DOCUMENT RESUME

ED 481 557 EC 309 864

| | |
|---|---|
| AUTHOR | Scheffel, Debora L.; Agnew, Jo |
| TITLE | Full Computer Access for People with Disabilities: The Goal of Transparency. |
| PUB DATE | 2003-05-00 |
| NOTE | 26p. |
| PUB TYPE | Information Analyses (070) -- Opinion Papers (120) |
| EDRS PRICE | EDRS Price MF01/PC02 Plus Postage. |
| DESCRIPTORS | *Access to Computers; *Accessibility (for Disabled); Adults; *Assistive Technology; Braille; Children; Computer Software; *Disabilities; Hearing Impairments; Physical Disabilities; Sensory Aids; Telecommunications; *Visual Impairments |
| IDENTIFIERS | *Transparent Models |

ABSTRACT

This paper examines the goal of providing transparent computer access to people with disabilities, especially those with visual impairments. First, four basic strategies to provide this population with access to technology are identified: (1) building features into the computer, operating system, or application programs; (2) using adaptive interfaces comprised of standard software or hardware products that provide modifications or alternate interfaces for accessibility; (3) establishing connectivity to personal assistive devices; and (4) developing custom adaptations. Application of these strategies is illustrated and discussed in case studies of people with visual impairments, physical impairments, and hearing impairments. Among the approaches reviewed in these case studies are Braille printers and computers, the Optacon, the Kurzweil Reading Machine, speech synthesizers, speech output software, magnification software, single-switch input systems, screen-based optical head pointing systems, voice recognition systems, StickyKey software, telephone devices for the deaf, the KEY plus keyboard system, and C-print. Discussion of future challenge considers the need to make graphic icons more accessible to the visually impaired in graphical user interface systems. (Contains 34 references.) (DB)

# Full Computer Access for People with Disabilities:

# The Goal of Transparency

Debora L. Scheffel, Ph.D.

Jo Agnew, Ed.D.



## INTRODUCTION

Full access to computers can significantly increase the level of productivity and independence for people with disabilities. Children and adults with disabilities make up one of the largest minority populations in the United States; represented by 49 million citizens who evidence a variety of disabilities. Those with disabilities have one of the highest unemployment rates in the nation (Galvin and Scherer, 1996). The potential of technology to increase the independence and productivity of people with disabilities is well recognized among those in the fields of special education and rehabilitation. This recognition has been supported by legislation designed to provide necessary access to technology. The 1996 amendments to the Rehabilitation Act (P.L. 99-506), the 1990 Americans with Disabilities Act (P.L. 101-336), the 1990 Individuals with Disabilities Education Act (P.L. 101-476), and the 1988 Technology-Related Assistance for Individuals with Disabilities Act (P.L. 100-407) have all placed significant emphasis on the use of assistive technology and have mandated that technology become more consumer responsive. The Telecommunication Act also requires accessibility to the information provided on the World Wide Web. For many, computer access and use are essential for use of assistive technology and are also important for success in a rapidly changing technological environment.

To achieve full access to standard computers and software, either for primary access to the computer or access to the computer as a link in using assistive technology, the goal is *transparency*. That is, the individual must be able to interface with the computer so that the special access technology is transparent or invisible to the computer. There are currently four strategies that enable people with disabilities to achieve special access to technology that is transparent or invisible to the computer:

- (1) building features into the computer, operating system, or application programs;
- (2) using adaptive interfaces comprised of standard software or hardware products that provide modifications or alternate interfaces for accessibility;
- (3) establishing connectivity to personal assistive devices; and
- (4) developing custom adaptations

The following case studies illustrate the use of the hardware and software features that support these four strategies in providing transparent access to computers for people with visual impairments, physical disabilities, and hearing impairments.

## CASE STUDY ON TECHNOLOGY FOR PEOPLE WITH VISUAL IMPAIRMENTS

Mary is sixteen years old and captain of her high school debate team. With a big debate coming up next weekend, she is practicing on the presentation of critical arguments related to her debate assignments with her mom, Gretchen. As Mary practices, Gretchen reflects on how proud she is of her bright and lovely petite daughter with blue eyes and long blonde hair. As a teenager, Mary is very well adjusted and has good friendships with her peers and the respect of her teachers. She also has a condition known as macular degeneration, which has resulted in a steady decrease in her vision. Currently she is able to distinguish between light and dark when presented within two inches of her better eye. Mary learned to read Braille as a child, when her eyesight started deteriorating. She uses a seeing-eye dog for mobility. Mary takes history and several other high school classes that require her to review information and write papers.

Computer access is necessary for users with visual impairments, who can utilize computers as speech-enabled training programs; Braille training programs; Braille translators; Braille, voice, and large-print note taking systems; speech output calculators; interfaces with other equipment; orientation and mobility aids; and dynamic Braille displays (Galvin and Scherer, 1996). The major barrier for computer use among those with visual impairments is the screen display. The increased graphics on computers have resulted in a net loss of accessibility to the computers and to the information presented through them to people with visual impairments (Galvin and Scherer, 1996). Those with visual impairments need access not only to input text, but also to text attributes, help information, prompts, messages, menus, and requested information. Compensation for the display can be in an auditory mode, tactile mode, or a combination. For persons with low vision, there is a need to enlarge the text and graphics to various pt. sizes. 27% of individuals identified as legally blind use primarily visual means to access text while 10% use primarily auditory means; the remainder use a combination of techniques (Smith, 1998). Thus a variety of means need be available to create access to computers for the visually impaired.

Understanding the application of the four strategies related to these current features is important in supporting the achievement of transparent computer access for Mary and other people with visual impairments. Current hardware and software features for people with visual impairments tied to the four strategies which support transparent computer access for people with visual impairments will be described and later summarized in this case study. Major hardware and software features include Braille note takers, Braille translation software, speech synthesizers with adaptive software, and screen magnifiers.

Braille is one way in which those with visual impairments can receive tactile input to replace or augment visual input. An example of the fourth strategy, developing a custom adaptation, is reflected in the method Fant (1982) created to allow brailing on the standard line printer. The adjustment to the printer is a strip of specially prepared cellophane tape. Since it is not necessary to remove the ribbon or adjust the impact force, printer output can be obtained concurrently with Braille output. When a specially designed printer is attached to a microcomputer, standard text can be translated into Braille, allowing a sighted person who does not know how to use Braille to produce Braille copies of handouts and other textual materials. Some printers produce Braille and print on the same page so that users may read along with those with visual impairments use (Smith, 1998). The disadvantages of Braille printers are that they are slower and noisier than ink printers, as they are driven by solenoids which emboss Braille dots on a page; depending upon the cost, the printers can produce 10 or more characters per second (Galvin and Scherer, 1996).

In addition to the use of Braille printers, refreshable Braille displays are separate devices which connect to a computer and display 20, 40, or 80 characters of text (Lazarro, 1993; Galvin and Scherer, 1996). Each Braille cell consists of six solenoids. The Braille letters are formed by sets of pins being raised and lowered electromechanically. As the input is typed in, the user can review it on the line display. The displays are refreshable in that they allow the information displayed to change as the user moves the display window around the screen. Each refreshable cell displays one character and costs approximately seventy dollars to build. The high cost of Braille displays forces many to develop skill using synthetic speech. Less expensive Braille displays are currently being developed; for example, the Freedom Scientific Corporation is marketing the JAWS program, as a screen reader program as well as Open Eyes software, and the new PacMate that will have a 40 refreshable Braille display on the market by Fall, 2003.

Portable Braille computers have also been developed. The keyboard consists of six standard keys that allow the user to produce a standard 6-dot Braille symbol. Computers can be used as input devices that interface with personal computers. Mary uses a Braille and Speak® to take notes during classes. Devices such as the one Mary uses, are known as Braille note takers. They are small battery-powered devices which allow the user to enter the information through the use of synthetic speech or through a Braille display. The information stored in the memory can be saved to a computer disk or printed when the user returns to the home or office (Galvin and Scherer, 1996). Portable Braille computers generally come with word processing and telecommunications software. Other possible features are compatible with most commercial screen reader software (Lazzaro, 1990, 1993).

Fant (1982) developed a software method using the Pascal language to allow brailing on a standard line printer. With the development of Braille printers came the need for Braille translation software. Translation consists of two steps. First, the print symbol in the source document is translated to a corresponding Braille symbol; second, text is reformatted to fit on the smaller page. This translation can be accomplished on various computers, as translation software is available for the IBM PC, and Macintosh. For example, the Duxbury Braille Translator from Duxbury Systems works with most word processing packages, including WordPerfect. In some packages, the software is placed on a ROM chip (Lazzaro, 1993).

Like Braille printers, a Braille display requires software to control it from the keyboard. Software allows reading the text line-by-line, word-by-word, or character-by-character (Lazzaro, 1993). One type of technology which recognizes graphic icons and uses synthesized speech or Braille, OCR (Optical Character Recognition) technology, requires software which handles document recognition. This document recognition may be accomplished using two methods, template-based and feature-based recognition. The template method involves scanning a collection of letters and finding the template which most closely resembles the ink mark. The feature method breaks an ink mark into a collection of features by identifying where strokes join and curve significantly (Wayner, 1993).

In the 1970's, Raymond Kurzweil developed the first computer-based reading machine which consisted of a flatbed scanner, central processing unit, and a detachable keyboard, which is an example using the first strategy of building features into the computer, operating system, or applications programs. The cost was $30,000. For over a decade, this was the only option for transforming printed text from a book, magazine, or newspaper into synthetic speech. In contrast to these stand-alone reading machines, there are PC-based reading machines that scan a page of print and convert the text to synthesized speech, Braille, or large print output (Hallahan and Kaufman, 1997). Because they are PC-based, they have the advantage of being usable with other typical computer software. Telesensory Corporation has developed a system to send output to a Braille printer, or the Optacon hand-held scanner which converts Braille to tactile letters using vibrating metal pins that are felt on the index finger. There is also an Optacon II that scans computer screens and can send output to a Braille display or a speech synthesis system. The hand-held scanners make it possible for users with visual impairments to access many documents found on the internet (Galvin and Scherer, 1996); however, these reading machines use computer based optical character recognition systems, and all have limitations on what types of fonts they can recognize. Using intelligent character recognition (ICR), some machines can now recognize thousands of typefaces and styles. The user must be able to use a keypad for adjusting volume, voice, and speech rate, as well as placing the document correctly so the page can be scanned (Kaplan, 1996). Mary uses a system that scans printed text into the computer and then uses a screen reader to read the text to her.

The development of the Kurzweil Reading Machine showed that speech synthesis was possible in the 1970's. In contrast to the Optacon, one of the advantages of synthesized speech is that it allows a rate of speech as fast as human speech. To enable a computer for synthesized speech output, the system generally requires software, a speech synthesis board with audio amplification, an interface to the personal computer bus, and a speaker that is external to the computer. Products are available as internal circuit cards or external devices that connect via serial or parallel ports. Synthesizers with higher speech quality are often more easily understood and require less training time, but have slower response times and are more expensive than those characterized by a robotic, artificial quality. The Microvox is an intelligent peripheral device designed for use in a wide number of applications. Its hardware is like a general-purpose computer with a speech synthesizer attached using a memory-mapped I/O port. By combining the text to speech algorithm with a dedicated processor, dependency on the operating system and application programs to support speech synthesis is no longer necessary. A computer with a sound card has a synthesizer capable of speech, and on a Windows-based PC, any command that can be performed with a mouse command can also be performed by a keyboard or series of keyboard commands.

Verbal input may be used in lieu of the keyboard to access computer technology. While there are no speech-enabled operating systems, there are now a number of speech-enabled application programs. This may be accomplished by using speech synthesizers, which require software that is commonly referred to as a screen reader.

Those with visual impairments can also receive computer information output through speech synthesizers with adaptive software. Software for the Microvox synthesizer allows punctuation symbols and abbreviations to be converted into words; speech output may also be synchronized with other information, such as text or graphics on the screen. A complete phrase can be entered before translation from text to speech;

this minimizes distractions which could arise if the software were to output each character of phoneme as it was entered. The Microvox can output the information in four modes of translation; these modes are text-to-speech, text-to-spelled-speech, phoneme-to-code, and music.

Screen readers now allow visually impaired persons to access commercial software with an unlimited vocabulary. The user can choose from a variety of verbal output modes, such as a character-by-character, word-by-word, line-by-line, and screen-by-screen. Additionally, various settings can be controlled, including volume level, pitch quality, punctuation marks pronunciation, pronunciation of numbers of digits or words, elimination of repeating or special characters, and indication of capital letters by changing the pitch or saying "capital" before the letter.

Users of speech output software encounter problems when they access the World Wide Web; these problems can be eliminated with foresight on the part of the web page designer. The designer should use “ALT” tags with all images, as users of speech output software or non-graphical browsers rely on these alternate text labels. The designer should also limit the use of image height and width tags to larger images; in browsers that maintain image size even when images are not displayed and ALT tag may not have room to display within the borders of a small image, and therefore will not be read properly. Finally, the designer should avoid using tables. Screen reader programs are often unable to interpret a logical order within tables and tend to read straight across a page, even when cells or columns contain wrapped lines (Illinois, 1997).

Since the majority of those who are legally blind and evidence low vision have residual vision, use of magnification devices is an important option for accessing computer displays. Compu-Lenz consists of a plastic lens and mounting hardware. One method to add large print to a computer is to use a hardware-based large print system which includes a special video card, a large monitor to increase font size, and a joystick or mouse to move the cursor (Lazzaro, 1993).

Magnification is necessary for users with low vision, as the icons on computer screens are often too small and detailed. For those people with visual impairments who have low vision, software is a more practical solution to magnification than hardware. Screen magnification software is often used to provide higher magnification and additional contrast and color enhancement, which can increase the user's access to the Work Wide Web if the web page designer does not consider the user's needs. HTML, the language which web page designers use, was not intended to control the appearance or layout of a page, but designers sometimes limit the user's choices in setting up the page design. Viewers should have complete control of how a page is displayed, including whether it is with large fonts, high contrast colors, or in a format compatible with a special accessibility program.

The current generation of magnification software is generally TSR (Terminate; Stay Resident), a program which is loaded and then disappears but stays active in the computer. Commercial software can then be loaded on top of it, and the TSR program automatically magnifies the output from the commercial software. Average magnification ranges from 1.4x to 16x, and it is advantageous that no additional hardware is needed with this software (Lazzara, 1990, 1993). Screen magnification is also a standard feature of Windows 95; this system allows magnification of up to 16x (Galvin and Scherer, 1996).

Current hardware and software features for people with visual impairments were described in this case study and include Braille note takers, Braille translation software, speech synthesizers with adaptive software, and screen magnification. Understanding the application of the four strategies related to these current features is important in supporting the achievement of transparent computer access for Mary and other people with visual impairments. Specific aspects of the use of these features as related to people with visual impairments in the context of the four strategies are briefly summarized below and were fully described in this case study:

- Strategy #1: Building features into the computer, operating system, or application programs;

  Example: Braille note takers and translation software

- Strategy #2: Use of adaptive interfaces comprised of standard software or hardware products that provide modifications or alternate interfaces for accessibility;

  Example: Adaptive interfaces for screen display as related to the need for text attributes, help information, prompts, messages, menus, and requested information that can be made in an auditory or tactile mode or combination of both

- Strategy #3. Establishing connectivity to personal assistive devices.

  Example: Speech synthesizers/Screen readers

- Strategy #4. Developing custom adaptations.

  Example: Magnification software, TSR

CASE STUDY ON TRANSPARENT TECHNOLOGY FOR INDIVIDUALS WITH PHYSICAL IMPAIRMENTS

Mike is fourteen and currently vice president of the art club at his high school. He was recently awarded 1st place for his unique graphic illustrations at the state art show for gifted young artists. Mike also is quadriplegic and uses a powered wheelchair for mobility. While he has limited use of his hands with no discernable individual finger manipulation, Mike does have good head and neck control. He is required to use his computer to complete assignments and to access his environment.

Technology has changed the lives of people with physical disabilities by allowing them to perform daily activities they would not be able to do without help. Computers may be used for augmentative communication, writing and printing, and creating smart rooms where the thermostat, lights, music, and doors are controlled by a computer panel (Smith, 1998). However, the user with physical impairments computer access is often hindered by the typical keyboard design, which necessitates the ability to execute multiple keystrokes with reasonable typing speed by those who are able to use the keyboard to some degree. The accessibility needs of the users with physical disabilities vary greatly due to range of movement capabilities; therefore, hardware and software must also show great adaptability in meeting their needs. The ABLEDATA and Tracebase databases list 20,000 assistive technology devices of all types, including communication, control, and computer access aids containing a wide range of adaptations. These adaptations include arm supports, copy holders, keyboard trays, paper loaders, and wheelchair interfaces. There are also a wide variety of software adaptations and switches listed (Galvin and Scherer, 1996).

For those users with physical impairments with severe disabilities, single-switch input systems can be used. Single-switch input systems may be placed so as to utilize those body parts that the user is able to move or apply pressure with; the user then activates the switch when the desired choice is presented. Other special input switches include brow movement switches; sip and puff switches; and lip, tongue, jaw, head, knee, touch, flex, squeeze, blink, or tip switches (Vanderheiden, 1987). Mouthsticks may be used by those with good control of neck and head muscles. Disadvantages in using these methods of input include their tendency to be slow and not to allow keys to be pressed simultaneously (Brody, 1989).

Screen-based optical head pointing schemes also may be used by those who have head control. The user may wear a small headband hat or headset; as the user moves the head, a sensor points to a function menu and activates the desired command. Head movements may also control the cursor on the screen (Kaplan, 1996). The H-Com hardware was designed for those with severe mobility limitations (Ciarcia, 1983). The H-Com was developed as a peripheral to do the same job as a keyboard; it allows use of one key as a single user-input point referred to as a switch. A more recent development is the use of a camera which can be attached to the head. The user then searches an emulated keyboard and selects a letter; if the gaze is held for a second, that letter is input as if it came from the keyboard. In the same manner, lightweight reflectors on the head or any part of the body can send an infrared signal to the position of the cursor, which then activates a switch. Mike uses a Headmaster®. It is a combination of software and hardware device that allows the user to control the mouse with his head movements. A pneumatic, or sip and puff switch, allows him to make selections. The software provides an onscreen keyboard for word processing.

A large number of individuals with physical disabilities can also utilize voice recognition systems. Voice recognition systems using both peripherals and circuit cards have existed or were in development in the early 1980's. Most products use a microphone that is worn on the user's head. However, the high signal-top-noise ratio can affect the computer's ability to recognize voice input. Other voice recognition systems use a standard microphone and an A/D (analog to digital) converter. The Kurzweil Voice Report system can be plugged into most PC compatibles (Lazzaro, 1990). Macintosh computers have built-in microphones; however, on other computers, and external microphone is attached through a jack without regard to whether a circuit card is used. External voice recognition systems are generally the size of an external modem and are attached to the serial or parallel port. On the Macintosh, a voice recognition system can be interfaced to the SCSI port (Lazzaro, 1993). The minimal hardware for a voice recognition system is a microphone and an ADC (A/D converter) chip, although a digital signal processor (DSP) can be used to increase the processing power. The purpose of the hardware is to convert analog speech into digital form, which is then processed by a DSP, a microprocessor, or both. A few computers are now available with some built-in hardware. Sun Microsystems' workstations include a microphone port and A/D converter. Compaq PCs may come with built-in speech hardware and include speech recognition software (Meisel, 1993).

For those users who are unable to use the keyboard or other physical input devices, voice recognition systems may be used, which also require software. Early voice recognition systems were limited in the number of words that could be recognized. The software needed to be trained to recognize words or phrases; a training session involved repeating each entry three times and typing it once. After training, the recognition rate was 98-100% in a quiet and controlled environment (Murray, 1982). Today's speech recognition software rarely involves a training session. According to White (1984), speech recognition systems which involved pattern-matching techniques were elemental, for they were limited to recognizing short phrases.

Voice recognition software can be classified by speaker dependency or by how words are recognized. The speaker-independent system recognizes voice with no training; however, it is restricted to a small vocabulary. A speaker-dependent system must be trained; this training time is approximately 1 hour on most systems. One of the most sophisticated systems uses a speech recognition board and software capable of understanding 25,000 common words with room for adding 5,000 special-need words. Multiple users can utilize this system if it is trained to recognize each voice. When words are entered during the training process, a template is built for later use. The input is converted to standard computer code, which is then compared against the template to do pattern matching. Words can be recognized as separate units or as blocks of words. Discrete-utterance systems require a slight pause between each word, while continuous-utterance systems understand uninterrupted bursts of speech. IBM began working on a discrete recognition project in the early 1980's; most systems are now speaker dependent and utterance-discrete (Lazzaro, 1993).

For those users with less severe physical impairment, expanded keyboards may be utilized. For those who are able to print but have a limited range of motion, small arrays of numbers can be used to specify letters and words by encoding (Vanderheiden, 1982). Miniature keyboards are an option for those with good control but a small range of motion. Those with limited upper limb control can use light pointers strapped to the wrist or attached to a headpiece; these pointers are used to direct a light beam toward a sensor panel or a screen drawing of the keyboard to indicate the chosen keys.

The keyboard may be adjusted with a keyguard, which prevents accidental keystrokes due to extraneous motion by pressing the keys. A key must be pushed by putting a finger or stick through a hole in the keyguard. The size of keyboards can vary, enabling individuals with large arm movements who lack finger control to use an oversized keyboard (Brody, 1989).

Macro programs allow modification of keyboards to combine common commands in a single keystroke (Brody, 1989). This can assist the users in performing activities related to word processing, database management, spreadsheets, telecommunications, bookkeeping, and programming. Macro programs also allow the redefinition of the keyboard by rearranging the keys into a more convenient pattern; this modification may be utilized when a key is in a position that is difficult for the individual to use. Built-in macro programs exist in some commercial software such as WordPerfect and Lotus 1-2-3. However, the macro program can only be utilized when the application is running (Lazzaro, 1993).

In addition to allowing the keyboard to be simplified or rearranged, StickyKey software and keyboard modification programs provide benefits for the physically disabled. StickyKey software is an option for individuals with spastic movements. This software makes it possible to enable keys that must be pressed simultaneously to be pressed in sequence; the capacity is also available to toggle keys such and Alternate (ALT) and Control (CTRL). Slowkeys adjust the length of time that a key needs to be held down before the character is accepted. MouseKeys is a keyboard modification that has the ability to emulate the mouse movement through use of the number keypad, and RepeatKeys slows down the effects of accidentally struck keys that repeat; BounceKeys direct the computer to ignore keys that are bounced or struck twice by users with tremors. SerialKeys allows a person to connect their personal assistive devices to a computer and use them instead of the keyboard or mouse (Galvin and Scherer, 1996). These software packages are compatible with most computer systems (Lazzaro, 1990, 1993).

Word-prediction software further increases the speed of inputting data through the use of a keyboard. The software monitors the keyboard for characters typed in sequence; based on those few characters, a list of possible words is supplied. The user may select a word or continue typing to narrow down the choice of words. Words utilized most frequently by the users are place at the top of the list (Lazzarao, 1990).

Eyegaze is another computer software product which can be used by users with physical impairments who cannot use single switches or voice systems. The computer is installed with a camera that follows the person's eyes and types the letters that he looks at on the screen. When the user is finished with the sentence, he looks at the enter button. This program is useful for regular word-processing and e-mail software; however, the cost is high at about $25,000 (Smith, 1998).

TECHNOLOGY FOR INDIVIDUALS WITH HEARING IMPAIRMENTS:

CASE STUDY:

Marty is an eighteen year old high school senior who has many goals for his future. He is profoundly deaf, yet, he doesn't allow this disability to slow him down. Marty can read lips and knows sign language. In addition, with support from interpreters in class and help from his classmates who take notes using a laptop computer and then e-mail copies of their class notes to him, Marty manages a full load of classes and is able to successfully complete all his assignments for each class. He is planning to go to business school at a state university after he graduates from high school. Marty hopes to work for a major corporation when he graduates from college.

It is important that users with hearing impairments continue to gain access to computers, as computers perform many uses for people with hearing impairments, such as capturing and translating spoken speech into text for visual display; providing real-time captioning for speakers at public and private events; teaching finger spelling and sign language; controlling home signaling and security systems; carrying on communication via e-mail and on-line chat sessions; and providing multifunctioning telecommunications access (Galvin and Scherer, 1996).

Telecommunication is important in the life of the person with a hearing impairment, as it is a bridge between the hearing impaired and hearing world when communication is vital. Computer systems allow people with hearing impairments to communicate via TDD (telephone device for the deaf)/TTY ASCII, speech recognition, speech synthesis, and Touchstone keypad to text translation. Users with hearing impairments can benefit from the KEYplus keyboard from Ultratec, which is designed for use on IBM-compatible computers. KEYplus contains a free-standing TDD and TDD call detector. The TDD contains a 48-character two-line titled display and a 24-character thermal printer. It can communicate with ASCII or Baudot modems, and it also allows a user to answer a TDD call without interrupting the operation of the computer (Galvin and Scherer, 1996)

It is difficult for people with hearing impairments to watch an interpreter and take notes at the same time. A system called C-print is useful in note-taking situations; this system uses a computer laptop, 2 commercial software packages, a standard word-processing program, and a computer shorthand system. To provide real-time translations, C-print uses a trained operator who listens to the lecture and types special codes that represent words into the computer; the translation is instantly shown on a special screen that sits on top of an overhead projector. Once the lecture is completed, the person with a hearing impairment can get a printout. Studies have shown that students have a higher rate of understanding lecture materials when using C-print, than they do when using sign language interpreters (Smith, 1998).

Present computers contain four types of built-in accommodations which allow further adaptations through software. Computers contain features such as controllable volume level, headphone/speaker jacks (which allow for amplification modification), SoundSentry features, and ShowSound features which include captions.

Special software can be used to convert audio output into a video format. Many programs can use captioning to display audio information in a visual format. Microsystems Software's SeeBeep allows the whole screen to flash or to have the word "beep" flash at the location of the cursor. Other software may display a small musical note in the upper left corner, change the screen color, or display the word "beep" at the cursor position (Lazzaro, 1990, 1993). The SoundSentry software adaptation, which is a standard feature on Windows 95, provides a visual on-screen indication whenever the computer emits a sound; although good for detecting simple warnings or beeps, it does not tell what type of signal it is. It is not useful if the signal is speech. The ShowSounds system level software, which is also a standard feature since Windows 95, is a flag or switch contained in the computer's control panel; it allows the user to have any important sounds that are created by the computer shown in some visual way on the screen.

For those users who may only have a partial hearing loss, the volume control in the control panel of the Macintosh can be set to any level (Lazzaro, 1990). If Marty sets the volume level on his computer to 0, the menu bar will flash in place of beep.

## FUTURE CHALLENGES

One of the biggest challenges for the future is to make graphic icons more accessible to the visually impaired, through tactile, magnified, or audible displays; present systems use small icons which are difficult to see, and users with visual impairments must use keystrokes to access the computer, as opposed to using the mouse. Graphical User Interface (GUI) systems use a pixel-based display (such as that which is used in Windows systems) rather than a physical or character-based display (such as that which is used in DOS systems). Screen readers also need to be enhanced so that they will accept low-level graphics commands and build a text database that models the display. A prototype, Screen Reader/PM from IBM, allows the user to maneuver the mouse or the keypad, while a voice synthesizer describes the icon displayed on the GUI or the graphical text shown on the screen.

In an effort to improve GUI accessibility, Outspoken for the Macintosh uses a database called an off-screen model (OSM); this is a data base reconstruction of what is visible and invisible on the screen. An OSM must manage text, off-screen bitmaps, icons, and cursors. Mouse movements must be tracked, positions must be matched with OSM icons, and the associated icon names must be vocalized by a screen reader. The OSM needs to provide the cursor information so the screen reader can vocalize the position. It also must know the dimensions, associated text string, and string character position. The cursor's window identification must also be tracked. When a window becomes active, screen readers must determine if it has a cursor and vocalize it (Schwerdtfeger, 1991).

In the quest to improve GUI accessibility, Boy, Boyd, and Vanderheiden (1990) describe three stages in the development of GUI access for the visually impaired. The first Customizing Stage involves utilizing applications whose purpose is to enable those with visual impairments to read text produced on graphical computer through speech or Braille. This is essentially a coping strategy. The second Single Sensory Mouseless Stage involves an interception strategy in which ASCII information is captured before it gets to the screen. Outspoken is the first commercial application to utilize an interception approach. This strategy also seeks to enhance the ability to recognize icons and simple graphics. The final stage is the Multi-Sensory Approach using a mouse. It involves extending capability across applications and operating systems and extending access to complex graphics. Currently, development is in Stage 2, Single Sensory Mouseless Strategy. The GUI should eventually provide the same benefits to those with visual impairments as it does for the regular user.

Voice recognition systems may not be a realistic input method for individuals with physical disabilities who also have a speech impediment or limited lung capacity. The Smith-Kettlewell Eye Research Institute has developed a brain-wave interface, which monitors electrical activity in the brain to determine where the user is staring on the screen. A theory exists that people's brains respond to words and ideas in similar ways; therefore, researchers intend to standardize computer input to the patterns of electrical activity. Electrodes will be used to determine the pattern of electrical activity that represents a word, and the word being thought of will then appear on the screen (Brody, 1999).

Efforts must also be made to see that users with disabilities have transparent access to computers. The person must be able to interface with the computer in such a way that the computer cannot tell that the user is not using a standard technique; in other words, the special access technology must be transparent or invisible to the computer. When an interface technique is truly transparent, the individual with the disability is able to access and use all of the standard software that is written for a computer that any user without a disability could use.

When people with disabilities are able to interface with computers to the degree that special access technology is transparent or invisible to the computer, they are able to achieve what is known as full computer access. In other words, full computer access for people with disabilities means they can access and use all of the standard software written for a computer that any user without a disability could use. Having full computer access significantly increases the independence and productivity of people with disabilities.

## REFERENCES

Boyd, L., Boyd, W., & Vanderheiden, G. "Graphical User Interface Crises: Danger and Opportunity." *Trace Authored Papers from the Thirteenth Annual Conference on Rehabilitation Technology*. 1990.

Branzburg, J. (2001). Models for student web-based research. *Technology and Learning*, 22(1), 22.

Brody, H. "The Great Equalizer: PCs Empower the Disabled." *PC Computing*. July 1999, 82-93.

Brown, C. "Assistive Technology Computers and Persons with Disabilities." *Communications of the ACM*. May 1992, 36-45.

Ciarcia, S. "Build the Microvox Text-to-Speech Synthesizer Part 1: Hardware." *Byte*. September 1982, 64-88.

Ciarcia, S. "Build the Microvox Text-to-Speech Synthesizer Part 2: Hardware." *Byte*. October 1982, 40-64.

Ciarcia, S. "Build the H-Com Handicapped Communicator." *Byte*. November 1983, 36-50.

Edyburn, D.L.(2000a). 1999 in review: A synthesis of the special education technology literature. *Journal of Special Education Technology*, 15(1),7-18.

Edyburn, D.L.(2001). Locating information about special education demographics. *Journal of Special Education Technology*, 16(3), 54-56.

Fant, A., Jr. "Braille Writing in Pascal." *Byte*. September 1982, 250-268.

Fennema-Jansen, S. (2001). Measuring effectiveness: Technology to support writing. *Special Education Technology Practice*,3(1),16-22.

Fons, K., & Gargaliano, T. "Articulate Automata: An Overview of Voice Synthesis."

Galvin, J., & Scherer, M. *Evaluating, Selecting, and Using Appropriate Assistive Technology.* Gaithersburg, MD: Aspen Publishers, Inc., 1996.

Glinert, E., & Ladner, R. "A Large Font Virtual Terminal Interface." *Communications of the ACM.* June 1984, 567-572.

Hasselbring, T.S. (1997). The future of special education and the role of technology. In J.Paul, M. Churton, W. Morse, A. Duchnowski, B. Epanchin, P. Osnes, & R. Smith (Eds.) *Special education practice: Applying knowledge, affirming the values, and creating the future*. Pacific Grove, CA: Brooks/Cole.

Illinois Dept of Human Services: Rehab Services: ATEC Center (http://www.dors.state.il.us/atec/), July 1997.

Kaplan, P. *Pathways for Exceptional Children.* Minneapolis: West, 1996.

Kurzweil, R. "Beyond Pattern Recognition." *Byte.* December 1989, 277-288.

Kurzweil.R. (1999). *The age of the spiritual machines*. New York, NY: Penguin.

Lazzaro, J. "The Search for Speech." *Byte.* December 1984, A48-A56.

Lazzaro, J. "Opening Doors for the Disabled." *Byte*. August 1990, 258-268.

Lazzaro, J. *Adaptive Technology for Learning and Work Environments*. Chicago: American Library Association, 1993.

McNulty, T., & Suvino, D. *Access to Information Materials, Technologies, & Services for Print-Impaired Readers.* Chicago: American Library Association, 1993.

Meisel, W. "Talk to Your Computer." *Byte*. October 1993, 113-120.

Murray, W. "The Cognivox VIO-1003: Voice Recognition and Output for the Apple II." *Byte*. September 1982, 231-238.

Myers, E. "If We Could Talk to the Terminals." *Datamation*. October 1983, 181-184.

Schwertfeger, R. "Making the GUI Talk." *Byte*. December 1991, 118-128.

Vanderheiden, G. "Computers Can Play a Dual Role for Disabled Individuals." *Byte*. September 1982, 136-162.

Vanderheiden, G. "Service Delivery Mechanisms in Rehabilitation Technology." *American Journal of Occupational Therapy*. November 1987, 703-710.

Wayner, P. "Under the Hood: Optimal Character Recognition." *Byte*. December 1993, 203-210.

White, G. "Speech Recognition: An Idea Whose Time is Coming." *Byte*. January 1984, 213-222.

Wilson, D. New Federal Regulations on Rights of the Handicapped May Force colleges to Provide Better Access to Technology. *Chronicle of Higher Education*. January 1992, A1-A22.

Wilson, D. System Allows the Disabled to Use Computers. *Chronicle of Higher Education*, January 1992, A22.

CG085111

U.S. Department of Education
Office of Educational Research and Improvement (OERI)
National Library of Education (NLE)
Educational Resources Information Center (ERIC)

# REPRODUCTION RELEASE

(Specific Document)

## I. DOCUMENT IDENTIFICATION:

Title: The Goal of Transparency

Author(s): Debora L. Scheffel, Ph.D. Jo Agnew, Ed.D.

| Corporate Source: University of Northern Colorado | Publication Date: May, 03 |
|---|---|

## II. REPRODUCTION RELEASE:

In order to disseminate as widely as possible timely and significant materials of interest to the educational community, documents announced in the monthly abstract journal of the ERIC system, *Resources in Education* (RIE), are usually made available to users in microfiche, reproduced paper copy, and electronic media, and sold through the ERIC Document Reproduction Service (EDRS). Credit is given to the source of each document, and, if reproduction release is granted, one of the following notices is affixed to the document.

If permission is granted to reproduce and disseminate the identified document, please CHECK ONE of the following three options and sign at the bottom of the page.

| The sample sticker shown below will be affixed to all Level 1 documents | The sample sticker shown below will be affixed to all Level 2A documents | The sample sticker shown below will be affixed to all Level 2B documents |
|---|---|---|
| Level 1 | Level 2A | Level 2B |
| [X] | [ ] | [ ] |
| Check here for Level 1 release, permitting reproduction and dissemination in microfiche or other ERIC archival media (e.g., electronic) and paper copy. | Check here for Level 2A release, permitting reproduction and dissemination in microfiche and in electronic media for ERIC archival collection subscribers only | Check here for Level 2B release, permitting reproduction and dissemination in microfiche only |

Documents will be processed as indicated provided reproduction quality permits.
If permission to reproduce is granted, but no box is checked, documents will be processed at Level 1.

*I hereby grant to the Educational Resources Information Center (ERIC) nonexclusive permission to reproduce and disseminate this document as indicated above. Reproduction from the ERIC microfiche or electronic media by persons other than ERIC employees and its system contractors requires permission from the copyright holder. Exception is made for non-profit reproduction by libraries and other service agencies to satisfy information needs of educators in response to discrete inquiries.*

**Sign here, → please**


Signature: Debora L. Scheffel

Printed Name/Position/Title: Debora L. Scheffel, Associate Professor

Organization/Address: University of Northern Colorado Campus Box 141 McKee Hall Room 30 Greeley, CO 80639

Telephone: (970) 351-1376

FAX:

E-Mail Address: debora.scheffel@unco.edu

Date: 5-20-03


(over)

## III. DOCUMENT AVAILABILITY INFORMATION (FROM NON-ERIC SOURCE):

If permission to reproduce is not granted to ERIC, or, if you wish ERIC to cite the availability of the document from another source, please provide the following information regarding the availability of the document. (ERIC will not announce a document unless it is publicly available, and a dependable source can be specified. Contributors should also be aware that ERIC selection criteria are significantly more stringent for documents that cannot be made available through EDRS.)

| |
|---|
| Publisher/Distributor: N/A |
| Address: |
| Price: |

## IV. REFERRAL OF ERIC TO COPYRIGHT/REPRODUCTION RIGHTS HOLDER:

If the right to grant this reproduction release is held by someone other than the addressee, please provide the appropriate name and address:

| |
|---|
| Name: N/A |
| Address: |

## V. WHERE TO SEND THIS FORM:

| |
|---|
| Send this form to the following ERIC Clearinghouse: |

However, if solicited by the ERIC Facility, or if making an unsolicited contribution to ERIC, return this form (and the document being contributed) to:

**ERIC/CSMEE**
**1929 Kenny Road**
**Columbus**
**Ohio 43210-1080**

**Attn: NIQUI BECKRUM**

**Phone: 614-292-6717**
**Toll Free: 800-276-0462**
**FAX: 614-292-0263**
**email: ericse@osu.edu**
**http://www.ericse.org**

EFF-088 (Rev. 9/97)
PREVIOUS VERSIONS OF THIS FORM ARE OBSOLETE.