of them are for web-based technologies but not all learning technologies are web-based. In addition, the guidelines do not cover all issues. Therefore, it is good practice, to involve disabled end-users throughout the process of designing, developing and testing learning (and other) technologies.

This deliverable has developed and presented a number of principles of good practice related to the design, development and use of ICT to support disabled adult learners. These principles were drawn from the results of a questionnaire (see Appendix) circulated to the partners in the Enable Project as well as the results of a survey of accessibility and usability of ICT educational games carried out by the workpackage leader and partner P12 (Consiglio Nazionale delle Ricerche, Istituto di Scienza e Tecnologie dell' Informazione, CNR-ISTI). The principles were organised into the following six groups: (i) designing, developing and modifying ICT learning technologies; (ii) accessibility and usability; (iii) pedagogical issues; (iv) contexts which support learning; (v) user issues and requirements; and (vi) evaluation of learning technologies.

The first group of principles for designing, developing and modifying ICT learning technologies includes a number of basic principles. They cover clarity of aims, accessibility and usability requirements with an interdisciplinary focus, awareness of the design choices and tradeoffs between design for all, design for specific groups of learners and modification of an existing technology. In the second group of principles, accessibility and usability are covered. This includes simple menus which are easy to navigate, clearly written and well organised documentation in a variety of different accessible formats and a variety of options related to audio and visual elements. Principles relating to learnability and challenge are also included as well as principles for customisation and diverse interface options. The aim is a combination of flexibility, simplicity, customisation and intuitive use to provide all learners and particularly disabled ones with the support and accessibility features they require, while avoiding accessibility barriers to disabled learners with sensory sensibilities. The third group of principles covers pedagogical issues. Inclusive pedagogies are required to ensure that all disabled students have access to equivalent learning materials and experiences and can use the same (or equivalent) learning technologies and other approaches as non-disabled students. Support for cooperative learning, meaningful and accurate feedback, making learning enjoyable, are equally significant.

The fourth group of principles covers contexts which support learning. Separate sets of principles are provided for institutions, the national context and the educational system, as well as consultation with disabled people. The principles emphasise the importance of institutions having an inclusive ethos and consultation with organisations of disabled people as well as individual disabled learners and staff, as well as the availability of free computers and internet access to disabled and other learners in both formal and informal education. In addition, principles of good practice for free education for all throughout the lifespan are presented. Thus, proactive rather than reactive approaches are required with the focus on overcoming barriers and making mainstream education accessible to all rather than

additional/add-on measures to support particular groups of disabled learners. A wide range of learning and assistive ICT throughout the education system should be available, so that learners can use the same technologies when moving to another level of education or another institution. Principles relating to teaching, IT and support staff are also included.

The fifth group of principles covers user issues and requirements. It includes principles about accessibility requirements, usability and practicality. In particular, learning technologies should be transferable between platforms and take account of individual characteristics. Principles relating to the choice of the best ICT learning system for a particular application, such as the involvement of disabled learner(s) and teachers and the factors to be considered, are also presented. The final group of principles covers the evaluation of learning technologies. This is provided here for completeness, but it should be noted that these principles have already been stated in deliverable 3.3 and Hersh (2014).

A number of case studies of the use of ICT learning technologies were presented and two examples of the satisfaction of some of the principles by two learning technologies were discussed. These examples met the principles to different extents, though the violations of the principles were not particularly serious.

Although developed specifically for ICT learning technologies for disabled adults, these principles are likely to be relevant for all learning technologies. They provide a useful tool for all stakeholders, including disabled learners, teachers and tutors and developers of learning technologies, to ensure that the learning needs of disabled (and non-disabled) adults are met. The application of these principles to both ICT learning technologies and learning contexts can be used to encourage enjoyable active and independent learning.

The principles also show the common characteristics that need to be met by effective ICT learning technologies for disabled adult learners. These characteristics include accessibility, usability including ease of learning and intuitiveness of use, flexibility and customisation. From the pedagogical perspective effective ICT learning technologies engage disabled adult learners in the teaching and learning process offering them quick feedback, developing their skills and knowledge and raising their achievement. Collaborative learning is also supported or encouraged by these technologies, as they can be used for both individual and group projects.

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Appendix: Questions from WP3 Questionnaire Used in this Deliverable

1. Provide a brief evaluation of the situation in your country with regards to:
(c) Any additional difficulties or barriers faced by disabled people in accessing education.
(d) Any enablers or good practice in access to education for disabled people.
(d) The availability of ICT learning technologies for disabled people
(e) Barriers, enablers and other factors that affect access to ICT learning technologies for disabled people.
(f) Any other comments

2. In the context of ICT learning technologies for disabled people, please explain what you understand by the following terms:
(a) Good practice
(b) Satisfactory practice
(c) Poor practice
(d) Bad Practice

3. Provide a number of examples of each of the following practices in the use of ICT learning technologies for disabled people in your country.
(a) Good practice. For each example, please explain what factors make the practice 'good'.
(b) Satisfactory practice. For each example, please explain what factors make the practice 'satisfactory'.
(c) Poor practice. For each example, please explain what factors make the practice 'poor'.
(d) Bad practice. For each example, please explain what factors make the practice 'bad'.

4. Provide suggestions for recommendations to improve:
(a) the access of disabled people over 16 to education.
(b) the availability of ICT learning technologies for disabled people

Please indicate whether these recommendations
(i) Relate specifically to the situation in your country.
(ii) Are more general.

(c) Provide examples of the use of ICT learning technologies by disabled people.
(d) What are the barriers to increased use of ICT learning technologies in lifelong learning in your country.

5. Please provide any other comments or suggestions on the use of ICT learning technologies with disabled adults.