

# Selecting and utilising assistive technologies in an e-learning context

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September 2006



**Australian Government**  
**Department of Education,  
Science and Training**

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ISBN 1 921045 74 4

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# 1. Introduction

This report builds on the 2005 *Adaptive and assistive technologies in e-learning report*. The definition of assistive/adaptive technologies will be broadened. The various technologies will be explained and their relevance to educational settings generally and to e-learning specifically will be discussed.

There are many facets to education in Australia today. In the most conventional setting, material is presented by a teacher/trainer giving an oral presentation, supported by handwritten notes on a board. Options for presenting learning material can now include far more sophisticated techniques. These range from computer-generated visual aids to highly complex multimedia presentations.

E-learning and online learning are now integral components of educational delivery. Mobile learning is also gaining acceptance as such technologies as mobile phones, computing, photography and networking converge.

In this climate, it is crucial that people who have disabilities are able to participate actively. Whether learning takes place in a conventional classroom, via a multimedia presentation or over the internet, some fundamental issues remain. The learner must be able to perceive information and instructions and, where necessary, keep notes of relevant points. It is also important that the learner's knowledge can be assessed.

The equipment discussed in this report has the potential to allow those criteria to be met. For that to happen, however, it is vital that students, teachers and administrators are aware of its availability and appreciate its significance. Equipment applicable to four major disability types will be summarised:

- vision impairment and blindness (Section 4)
- hearing impairment and deafness (Section 5)
- physical disability (Section 6)
- neurological disability (Section 7).

While dividing disability types can be helpful when summarising available technical options, it is recognised that such divisions are not always appropriate. Firstly, there are marked variations in both severity and nature of disability within each group and some people's problems are not confined to one category of disability. Secondly, many factors other than the disability will impact on each individual's aspirations and potentials. As will be evident, some of the technologies also have relevance to more than one disability type. Notably, a separate section has been allocated to synthetic speech because of its relevance to a broad range of people.

Sections 4 to 7 begin with a very brief summary of the disability and then provide an overview of some of the more significant assistive technologies. Section 8 puts these resources into the context of educational environments, with particular focus on e-learning. It will also be shown in Section 8 how these specialised products allow students who have disabilities to benefit from broader technological developments that are being utilised in the education sector. These resources can play a crucial role in allowing students who have disabilities to participate fully in today's educational environment. Furthermore, when used effectively, they help to foster skills and knowledge which are crucial to a full vocational and social life.

[Section 8](#) extends the discussion about assistive equipment and disability by linking it to issues that limit educational opportunities and identifies the potential that technology has to expand them. [Section 9](#) acknowledges the work done by the Australian Flexible Learning Framework to commission research and trial e-learning tools and technologies with students who have disabilities in the vocational and technical education system. It includes a web link to Framework resources, design guidelines and case studies for practitioners working with students who have a disability.

It is not possible in a report of this size to provide anything like an in-depth coverage of the available technological options. Nor are specific examples within each category cited. To document accurately even a representative sample of available products is a task which is beyond the scope of this report. Prices which are given are approximate and have often been rounded for easier reading.

## 2. Definition of terms

In this report, 'assistive technology' and 'adaptive technology' are used interchangeably. Assistive technology is defined as equipment, either purpose-built or a modified product, designed specifically for use by people who have disabilities. Examples include electronic Braille displays, hearing aids and membranous keyboards. 'Mainstream equipment' is that which was not designed specifically with people who have disabilities in mind. Some such products, however, have particular relevance to people who have disabilities. Examples include speech-to-text software, interactive whiteboards and optical character recognition programs. Depending on circumstances, mainstream products may be used separately or in conjunction with adaptive technology to provide educational resources for students who have disabilities.

Because of the context, this report focuses on equipment which is relevant to educational settings. That is, the vast range of equipment which aids with daily living, as important as it is, will not be considered here.

## 3. Synthetic speech

The evolution of synthetic speech over the past two and a half decades is arguably the most significant development for people who have a print disability. It has the potential to benefit people who have such problems as vision loss, dyslexia, specific learning difficulties, intellectual impairment, acquired brain injury and speech difficulties. It is also arguable that, in a highly visual educational environment, its full potential has not always been recognised.

Speech synthesizers initially consisted of external devices which connected to a computer's serial or parallel port. Some external examples are still available, usually connecting via the USB port. However, synthetic speech can now be produced within a computer by utilising its in-built sound card. That is, any Window-based or Apple Macintosh computer has the potential to provide synthetic speech. In fact, both operating systems provide synthetic speech utilities, albeit that the standard Windows speech is of a very poor quality.

Speech quality has been a major talking point since the inception of synthetic speech. There are three factors to consider here. The first, and often the most important, is the intelligibility of the speech. Highly intelligible speech has been

available since the mid 1980s. The second is consistency of pronunciation across a broad vocabulary and some examples do this better than others. The third issue is the degree to which the speech is human-sounding. Whether this is an important consideration or not will depend partly on individual preference and partly on the purpose for using synthetic speech output. Many blind people who use synthetic speech in conjunction with a screen reader ([Section 4.6](#)) prefer a flat intonation, which provides easier comprehension at high speed. On the other hand, human-sounding speech is more important for people using synthetic speech in an augmentative communication device ([Section 6.10](#)). Some who use it to augment visual reading will also prefer more human-sounding speech.

The cost of computer-based synthetic speech has reduced markedly over the past decade. External devices costing in the order of AUD\$1,500 were once commonplace. As well as those provided free on both Windows and Macintosh operating systems, very natural-sounding software synthesizers are now available for well under AUD\$100 in a broad range of languages. Most software requiring synthetic speech includes it in the cost of the product.

A distinction is made between synthetic speech and digitised speech. The former uses phonetic rules and exceptions to pronounce a broad vocabulary. Digitised speech, on the other hand, is pre-recorded human speech which is then stored digitally. Vocabulary is limited to a small number of words or phrases and speech should be both clear and human-sounding. It is used in an increasing range of specialised and mainstream products such as talking clocks, [calculators](#) and glucometers, car navigation products, lifts and automated telephone systems.

## **4. Vision impairment and blindness**

### **4.1 Brief introduction to vision loss**

When considering equipment for use by a person who has vision impairment, it is crucial to be aware of the nature and severity of the condition. Importantly, most people who have a serious visual loss have some useful vision. While this is valuable, it can also involve complexities not faced by those who have little or no sight. A person's level of vision loss is often erroneously referred to as a percentage. For example, "He has 15% sight." This is not very helpful in determining what difficulties the individual faces and what equipment is likely to be most useful. Vision loss is not simply a reduction of vision. The specific condition which causes the loss will affect what areas of visual performance will be compromised.

Visual acuity is a measure of distance vision. A person who has 6/6 vision as measured with a standard eye chart is said to have normal vision (a measure of 20/20 is equivalent in feet). That is, the person sees what is normal at that distance. If the acuity figure is 6/9, the person sees at six metres what is normal for nine metres and so on. A person with acuity of 6/60 must be 10 times closer than someone with normal vision to see the same object with the same level of clarity. Near vision is the eye accommodating to focus at distances between 25cm and 60cm. This is important for reading and other activities involving objects close to the eyes.

Visual field is a measure of how much can be seen while the eye is stable. A normal visual field is approximately 160 to 170 degrees. Field of view can be seriously limited by some conditions. A constricted field poses major difficulties for moving about, as many objects will not be seen. Another issue is that the periphery of the

eye provides vision in dim light. A person who has seriously constricted visual fields will therefore have little or no vision at night.

Photophobia is sensitivity to light. It affects many people who have a significant vision loss.

Legal blindness in Australia is determined by the following criteria. Corrected vision (with spectacles) in the best eye is less than 6/60 or visual field binocularly is less than 15 degrees. A person who is legally blind is entitled to various government benefits.

## **4.2 Conventional magnification aids**

It is important to understand that most people who have vision impairment have some useful vision. Due to the wide variation in nature and severity of vision loss, careful assessment of each individual's visual status should be undertaken prior to deciding on which aid(s) will be most helpful. This would usually be done by an optometrist or orthoptist who is skilled in prescribing equipment for people who have significant vision loss.

There is a wide range of conventional magnification aids. As already noted, it is important to match the aid with the individual's visual status and the intended use. Achieving the correct level of magnification is crucial. Insufficient strength has obvious implications. An aid which is too powerful will unnecessarily slow reading speed because the field of view decreases as magnification increases.

Benefits of this equipment include relatively low cost and, in most cases, a high degree of portability. Disadvantages can include difficulty in adjusting focus between notes and the whiteboard. Fatigue can also be an issue. Cost ranges between AUD\$20 and several hundred dollars.

## **4.3 Closed circuit television magnifiers**

This equipment may be helpful to people whose level of vision loss makes conventional magnifiers unsuitable. A camera transmits the image from the page to a screen. Some models can magnify to more than 50 times the original size. Some examples are quite small, fitting into a bag or briefcase. They are intended for incidental reading in such venues as libraries and perhaps in a class setting. Others are bulky and heavy and would usually remain in one location, with reading material being brought to them. Contrast and many other visual adjustments allow tailoring to individual needs. Depending on model, full colour is available. Many models can also be used to aid with handwriting. Some models can also be linked to a computer, allowing the user to switch between a paper document and information on the computer screen.

Benefits include a wide range of magnification and capacity to adjust levels of illumination and contrast. While primarily designed for reading, appropriate examples can also be used for viewing small details on such items as electronic circuit boards. Cost can be a prohibiting factor, ranging between less than AUD\$2,000 to over AUD\$7,000. Smaller, less expensive examples are less versatile. On the other hand, more powerful machines are more expensive and are usually quite bulky.

#### **4.4 Text/graphics enlargement on computer screens**

Both Windows and Apple Macintosh operating systems provide some magnification features. There are also several quite powerful software products available for Windows-based computers. Magnification up to 36 times original is available, together with a host of colour adjustment and layout options. Major developers also offer augmentation of the visual display with [synthetic speech output](#).

The principle benefit of this software is much improved access to computer-based information by people who have poor vision. Importantly, it can obviate the need to lean towards the screen, and therefore aids good posture. Apart from the cost, the biggest disadvantage is that magnification disrupts the original screen layout. This issue becomes more significant as magnification level is increased.

#### **4.5 Electronic Braille displays**

A Braille cell consists of dots in a matrix of 3x2 or 4x2 in any combination. Electronic (also called 'refreshable') displays consist generally of between 18 and 80 cells. Plastic pins are triggered electronically to form characters. An electronic Braille display can receive output from a screen reader ([Section 4.6](#)). They can also be used in purpose-built personal digital assistants ([Section 4.7](#)).

For people who prefer Braille to synthetic speech, this type of display is a very effective option. Hardcopy Braille is a very bulky medium and this technology overcomes that problem. Unlike synthetic speech, all punctuation is readily available. To some extent, a Braille display also helps with discerning document layout.

Cost is high, starting in the order of AUD\$5,000. For that reason, size of displays is limited. Due to the intricate nature of the display, there is potential for mechanical problems, but reliability is generally good.

#### **4.6 Screen readers**

A screen reader is software which captures information on the computer screen and sends it to a speech synthesizer and/or an electronic Braille display. Current examples are highly sophisticated in the way they present information to a user who is blind and who has requisite skills. A screen reader allows a blind person to access information and perform a wide range of computer-related tasks. Significantly, screen readers provide very impressive access to the internet.

It is important to be aware that a screen reader essentially only reads text. There are facilities for 'labelling' icons and, depending on various factors, this may require sighted assistance.

A potential user is confronted with quite a lot of learning in order to master the computer operating system and the various programs (word processor, spreadsheet, email, internet etc) to be used and the considerable number of screen reader commands. This is in the context that the user is working in an environment strongly geared towards visual presentation. Cost is moderately high, ranging between approximately AUD\$1,000 and AUD\$2,000 for Windows-based screen readers. A screen reader, VoiceOver, utilising speech output is provided on the Apple Macintosh. However, it currently works with a limited range of applications.

## **4.7 Personal digital assistants**

There is an increasing number of personal digital assistants (PDAs) specifically designed for use by people who are blind. Depending on brand and options, output is via synthetic speech and/or electronic Braille display. Some provide a QWERTY (standard) keyboard. Others employ a Braille keyboard, consisting of six or eight keys plus the spacebar and usually some additional function keys. This configuration has the potential of allowing the PDA to be very small.

These products are smaller and lighter than notebook computers. Battery life is also several times longer, commonly between 15 and 20 hours. Another advantage over a notebook, especially relevant in an educational setting, is that they can be switched on and off instantly. Being purpose-built, their interface does not mirror the visual concepts employed with mainstream computers and PDAs. This makes them ideally suited to note taking situations. Material can be transferred between PDAs and other computers easily. However, they do not support the majority of software which is available on mainstream computers. Current examples include such facilities as USB ports, Bluetooth and wireless internet access.

Due to most PDAs specifically for use by people who are blind not having a screen, together with an unfamiliar interface, teachers may have difficulty when instructing a student or checking the student's work. Cost starts at more than AUD\$3,000 for synthetic speech models and can extend to more than AUD\$10,000 for models with 40 cell Braille displays.

## **4.8 Braille embossers**

A Braille embosser is equivalent to a printer, except that raised dots are embossed onto the page rather than ink being placed on it. Therefore in the same way that text can be printed to a page, so it can be printed or, more correctly, embossed into Braille. It is possible to send material straight from a word processor to a Braille embosser, but it must be kept in mind that only 27 lines by 30 columns of text will fit on an A4 page. It is more usual, however, to use grade 2 Braille, which involves a complex series of abbreviations and contractions. The conversion from normal text to grade 2 Braille is done with sophisticated software, usually on the computer but in at least one product range within the embosser.

Text and basic graphics can be made readily available to Braille readers. While electronic Braille displays have many advantages, some material is more meaningful on paper. This is especially the case for mathematics. Furthermore, graphics cannot be displayed at all on electronic Braille displays. Some people are also more comfortable with paper-based study material generally

Braille can be embossed onto standard weight (80gsm) paper. For ephemeral material, this can be satisfactory. For material which is intended to be longer-lasting, heavier paper is preferable. Historically, some non-standard paper sizes have been used to accommodate Braille writing. This was in deference to its bulky nature. More recently, there has been a move to using standard sizes such as A4 and there are strong arguments for doing so. Benefits include easier handling of books by readers, easier storage and wider availability of paper.

Some embossers can write on one side of the paper only, while others can utilise both sides. Benefits of double-sided embossing are paper conservation and reduced bulk. While people who are blind are comfortable reading material on both sides of

the paper, sighted teachers who read Braille visually can find it confusing due to the indentations created when producing the dots on the opposite side.

If layout and/or content is critical, knowledge of Braille is required to ensure an accurate translation into grade 2 Braille. Braille is a very bulky medium. Compared to ink printers, Braille embossers are very noisy, slow and expensive. Cost starts from over \$3,000 for low volume examples, printing at less than 20 characters per second. Price rises to many thousands of dollars for high-speed equipment. For low to medium volume machines, cost is in the \$6,000 range.

#### **4.9 Recorded books and reference material**

This information is applicable to both some students who have vision impairment and some who have neurological disabilities. The discussion is contained in [Section 7.3](#).

## **5. Hearing impairment and deafness**

### **5.1 Brief introduction to hearing loss**

Hearing loss can be mild, moderate, severe or profound. Conductive loss is caused by a blockage in or damage to the outer, and/or middle ear. Sensorineural loss results from damage to, or malfunction of, the cochlea or auditory nerve. A mixed hearing loss is due to a combination of conductive and sensorineural damage.

As well as level of severity, crucial issues are when the loss occurs and when the diagnosis is made and intervention begins. Prelingually deaf people generally see themselves as belonging to the deaf community, which may or may not be the case for those whose loss occurs later. A distinction can be made between people who are deaf and those who are hard of hearing. The term 'deaf' applies to people who have a prelingual severe to profound hearing loss. 'Hard of hearing' applies to people who have a mild or moderate loss or a severe loss which occurs later in life.

Many prelingually deaf people cannot comprehend spoken English and communicate most effectively with Auslan (Australian Sign Language). An important consideration when working with students who are deaf is that they may have low literacy levels. This is due, in part, to English being a second language.

### **5.2 Hearing aids**

This summary provides some insight into the science of hearing aids and to the educational implications.

There are five types of hearing aid. The largest is the body aid. It can be carried in a pocket, clipped to clothing or hung around the neck. A cable carries the signal from the aid to the ear. It is robust and powerful. On the other hand, its bulk is often seen as a detraction by the user.

Behind-the-ear aids combine small size with considerable power. The aid, including microphone, rests behind the ear. They are more robust than smaller ones, have more features and are easier to repair. Some people are embarrassed because the aid is visible, while others find it helpful that people know that they have a hearing loss.

In-the-ear, in-the-canal and completely-in-the-canal aids are progressively smaller. Importantly, as size reduces so does power. Therefore, none of these aids are suitable for people who have a severe or profound hearing loss. As size diminishes, so does the scope for including features. One notable omission on very small aids is the T (telecoil) switch. The T switch allows clear reception of sounds from several external amplification sources, including a magnetic field loop described in [Section 5.5](#).

Hearing aids commonly have two or more listening programs for different situations. A remote control unit will be used to select the most suitable setting for the current environment. It is crucial that the aid is programmed for each individual by an audiologist.

A well adjusted hearing aid can be highly beneficial to some people who have a hearing loss. Importantly, it does not restore normal hearing and effort will often be required to derive significant benefit. Sound quality deteriorates significantly with increasing distance between the speaker and the listener. Because the aid amplifies all sounds, noisy environments can be especially challenging.

Cost starts from approximately AUD\$1,000 (cost doubles if both ears require aids). People under 21 and those receiving Social Security benefits are entitled to free service from Australian Hearing and approved service providers.

### **5.3 FM systems**

The person who is speaking talks into a microphone which is connected to a small FM (frequency modulation) radio transmitter. The person who has the hearing loss has a small radio receiver tuned to the same frequency as the transmitter. A number of options are available for getting the signal from the receiver to the listener's ears, depending on personal preference and level of hearing loss. These include audio shoe, induction plate and neckloop, all of which are hearing aid products. Some people find a set of headphones connected to the receiver adequate.

The major benefit is that the listener does not have to be close to the speaker to receive a clear signal. This is especially helpful in a classroom/lecture situation. If more than one person is speaking, it is important that the microphone is made available to each speaker.

One potential problem is that the transmission can extend beyond the room. In some circumstances this can create a security risk. If two systems are used near to each other – for example in adjacent rooms – listeners can receive signals from both sources, resulting in confusion. That problem can be avoided by using systems set to different frequencies or by using the more sophisticated (expensive) systems which allow user-selectable frequencies.

### **5.4 Infrared systems**

As with FM systems described in [Section 5.3](#) above, the speaker uses a microphone connected to a transmitter and the listener has a receiver which is connected to hearing aid or headphones. Because infrared transmission is line of sight, the signal rarely travels beyond the room, thus reducing the likelihood of interference. There is a risk that someone moving between the speaker and the listener will disrupt the signal, but this is not usually a problem.

## **5.5 Magnetic field loop**

This consists of a loop of cable, within which is created a magnetic field by electrical current produced from a microphone and amplifier. When switched to the T (telecoil) position, hearing aids within the range of the loop will respond with a clear, strong signal. A magnetic field loop can be set up permanently in a venue such as a classroom or lecture theatre. Alternatively, a temporary loop can be installed.

A loop can be a valuable resource in a learning environment. By using a suitably equipped hearing aid or a loop receiver (a small, battery powered device), a person who has a hearing loss can hear the speaker without intrusion of noise from within the room or from adjacent areas. As with FM systems described in [Section 5.3](#), the signal can be received outside the room where the loop is installed. Again, this can be an issue if proceedings are confidential. It is important that the lecturer is aware of the loop's presence and how to turn on the amplifier. To this end, suitable signage should be provided.

Costs starts at several hundred dollars and increases depending on the size of the venue.

## **5.6 Cochlear implant**

In summary, the cochlear implant is a device which provides people who have a severe to profound hearing loss with a perception of hearing. There are two major components: internal and external.

The internal component—the implant—is surgically inserted into the mastoid bone (the bone behind the ear) of the user. The external component consists of a microphone, speech processor and coil. The microphone is located on the user's head, held in place by the pinna (the external portion of the ear). The speech processor is either worn somewhere on the body (usually clipped to a belt) or behind the ear. Sound is received by the microphone and sent to the speech processor. Information is then carried between it and the coil by a cable—a very short cable in the case of a behind-the-ear speech processor. Information is transmitted from the coil to the implant by RF (radio frequency) signals.

Many of the ancillary facilities available with hearing aids are also possible with cochlear implants. These include telecoil, connection to FM receivers and direct connection to sound sources such as radio and television.

Candidates for use of the cochlear implant are selected very carefully. The fundamental criterion is that the individual will derive more benefit from the implant than from a hearing aid. Thorough medical and psycho-social assessments are undertaken prior to a decision being made.

## **5.7 Vibrotactile devices**

These devices convert sound information into patterns of vibrations that can be used by people who are profoundly deaf to assist their understanding of speech and awareness of environmental sounds. The most basic simply vibrate when there is a sound and do nothing when there is not. More sophisticated systems have multiple channels, each channel responding to a particular frequency range.

Vibrotactile devices consist of a processor and vibrators. The processor contains the electronics, system controls, batteries and microphones. If it is included in the particular model, the processor also contains a telecoil, which provides access to a loop in the same way as a T switch on a hearing aid. The vibrators, depending on the model and user preference, can be worn on the wrist, stomach, chest or neck. Sound is received by the microphone and is then processed and converted into a vibratory signal. In multi-channel systems, specific vibrators oscillate in response to particular frequencies.

With appropriate training, people who are profoundly deaf can learn to identify environmental sounds when wearing vibrotactile aids. An improvement in lipreading ability can also occur. Many people wearing vibrotactile aids can also learn to understand some speech in quiet situations. Vibrotactile aids may provide information not available via the hearing aid (for example, high frequency speech sounds such as 'sh' and 's'). Costs start at AUD\$1,500.

## **5.8 Captions for television and multimedia presentations**

Captions are text-based information which replicates what is spoken. There are two types of captions: open and closed. Open captions are permanently on the screen and cannot be removed. The only open captions available in Australia occur on some videos that can be bought or hired.

Closed captions can be turned on and off. They appear on television programs, videos and digital video disks (DVDs).

All digital settop boxes for televisions and digital cable television services can display closed captions. These will be recorded by analog video recorders (those recording onto tape) as open captions, whereas hard disk recorders can record them as closed captions. A teletext television can display closed captions. However, the captions cannot be recorded without the intervention of a digital settop box. Some analog video recorders can display and record closed captions. However, these are no longer sold in Australia.

Most, but not all, commercially available DVDs include closed captions. A DVD player will allow these to be turned on and off through its menus. Multi-language DVDs will include subtitles. While of benefit to deaf viewers, they are not as good as captions as they lack sound effects and do not indicate who is speaking. Some video tapes for purchase or hire will include open or closed captions.

Captions are typically produced by television networks, large film production companies and organisations specialising in captioning. However, tools for creating captions and/or audio-descriptions of multimedia material are available and these should be of interest to producers of educational material. The National Center for Accessible Media in the USA offers the free MAGpie software. It, together with a great deal of information, is available from <http://ncam.wgbh.org/richmedia/>. The Centre for Learning Innovation within the New South Wales Department of Education and Training has made considerable progress with both captions and audio descriptions by using Macromedia Flash (<http://www.adobe.com/products/flash/flashpro>) in conjunction with Hi-Caption from HiSoftware (<http://www.hisoftware.com/hmcc>).

## **5.9 Live Captions**

The Australian Caption Centre (<http://www.auscap.com.au>) offers captioning of teleconferences, lectures and other meetings. A stenographer, connected by telephone, records all spoken communication. A textual transcript is sent via secure internet connection to participant(s) who require it. A person who is deaf can therefore have immediate access to proceedings, whether physically present or at a remote location. Cost is \$225 per hour.

Another method for providing live captioning utilises speech-to-text software. The captioner repeats what has been said by participants into a microphone connected to a computer hosting the software. At this point in the evolution of the software, it would be problematical to have the lecturer and certainly other participants speak directly into the microphone. As discussed in more detail in [Section 6.9](#), albeit focusing on people who have physical disabilities, speech-to-text software still requires a degree of expertise for acceptable results. That said, as technology and techniques improve, speech-to-text software may prove to be an even more valuable tool in the future. Note particularly the Liberated Learning Project ([Section 8.8](#)).

## **6. Physical disabilities**

### **6.1 Brief introduction to physical disability**

Variation in the nature and severity of physical disabilities is huge. Problems can range from minor limitations affecting one part of the body to severe and generalised ones. Some conditions will improve over time, some will deteriorate and some will remain relatively static. Even for people who have similar clinical conditions, the degree of incapacity can be quite different. In turn, the technical solution which suits one person may not suit someone else with a similar problem. This can be due to a similar medical condition being manifested differently or to personal preference.

As mentioned above, it is vital to recognise that an individual's needs may change over time. For example, a person who has suffered a severe injury may initially use a particular device(s). As skills develop and confidence grows, other options may become suitable. On the other hand, a person with a deteriorating condition may require additional resources over time. All of these issues can make selection of aids for an individual very difficult and formal assessment will often be required.

### **6.2 Keyguards for computer keyboards**

The keyguard is made from a flat sheet of either plastic or metal. It is fixed above the keys; holes in the surface allow access to the keys. The keyguard prevents, or minimises, the pressing of incorrect keys by people who have poor motor control and/or tremor of the hands. It is also helpful to people using head-pointing devices to operate keyboards by minimising incorrect key presses. Conditions which may cause these problems include cerebral palsy, muscular dystrophy and multiple sclerosis.

The keyguard can be removed quite easily to allow use of the keyboard by a touch typist. It is now possible to have keyguards made for a wide range of keyboards. However, a keyguard will usually not be viable on a notebook computer.

### **6.3 Software to modify computer keyboard functions**

The action of keys can be modified through software to reduce errors and/or to allow easier operation. The following options are commonly available.

- Repeat rate can be reduced or eliminated. That is, when a key is held down, more time will be required before the character is repeated. This can be helpful in preventing accidental multiple presses of a key.
- Modifier keys—shift, alt and control—can be pressed in sequence before the key to be modified, rather than simultaneously. This facility is commonly referred to as ‘sticky keys’. It is an important feature for people who have difficulty pressing two keys at once. Pressing the shift key twice in succession will act as a shift lock. All following characters will be uppercase until the shift key is pressed again to release the shift lock. In many cases, but not all, the caps lock key can serve the same purpose.
- The numeric keypad can be used to emulate the mouse. For people who have difficulty controlling a conventional mouse, keys on the numeric keypad can be used to move the mouse horizontally, vertically and diagonally. Left and right mouse buttons are also available.

These facilities are provided in both Windows and Macintosh operating systems. In Windows, select Accessibility Options from the Control Panel or Accessibility from Accessories. On Macintosh (OS X), use Universal Access.

### **6.4 Alternative keyboards**

A variety of computer keyboards is available for people who have difficulty using standard ones. A brief description of each type is provided.

Compact keyboards have smaller keys, which may be closer together than usual. A numeric keypad is not provided. They can benefit people typing with one hand or using a pointing stick, as the target area is smaller. They also allow placement of a separate keypad, a mouse or trackball closer to the user’s midline, which is helpful for people who have difficulty with reaching greater distances. The separate keypad can be placed on the left side, which suits some one-handed typists. Cost starts at AUD\$100.

Expanded keyboards, on the other hand, offer larger keys. This can be done in one of two ways. Some examples use large keys. Others provide a membranous surface which can be programmed. In the latter case, a key or function can occupy an area as small as 2mm square or the whole area of the keyboard’s surface. These keyboards can benefit people who lack fine motor control. With suitable configuring, membranous keyboards can assist people who also have intellectual and/or visual deficits. Cost ranges upwards from several hundred dollars.

Keyboards specifically designed for one-handed use are available. Key layout is entirely different to regular keyboards. Cost can be very high (close to AUD\$1,000) and a person relying on such keyboards may face difficulties when one is not available.

### **6.5 Switch access to computers**

A switch, or more than one, can provide a person who has severely restricted movement with computer access. The type of switch and its placement will be

determined by a qualified clinician. Methods of activating switches include various levels of direct pressure, tilting, detection of eyebrow movement and sucking and/or blowing through a tube connected to the switch. The switch is connected to the computer via specialised hardware. It is used in conjunction with [predictive software](#) and [on-screen keyboards](#). Due to the specialised nature of this equipment, further details will not be provided here.

## **6.6 Head-mounted pointing devices**

Candidates for these products have head movement, but cannot use hands to operate a computer. One approach is described here: A small, adhesive dot is placed on the user's forehead, cap or glasses. A small unit mounted above the computer screen tracks movement of the dot via an infrared beam and the mouse pointer is moved around the screen accordingly. Clicking and dragging is achieved with a suitable switch. An alternative to a switch for clicking is to dwell for a pre-determined period on an item. Cost ranges from several hundred to several thousand dollars. On-screen keyboard software is necessary and predictive software is very helpful.

## **6.7 On-screen keyboards**

This is software which provides a representation of the keyboard on the computer screen. Characters are selected with the mouse or mouse substitute such as a switch or head-mounted device. A character may be selected directly or by way of a scanning array. The latter approach is necessary for some people who have very limited movement and is, necessarily, a very slow process. Most on-screen keyboards include predictive software which, to some extent, accelerates the writing process. Cost ranges from less than AUD\$100 for simple examples to more than AUD\$1,000 for highly sophisticated ones.

## **6.8 Predictive software**

As the user enters text, this software (also known as word prediction) attempts to predict the word which is being written. A list of possible words is displayed and the user chooses the correct one if it is presented. Typically, software 'learns' the user's word usage and can therefore make more accurate predictions. Some examples include synthetic speech output. Interestingly, word prediction is now built into mobile phones as text messaging has become increasingly popular.

Predictive software can help to increase the speed of text entry for people who must use methods which are intrinsically slow. It can also reduce physical effort which, for some people, can be considerable. Its potential benefit does rely on the user having reasonable vision. It is also important that the user has a reasonable literacy level when choosing from the word list. Cost starts from AUD\$200. Note that most on-screen packages include word prediction.

## **6.9 Speech input to computers**

This equipment is broadly recognised as an option for people who have difficulty using a computer keyboard. While it is not specifically produced for people who have physical disabilities, it is included in this section of the report because of its particular relevance. It comprises a microphone (either head-mounted or free-standing) which connects to the computer's sound card and software which provides the speech-to-text processing.

Speech input has the potential to allow a person to operate a computer and to write material without using hands, although some access to the keyboard and/or mouse is very helpful. Under best circumstances, a high level of accuracy is achievable. However, it does not yet represent the panacea which is sometimes attributed to it. Due to the importance of the technology and to the complex issues which surround its use, some factors requiring attention when contemplating its use will be summarised.

Typically the software must be 'trained' by each user, albeit that one example makes this optional with the latest version. The initial process involves reading passages of text and correcting the output until accuracy is satisfactory. To continue to achieve good results, however, it is important that the user maintains a regime of correcting errors as they occur. It is also necessary to maintain disciplined speech. That is, mumbling or slurring words will result in poorer accuracy.

If the user's voice changes due to tiredness, frustration or illness, accuracy is likely to deteriorate. A change of venue, where acoustics alter, may also have an adverse effect on accuracy. Use in a classroom setting is problematic, both in terms of background noise interfering with accuracy of the software and the user's voice disturbing colleagues. It is important that the user is motivated to use the system. Crucially, it is also necessary that the user has an adequate knowledge of both the operating system and the applications to be used. That is, formal commands to the application and operating system are required. Given the above considerations, speech input has the potential to be a valuable resource for people who have difficulty in operating a computer with their hands. If it suits the individual and circumstances, input can be both fast and accurate.

Windows XP includes a speech-to-text facility. Macintosh OS X includes a speech command facility. Cost of alternative software ranges from approximately AUD\$100 to more than AUD\$1,500.

## **6.10 Augmentative communication devices**

Communication aids such as symbol boards and alphabet cards may be used, but focus here is on communication devices. This equipment helps people who cannot use speech for all communication needs to communicate with others. There is a very wide variety of available options.

While people who are candidates for this type of equipment cannot use speech for all communication needs, many also have other disabilities. Many devices therefore provide a number of input methods. Options include QWERTY keyboard, various alternative keyboards, joystick, head pointer, touch-sensitive screen and switches. Storage of standard phrases is a common feature. Output can be via a screen, synthetic speech or digitised speech. In the case of digitised speech, a person other than the user speaks the required message and the message is stored in the device's memory.

Some programs run on personal computers and may be referred to as integrated systems. Dedicated devices are also available. Screen display may be text-based. Alternatively, a pictographic display may be employed, the screen changing dynamically in response to a given symbol being selected.

An appropriately selected augmentative communication device can do a great deal to benefit a student in educational settings. It may markedly improve capacity to interact in one-to-one and class discussions and make possible direct interaction via

telephone. There is also the potential to allow presentation of lectures, as demonstrated by the celebrated case of Steven Hawkins.

While purpose-built devices can be expensive, people who have good fine-motor control could use quite inexpensive tape or digital recorders. Another person would, of course, record the messages. Small digital recorders which have lengthy recording time and facilities for storing multiple messages should prove very effective for some people. Inexpensive software with high-quality synthetic speech and which is effective for people who have reasonable keyboard skills is also available for use on personal computers. With so many alternatives being potentially available, the price range is correspondingly broad, ranging from under AUD\$100 to AUD\$15,000

## **7. Neurological disability**

### **7.1 *Brief introduction to neurological disabilities***

Both the nature and severity of neurological disability can vary markedly between individuals. Three distinct categories of neurological disability exist and should not be confused:

- Intellectual disability, which usually occurs at or shortly after birth. This is a generalised intellectual deficit.
- Acquired brain injury (ABI) is as a result of trauma, usually as an adult. This may involve a blow to the head, loss of oxygen or medical events such as stroke (cerebrovascular accident). Symptoms are sometimes very subtle. Standard intelligence tests may not reveal any deficit, but problems such as short term memory loss can affect performance in an educational setting.
- Specific learning disabilities are a group of hidden disorders leading to difficulties in any or some of the processes of listening, speaking, reading, writing, reasoning or performing mathematical calculations. They are inconsistent with a person's general ability.

Specific problems faced by individuals must therefore be considered when exploring technical options.

### **7.2 *Talking calculators***

These products augment the visual display with digitised speech output. They are helpful to people who have difficulty with visual reading for any of a variety of reasons. Because the speech is digitised rather than synthetic, it is very clear. Some examples include an earphone jack, which avoids disruption in class settings.

Talking calculators can be obtained through electronics retailers. However, availability of specific models can be transient and supply is problematic. More reliable sources are agencies providing resources to people who have vision impairment. Cost for basic models ranges from AUD\$20 to AUD\$50. However, examples of scientific calculators are both rare and expensive, costing more than AUD\$600.

### **7.3 *Recorded books and reference material***

Talking books were originally produced to meet the needs of people with severe vision impairment, but are also relevant to people who have print disabilities for

reasons other than vision loss. Over more than half a century, the storage media have changed several times, ranging from analog formats such as vinyl records to various magnetic tape formats and to digital formats such as compact disks. Many formal talking books have been produced to provide recreational reading. While potentially useful as educational resources, they have the disadvantage of not including page numbers and spelling of important terms.

The reading of study material onto compact cassettes, often by volunteer readers, became an important resource since the mid 1970s. There has been a decline in popularity of this medium over the past several years and a concurrent increase in affordability and availability of digital recording facilities. The use of compact disks and CD-ROMs has therefore gained popularity. As well as material produced by specialist agencies, a substantial amount of audio material is now produced commercially, with the ongoing caveat that it lacks indexing and spelling.

The DAISY (Digital Audio Information System) Consortium (<http://www.daisy.org>) continues to refine the process by which audio material is indexed. Specifications cover audio only, text only, synchronised text and audio. This approach largely overcomes the navigational limitations of conventional recordings, which are not indexed. It is possible that as more DAISY material becomes available, together with equipment for reading it, audio material will continue to be an important educational resource. The availability of inexpensive recording software, which allows effective division of material, is also a positive development. These recordings can be distributed by a wide variety of media including compact disk, CD-ROM, mainstream and specialised MP3 players and the internet. The availability of software which utilises synthetic speech to produce audio files at high speed (Section 7.4) has been shown to be effective when used with suitable material and has the potential to replace human readers in some circumstances. Given the facilities discussed in Access to Reading Material (Section 8.4), there is a strong case for encouraging access to educational material via electronic documents rather than audio output in many circumstances.

## **7.4 Multimedia reading assistance**

This heading covers a broad range of technological options for people who have very diverse problems related to reading. Some products are inexpensive mainstream products which represent excellent resources when used appropriately. Others are purpose-designed to help people who have visual reading difficulties and are highly sophisticated.

Software is available which will provide simultaneous display of text on the computer screen and synthetic speech output. Text can be copied and pasted to the application. Some examples will also provide speech output directly from Microsoft Word, PDF files and web pages. An alternative to simultaneous display is to have text processed at high speed and sent via the speech synthesizer to an audio file. The material can then be put onto CDs, MP3 players etc. These products are available for under AUD\$100, including optional high-quality speech synthesis.

Products which are designed to help people who have reading and/or literacy problems also offer speech synthesis while displaying visual material. Both graphics and text can be displayed, reformatted and annotated. Computer-based material can be accessed directly and some products allow access to paper-based documents with the addition of a scanner. For that purpose, the software includes optical character recognition facilities. Cost range is broad, stretching from approximately AUD\$200 to AUD\$2,000.

## **7.5 Word prediction and contextual assistance**

The sophisticated software discussed in Multimedia Reading Assistance (Section 7.4) also includes features which assist in the writing process. Word prediction anticipates the word being written in order to accelerate the process. It goes further than that discussed in Predictive Software ([Section 6.8](#)) by alerting the writer to homonyms and providing examples of usage. A variety of tools provides help with sentence construction and grammatical rules. Some products are self-contained, while others are used in conjunction with mainstream applications such as word processors.

## **7.6 Membranous keyboards**

These were discussed in Alternative Keyboards ([Section 6.4](#)) primarily in the context of physical disability. They can also be of major benefit to people who have intellectual or cognitive deficits. This is because the keyboard can be configured to suit a specific learner and/or a particular task. The keyboard can be set up for text input in a variety of configurations. Other possibilities include object matching and selecting an item from various choices. To fully exploit these resources, time and effort may be required to produce suitable configurations.

## **7.7 Electronic dictionaries**

These can be computer-based, internet-based or self-contained products. Facilities such as a thesaurus, presentation of homonyms and examples of word usage may be included. Popular dictionaries are available on CD-ROM. Free and inexpensive dictionaries are available for download from the internet. Dictionaries can also be accessed from various websites. Self-contained products are small and battery powered and at least one example supplements the screen display with synthetic speech output.

A major benefit of electronic dictionaries over paper-based ones is speed of access. This is especially the case if the user's spelling of the target word is not accurate. In that event, it is common for these products to offer suggested alternatives. Some will offer only words close to the spelling entered by the user, while others will use sophisticated phonetic algorithms to try to determine the word being sought. Wildcard searching is also a common and very helpful feature. For example, entering tel\*e will find all words starting with 'tel' and ending with 'e'.

As mentioned above, some very useful resources are available for little or no cost. Portable products range in price, depending on features, from under AUD\$100 to more than AUD\$500.

# **8. The student, education and technology**

Under the best circumstances, students who have a disability will achieve educational outcomes in keeping with individual abilities. Unfortunately a number of factors militate against optimal outcomes for many students. Some of these will be considered below, together with recommendations for resolving issues which limit educational opportunities.

## **8.1 Social expectations**

While the primary task of this report is to promote effective exploitation of available technologies in the education of students who have disabilities, it is important to mention the social factors that may impinge on the learning process. Broadly held social expectations and stereotypes surrounding disability must therefore be confronted and, where applicable, challenged. There is a substantial body of research and anecdotal evidence which demonstrates a persistent societal belief in reduced performance by people who have major disabilities. To the extent that these beliefs are shared by parents, teachers and educational administrators and especially by people who have disabilities, they become self-fulfilling prophecies. Too often, a person who has a disability is seen as outstanding when performing what would normally be unremarkable tasks or pursuits.

Space and context does not permit further consideration of this topic. The importance of recognising ones expectations of people from various backgrounds is, however, essential. It will also be necessary from time to time to challenge beliefs of others, including those who have disabilities.

## **8.2 Selecting equipment**

It cannot be said too often or too strongly that appropriate selection of equipment for each individual is crucial. A poor choice can result in frustration for all concerned and an ongoing false belief that benefits of assistive equipment are illusory.

Especially when issues raised by the disability are significant and/or complex, involvement of expert(s) in the disability field who have strong knowledge of available resources will be very important. In some cases, this will include ensuring that use of proposed equipment will not further exacerbate the student's disability. While this process may involve initial cost, it should prevent frustration and avoid wasted resources.

It is also very important to involve as much as possible the person who is the candidate for the equipment in the decision-making process. While experts can provide valuable input, personal preference should not be overlooked. Where viable choices between different products are available, it is important that the student's preferences are seriously considered. In the case of younger students, it will also be helpful to involve parents or carers in the selection process.

## **8.3 Skill development**

Providing the very best equipment will not, of itself, guarantee optimal educational outcomes. Especially in the case of more sophisticated items, it is crucial that students receive adequate instruction in their use. While that may sound like an obvious point, the ramifications are considerable.

In the case of schools that provide education for students who have a specific disability, staff are more likely to have a thorough knowledge of specialised equipment. In mainstream schools and tertiary institutions, availability of staff with suitable knowledge is more problematic and challenges are even greater when students are studying remotely. In some circumstances, specialist agencies may offer instruction and some distributors will also do so. In both cases, a cost may be involved.

It is therefore essential that students' skill acquisition is part of the consideration during the equipment selection process. Whether instruction is provided by the teaching institution or by an external provider, it is crucial that students are equipped with the knowledge and skills to utilise the resources which are available. While some more adventurous students will teach themselves to use even quite complex products, it should not be assumed that such a situation is ideal or necessary. That said, students should certainly be encouraged to work diligently in order to exploit equipment fully.

## **8.4 Access to reading material**

It is difficult when discussing such a wide variety of students, equipment and circumstances to make prescriptive comments on potential benefits of actively pursuing technological solutions. Some broad observations, however, will illustrate what is possible.

A common feature of most of the products listed in Sections 3 to 7 is their provision of electronic information. The products which have been selected (and others) lend themselves to modern educational environments and they are especially relevant to e-learning. In some cases, provision of adaptive technology will be sufficient to meet a student's needs. Increasingly, however, its effectiveness will be enhanced by combining it with mainstream products in the electronic information field. The following discussion will illustrate this point.

A vast amount of information is now available electronically. Additionally, under ideal circumstances, hardcopy material can be converted to an electronic format relatively easily, discussed in Optical Character Recognition ([Section 8.5](#)). This means that students who need material in a variety of formats can potentially have it quickly and easily. For various reasons this ideal is often not achieved, but advancements of technology are continually improving the situation.

Once material is available electronically, students can access it through such means as a conventional computer screen, synthetic speech output, electronic Braille and text/graphics enlargement software. Importantly, students who have physical disabilities may find it easier to read from a computer screen than to manipulate a hardcopy book. It is not important whether text is read on a mainstream computer or a purpose-built device. Similarly, the same document is readily available to those reading from the screen, via synthetic speech or electronic Braille.

To ensure that the above does not suggest utopia, some caveats are provided. Speech synthesizers, for example, cannot interpret graphics. For students who use a synthesizer to augment visual reading, this may not be a serious issue, but it is for those relying solely on the synthesizer, Especially if the graphical content is vital to understanding of the subject. Graphical content will also not be available to people using electronic Braille displays. Depending on specific equipment and the user's skill level, complex layouts such as multiple columns and tables can also raise access barriers for those using synthesizers and Braille displays. While a topic in itself, it is very helpful if thought is given to such matters when material is being developed.

The developers of educational resources should aim to create content which is accessible to a diversity of users, particularly people with disabilities. Advice about this is available from the Australian Flexible Learning Framework's *E-standards for Training Project*:

<http://www.flexiblelearning.net.au/e-standards/topics/accessibility.htm>

## **8.5 Optical character recognition**

This involves a hardcopy document being processed by a scanner – essentially making an electronic image of the page. The image is then processed by software, either in a purpose-built scanner or more commonly on a standard computer, and characters are recognised. Once on a computer, the text can be treated like any other file. Some scanners include a sheet feeder, allowing multiple pages to be processed automatically. Books cannot be processed automatically without the intervention of a guillotine.

Cost of both scanners and optical character recognition software has reduced markedly over the past two decades. A basic scanner and software can now be obtained for less than AUD\$300. This, of course, assumes availability of a computer. Accuracy of recognition has also improved considerably. This, however, remains dependent on the quality of the original document and complex formats can also pose problems. While there can be frustrations, under many circumstances this is a very effective means of putting hardcopy material into an electronic format.

A distinction is made between optical character recognition and simply scanning an image of a document. The latter process is a quick and sometimes convenient method of making a document available electronically. However, it will not be accessible to people using speech synthesizers or electronic Braille displays and it cannot be searched electronically for specific words.

## **8.6 Interactive whiteboards**

While intended to enhance the learning experience of students generally, this technology can be utilised to markedly improve information provision to students who have disabilities. Firstly, the availability of these boards will further encourage computerized preparation of material to be presented in a teaching setting. As discussed in Access to Reading Material ([Section 8.4](#)), that material can be readily provided to students for access via adaptive technology. Anything written on the board during a lecture is also available for retrieval from the computer and handwriting recognition is available in interactive whiteboard software.

Another option is to send the output from the board to a notebook computer on the student's desk. Not only does this make it available for later revision, but a student who has reduced vision can read from the screen on the desk as material is added, rather than having to read from the board at the front of the room.

## **8.7 Note taking**

This is often a vexed issue. Many of the adaptive technology resources discussed in previous sections, combined where applicable with mainstream equipment, will often do much to resolve problems. While specific choice will vary according to individual needs and preference, there are many possibilities. These include purpose-built [PDAs](#), mainstream PDAs and notebook computers (with or without assistive software). Another possibility, discussed in more detail in Recorded Lectures ([Section 8.8](#)), is use of audio recording equipment. These tools have the benefit of allowing convenient editing, archiving and revision. Some powerful options become available when this equipment is used in conjunction with [interactive whiteboards](#).

There are good educational reasons for encouraging students, where feasible, to take their own notes. To this end, suitable equipment should be sought and skills

developed. There will be occasions when a student cannot satisfactorily take notes, perhaps due to the level of disability and perhaps contributed to by the nature of the subject matter. In these cases, it is important that the student is provided with adequate summaries.

## **8.8 Recorded lectures**

For many years, some students have circumvented note taking problems by recording lectures. This allows the lecture to be reviewed subsequently, at which time notes can be made. The advent of relatively inexpensive digital recorders over recent years allows enhancement of this process. Some examples allow rapid transfer to a computer for editing and/or storage. They are also small enough to be carried by the lecturer, thereby achieving a better recording than if held by the student at a distance.

One note taking option which has not been widely popular but which has some merit is dictation of notes by the student into a small voice recorder during the lecture. For this to be successful, a necessary skill is to speak loudly enough to make the notes audible and softly enough not to disturb fellow students. A benefit of this approach is that the equipment is very portable. With a little practice, notes can be dictated very rapidly. A disadvantage is that the dictated notes require subsequent transcription into a more permanent format. With the advent of specialised and mainstream PDAs, dictation equipment is likely to assume even less importance for many students. Nevertheless, there are circumstances in which it could still be a useful option.

Some progressive institutions have provided recordings of lectures for several decades. The primary purpose was to meet the needs of external and part-time students, but recordings could also be utilised by students who had difficulty with note taking during lectures.

As technologies have evolved, both the recording process and distribution of recorded lectures have become more sophisticated and some sites can now make the lecture available for download from the internet within an hour of the presentation. This allows students to listen to the lecture at a suitable time and speed. Significantly, some equipment allows audio material to be played back at speeds faster or slower than normal without altering the pitch. That allows a student to skim through a lecture to find salient points or to slow down a presentation if that is required to digest the information. A process which was undertaken by a small number of students due to specific needs has, then, become a mainstream resource.

The Liberated Learning Project (<http://www.liberatedlearning.com>) aims to provide multi-sensory access to lectures. Sponsored by IBM, it commenced at St Mary's University in Canada in 1999 and two Australian universities, University of the Sunshine Coast and Australian National University, are also involved. Speech-to-text software not only provides a transcript of a lecture but can also present the lecturer's words on a screen as they are being spoken. An audio recording is also available. Work is continuing on refining accuracy of speech-to-text conversion in order to reduce post-lecture editing. While currently costly, the project has the potential to markedly improve access to lectures for students who have diverse needs and learning styles.

## **8.9 Education and the internet**

Under the right circumstances, the internet has the potential to narrow the gap between students who have print disabilities and those who do not. Those circumstances include availability of adequate internet access and of relevant assistive technologies. With suitable resources and skills, a vast amount of information is available to a student immediately which, at best, would have previously taken weeks or months to convert into a usable format. [Screen readers](#), for example, present web-based textual material very effectively for blind readers. This is dependent to some degree on structure of the web page, which is a topic in itself (see <http://www.cli.nsw.edu.au/optionkeys>). Nevertheless, whether a student is seeking information from an institution's intranet or from a website anywhere in the world, the combination of the internet and adaptive technology represents a very powerful learning and information-gathering tool.

It is important to be aware of the substantial amount of public domain material which is available via the internet including many classical works. As well as this free material, publishers are increasingly producing electronic versions of books and making them available via the internet. Some of these are in proprietary formats which will preclude access with some assistive equipment and this issue should be investigated if a purchase is being considered. Some, however, will be readily accessible.

The internet therefore provides an excellent opportunity for students who have disabilities to gain ready access to a vast quantity of educational material. It is important to appreciate that the same document, often with no adjustment or reformatting, can be presented in a variety of ways. Options include electronic Braille, synthetic speech and text of a wide variety of shapes, colours and sizes. With inexpensive software (and usually some massaging), text files can also be converted into audio material to be played on CDs or MP3 players.

## **9. E-learning resources and technologies**

The national training system's e-learning strategy, the Australian Flexible Learning Framework through its Inclusive e-Learning Project, is helping people with disabilities to realise their potential by using technology to support their learning needs and increase their employability skills.

The Framework's Inclusive e-Learning Project aims to increase the uptake of e-learning resources and technologies among people with disabilities to improve employment-related training opportunities.

Information about e-learning resources and technologies research, guidelines, resources and case studies for practitioners in the vocational and technical education system working with students who have disabilities, can be found at:  
<http://www.flexiblelearning.net.au/inclusive>

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