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ABSTRACT

Assistive technology that can help disabled computer users is described, and a resource guide to computer help for the disabled is presented. The Americans with Disabilities Act of 1990 has broad implications for higher education, in that it mandates that colleges and universities give disabled students equal access to computers on public campuses. Broadly defined, assistive technology includes any device or piece of equipment that increases the independence of a disabled person. The ordinary personal computer or network station has several potential problem areas for the disabled person. Common access problems and their solutions are described, grouping current technologies that assist the disabled into the following categories: (1) visual impairments; (2) mobility impairments; and (3) speech, language, and hearing impairments. The resource guide lists and briefly describes 14 resources for the disabled computer user, divided into categories for the United States, Canada, and North Carolina. It also lists electronic resources, including two Internet/Telnet sources and nine Bitnet list servers. (SLD)

Assistive Technology for the Disabled Computer User

by Linda Wilson

The Institute for Academic Technology
(Information Resource Guide series # IRG-20)

Purpose

This technical paper has two purposes:

- To introduce administrators and staff of colleges and universities to the assistive technology that helps the physically disabled student use a computer; and
- To refer those who need more specific information – whether on products and prices, or on agencies that work with and assist the disabled – to resources in their area.

Introduction

The Americans with Disabilities Act (ADA), approved by Congress in 1990, has broad implications for higher education. Although colleges routinely offer disabled students services such as interpreters and readers, elevators, wheelchair ramps, and curb cuts on streets, access to computers is not as widespread. The ADA not only requires employers to make reasonable adjustments to accommodate the disabled in a job or work environment, but also mandates that colleges and universities give disabled students equal access to computers on public campuses.

The ADA reinforces two earlier laws that had a profound effect on American education: the Rehabilitation Act of 1973, and its successor, Section 504. The Rehabilitation Act prohibits discrimination against the handicapped at institutions receiving or benefiting from federal funds. Section 504 of the Rehabilitation Act, which took effect in 1977, requires the removal of barriers that prevent the disabled from participating in higher education.

The ADA is likely to have two long-term effects on higher education:

- Increased enrollment of disabled students, many of whom would have been too discouraged to apply for admission before passage of the ADA; and

- Financial savings to colleges and universities. One-time expenditures on assistive technology for disabled students will be more than recouped as the jobs of readers and helpers become obsolete. In addition, as the independence and self-esteem of disabled students on campus increases, so too should retention rates for these students.

Assistive Technology Defined

Computers were designed to perform at maximum efficiency when used by the nondisabled. But almost all of us employ some type of *adaptive* technology when using the computer. Adaptive technology ranges from wearing eyeglasses or wrist supports, to simply adjusting the brightness of the screen display or the height and angle of the monitor.

Broadly defined, assistive technology includes any device or piece of equipment that increases the independence of a disabled person. Assistive technology for the disabled, of course, is not new. For instance, the wheelchair has long been an indispensable assistive device for those with impaired mobility.

The distinction between adaptive technologies employed by the nondisabled and assistive technologies for the disabled blurs at times. Some of the assistive technologies designed for the disabled have proven so ergonomically sound that they have been incorporated as standard features. One such example is the placement of the keyboard on/off switch on the Macintosh computer, which was originally designed so that people with motor impairments would not have to reach to the back of the machine to turn the power on and off.

Assistive technology has increased enormously the ability of the disabled to lead independent lives. Computer-based environmental control units allow disabled users to turn on lights, appliances, and open doors from a wheelchair. Augmentative communication devices enable those who cannot speak to voice thoughts and needs using touch- or light-activated keyboards coupled to synthetic speech systems. Screen reading programs for the blind, screen magnification systems for those with low vision, and special ability switches that permit the mobility-impaired to use a computer are only a few examples of the technology by which the disabled gain access to the computer screen and keyboard.

Although this technical paper addresses only those assistive technologies that help the disabled use a computer, more information on environmental control technologies and augmentative communication may be obtained through many of the sources listed in the Resource Guide, which follows the conclusion section of the paper.

Problem Areas for the Disabled in Computer Access

The disabled user wants access to the personal computer or network workstation for the same reasons as the nondisabled. However, modifications and even alternatives to standard computer hardware and software are often necessary to make the computer accessible to the disabled user.

The standard personal computer system – disk drive, keyboard, mouse, monitor and screen – can present barriers to certain disabled users. Some common access problems are discussed below.

- **Disk drive** – Handling diskettes is impossible for some users due to lack of strength or dexterity. In addition, those with impaired mobility may not be able to turn the computer on or off if the power switch is located to the rear of the hardware, as is frequently the case.

- **Keyboard** – The standard QWERTY keyboard used on most personal computers is often inaccessible to people with impaired mobility or fine motor control. Many disabled users do not have the strength required to press the keys on a standard keyboard. Those with limited range of motion

are not able to move their hands easily from the alphabetic keypad to the arrow keys, function keys, or number keypad. Other users with uncontrolled or involuntary hand movements make frequent typing errors by pressing the wrong key, or by pressing a key longer than normal, inadvertently activating the automatic key-repeat feature of many keyboards.

- **Mouse** – Using a standard two- or three- button mouse may not be possible for those with impaired vision, mobility, or motor control; successful use requires not only sufficient vision to follow the graphical representation of the mouse on-screen, but also adequate fine motor control and strength to activate and control the mouse. Manipulating text and graphic displays by clicking, pointing, and dragging with the mouse is an acquired computer skill for *all* users, and requires considerable practice before mastery. Use of a mouse also requires sufficient strength and motion in the shoulder and arm to position and manipulate the device on the desktop or mousepad.

- **Monitor and Screen** – The screen display is not accessible to blind users or those with low vision without magnification or text-to-speech conversion. On the other hand, the screen display is accessible to the deaf user, but requires modification so that audible error messages or "beeps" are converted to text that the deaf user can read.

Intended Users of the Technologies

Five areas of human functioning – the ability to see, to hear, to move about freely, to speak, and to learn – are so critically important that by almost any criteria, irreversible loss of any one of these abilities is disabling. Among college and university students, access to computers is most often compromised by impairments of vision, hearing, and mobility.

For the disabled user with low vision, access to the computer requires one or more means of assistance: speech, large print, or Braille. The blind user employs speech, Braille, or a combination of the two.

The hearing-impaired or deaf user usually adapts most easily to using the computer, since the standard medium of exchange between user and computer is visual.

Often only minor modifications, such as an alternative to the audible warning beep, are needed for this user.

Users with impaired mobility and motor disorders must be evaluated carefully so that their best remaining function is incorporated in the plan of access to the computer. The ability to stand and walk unassisted, the range of motion of the joints and spine, and any loss of muscle strength, motor control, or coordination are all considered when selecting the appropriate assistive technologies. A disabled user whose best voluntary, controlled movement is the raising of an eyebrow can be fitted with a switch to access the keyboard. Those with impaired mobility use alternative input devices such as joysticks, ability switches, and modified keyboards. Keyguards cut down on extra keystrokes, while software modifications deactivate the automatic keystroke repeat feature.

Current Technologies

Visual Impairments

The technology available to disabled computer users who are blind or have low vision is extensive. The choice of the appropriate technology depends on a number of factors. Among these are the cause of the visual loss, the extent of loss of visual acuity, the quality of peripheral vision, and any other physical or mental limitations that might affect use of a computer. What follows is a description of the major types of technology available to the blind or low-vision computer user. Examples of products on the market currently are by no means exhaustive.

Screen reading programs usually consist of two parts: a software program and a speech synthesizer. The software program, working as an overlay between a popular off-the-shelf application program and the disabled user, directs keyboard input to the speech synthesizer. IBM ScreenReader is a well-known screen-reading software program used in conjunction with many brands of speech synthesizers.

The speech synthesizer attaches to a computer's RS232C port and converts standard ASCII text into speech. The synthetic speech can be directed to headphones, so that it does not disturb others. The user has the option of controlling the output of the speech synthesizer in several ways; for instance, the rate of speech produced may be adjusted, or the output may be read character-by-character, or line-by-line. When spelling out words or numbers, the synthesizer can also be set to pronounce all spaces and punctuation marks as well. A capital letter is read with altered pitch. The aesthetic quality of synthetic speech varies greatly, ranging from the metallic quality of cheaper synthesizers to the almost lifelike voices produced by DECtalk from Digital Equipment. DECtalk, widely acknowledged to represent the state-of-the-art in speech synthesis, offers pleasant speech output in the user's choice of nine different speaking voices.

Large print screen displays are created in one of two ways: stand-alone software programs, or hardware- and software-based magnification systems.

- *Stand-alone software magnification programs* enlarge the normal text display of other application programs. One such program is AI Squared's ZoomText, which can enlarge the text display by a magnification power of 16. Such programs operate as an overlay between the application and the user.

- *Screen magnifying systems* employ both hardware and software adaptations to magnify the screen display. Vista, made by Telesensory Corporation in Mountain View, California, is a hardware-based screen magnifying system that uses a circuit card, a mouse, and cursor-tracking software to provide on-screen text magnification of up to 16 times the standard screen display. The user has a choice of presentation modes – full screen, single line, rule: view, dual view, zooming glass, and magnifying glass – all of which enlarge selected text and graphics. In dual view, for instance, the user points to any portion of the standard screen display with the magnifying bar controlled by the Vista mouse, and the same part of the display appears, magnified, along the bottom of the screen. The user can customize the magnification to his preference. Other options include the ability to invert the screen display to show dark letters on a light background, since many people find the reverse display reduces eyestrain.

Braille computer systems allow users to access the screen display in Braille one line at a time. The user types input from a keyboard. Fitting between the user and the keyboard is a hardware device that accepts input from the keyboard, and translates it line-by-line into a tactile Braille display for the blind user. The Braille-based computer system is especially useful to those who work with large amounts of data. Navigator by Telesensory, a well-known Braille display system, couples to any DOS-based computer

via a serial port and contains the software necessary to read the screen.

Pocket Braille computers such as Telesensory's BrailleMate and Blazie Engineering's Braille 'n Speak contain both speech synthesizer and Braille keyboard. They are used as portable note takers, address books, calculators and clocks. BrailleMate stores up to 128 Braille pages in internal memory; the information can be downloaded to a Braille display system such as the Navigator, or to a PC via a standard serial port. Braille 'n Speak has a 200,000-character memory and an optional disk drive accessory that permits the user to save files from Braille 'n Speak to standard 3.5 inch diskettes.

Braille software translators and embossers enable users to print high-quality Braille documents from a PC. Duxbury Braille Translator is a well-known software translation program. The software converts the screen display to Braille before it is sent to the Braille embosser to be printed.

Reading systems perform optical character recognition to convert printed text into speech or computer files. The Kurzweil Reader by Xerox is a self-contained system that uses a scanner, a computer, and a speech synthesizer to read aloud the contents of printed material placed on the scanner. The machines are limited to reading printed material only; handwriting and most newspapers are indecipherable. OsCaR by Telesensory and Arkenstone are other well-known optical character recognition scanners.

Mobility Impairments

Many adaptations are available to assist those with impaired mobility use the computer. Although a standard keyboard and mouse are the input devices of choice for most people, other devices have been developed. Among the most frequently used are modified and alternate keyboards, ability switches, and headpointers and joysticks. These methods are used in many variations and combinations, based on the abilities and needs of the mobility-impaired user. Whatever the method, the computer treats the input from these methods as if it had been received through the standard keyboard.

Modified keyboards include some relatively simple assistive technologies designed to decrease the number of typing errors, and thus increase productivity of those with impaired mobility. Descriptions of three of these follow

- The keyguard is a lightweight overlay, often plastic, that fits over the regular keyboard; holes are punched out of the plastic so that each standard key can be pressed if chosen deliberately, either with the fingers or mouthstick. The keyguard cuts down on accidental keystrokes substantially.

- Permanent large print key labels can be placed on each character, number, and punctuation mark of the standard keyboard. The visually impaired user may benefit from this adaptation, as do children.

- Software exists that will disable the automatic-repeat feature of most keys on the IBM keyboard.

Alternate keyboards come in many styles. The keyboards consist of a series of membrane switches arranged for ease of use. Some alternate keyboard designs keep the standard QWERTY keyboard arrangement, but omit numbers and enlarge the letter keys. On the other hand, users who input only numeric data may opt for a keyboard consisting entirely of enlarged numbers. Other keyboards are arranged so that the most frequently used characters and numbers are in central position. Miniature keyboards are available for those with good pointing skills within a limited area. Many alternate keyboards require a separate hardware interface unit between the keyboard and the serial port, although the trend is toward alternate keyboards capable of direct attachment to the keyboard port. Popular interface units are Ke:nx (pronounced CONNECTS) for the Macintosh, Expanded Keyboard Emulator or DADA Entry for IBM and compatibles, and the Adaptive Firmware Card for Apple IIs.

Ability switches provide access to the screen display without using a keyboard. Optimum use of ability switches requires careful assessment of the user's best voluntary function. The switches can be mounted mechanically to wheelchairs, desks, or almost anywhere else the user might need the switch positioned. Switch mounting systems often consist of adjustable arms attached to clamps and allow many users who have severe motor disabilities to use a computer. A switch interface unit acts as the link between the switch and the computer.

Due to the wide variety of user abilities, many types of switches are available. Switches exist that can be activated by only a raised eyebrow, if that is the user's most reliable movement. Ability switches can provide feedback for users who require it. This feedback often occurs in the form of an audible click upon activation. Commonly-used switches include the following:

- Button switch
- Plate switch
- Infrared switch
- Sound-activated switch
- Treadle switch – for those with arm, elbow, foot, or knee control
- Pillow switch – a soft, fabric-covered switch often used when activation is by a facial movement
- Sip-and-puff switch – controlled by voluntary inhaling and exhaling, frequently used by those with spinal cord injuries
- Eyeglass switch – activated by a purposeful eye movement
- Arm slot control switch – for those without fine motor control. Shifting the arm among the five arm slots activates switches that reproduce joystick or mouse control.

Operating a computer with switches involves learning one of two techniques:

With scanning, the cursor moves repeatedly from one character, or group of characters, to the next, often in a clockwise or counterclockwise motion. The user selects desired characters or words from the computer display by activating the switch when the cursor falls on that character or word.

With direct selection methods, the user points to target items with a headpointer, mouthstick, or joystick. Pointing devices allow users who have at least one voluntary, functional movement access to the computer. The Magic Wand Keyboard from In Touch Systems of Spring Valley, New York, incorporates a full-function PC keyboard with built-in mouthstick. The unit plugs directly into the keyboard port of any IBM or compatible, and is designed for mouthstick users. It requires very little strength to operate.

Speech, Language, and Learning Impairments

Online computer instruction is a particularly good medium for intensive remedial training. The strengths of the computer in education include its capacity for constant, individual feedback to the student, along with an unlimited ability to carry out drill and practice exercises until a subject is mastered.

Computer packages have been designed to improve the speech and language capabilities of those with poor hearing and speech, and also to assist those with cognitive injuries or learning disabilities. Among the current adaptations are IBM SpeechViewer, a vehicle for speech therapy, and word prediction software programs.

IBM SpeechViewer increases the efficiency of speech therapy by synchronizing audio playback with interactive graphic displays of the user's speech. The hearing- or speech-impaired user speaks into a microphone, and if, for instance, loudness is the attribute being measured, a balloon on-screen inflates as he speaks at the desired level.

Word prediction software programs are beneficial not only to the learning disabled, but also to users with mobility impairments. The programs operate in a way similar to the spelling check feature found in many word processing programs: as the user types the first letters of a word, the word prediction program compares it to a dictionary of words that begin with those same letters. A window appears on-screen with the list of words; if the user finds his intended word in the list, he enters one keystroke, and the word is inserted into his document. If not, he continues typing until the program presents him with the match. Proper names and terms not included in the software can be added to the program's dictionary for future use. For those with mobility impairments, the saving in keystrokes adds greatly to their productivity. Dyslexic students also benefit from the word prediction programs. MindReader is a word prediction program available as shareware.

Conclusion

No doubt the scope of assistive technology for the disabled computer user will enlarge in the future. New opportunities for the disabled student in higher education will naturally lead to increased assimilation into the work force upon graduation. Assistive technology for disabled computer users supports the precept behind the Americans with Disabilities Act – equal access to opportunity for the disabled.

Resource Guide

The following section lists resources – both nonprofit and for-profit – for readers who need more information about assistive technology.

Resources available throughout the United States are listed first; resources open only to residents of North Carolina are listed second; and resources for readers with access to electronic computer networks are listed third.

USA and Canada

American Speech-Language-Hearing Association (ASHA)
10801 Rockville Pike
Rockville, MD 20852
(301) 897-5700

ASHA is a professional association of speech-language pathologists and audiologists who develop computer technology to assist the disabled.

Baruch College
The City University of New York
17 Lexington Ave
Box 515
New York, NY 10010
(212) 447-3070

Baruch College Computer Center for the Visually Impaired is a research and training center devoted to assistive technology for the visually impaired nationwide. The center offers frequent training classes in software applications, primarily WordPerfect, DOS, dBase, and Lotus. They also consult with employers of the visually impaired on hiring and equipment needs. The center has a facility for producing Braille maps and graphics, as well as documents in large print and Braille.

Carroll Center for the Blind
Computer Access
770 Centre St.
Newton, MA 02158
(617) 969-6200

A private, nonprofit rehabilitation center for the legally blind, Carroll Center includes a computer division offering training in technical skills.

Closing the Gap
P.O. Box 68
Henderson, MN 56044
(612) 248-3294

This organization hosts an annual national conference, and publishes *Closing the Gap*, a bimonthly newsletter about assistive technology for the disabled. A subscription costs $26 per year, and includes a copy of the annual resource directory.

IBM National Support Center for Persons with Disabilities
Independence Series
Building 5, 3rd Floor (IBM)
P.O. Box 1328
Boca Raton, FL 33429
(800) 426-4832 - Voice
(800) 426-4833 - TDD

The Center serves as a clearinghouse for information on technological advances that offer greater opportunity and independence for disabled people in the home, school and workplace.

National Braille Press, Inc.
88 St. Stephen St.
Boston, MA 02115
(617) 266-6160

National Braille Press publishes books for the blind and visually impaired, primarily in Braille, but also in print, cassette, and computer diskette versions.

Solutions - Access Technologies for People Who Are Blind is NBP's updated guide to computer hardware, software, and peripherals for the blind and visually impaired. Issued in 1992, the print copy costs $26.45 (shipping included); Braille, cassette, or IBM/compatibles diskette versions cost $21.95 each (no shipping charges).

National Easter Seal Society
70 East Lake St.
Chicago, IL 60601
(312) 726-6200

The National Easter Seal Society publishes a newsletter, *Computer-Disability News: The Computer Resource Quarterly for People with Disabilities*. Subscription price is $15 for one year, $27 for two years, and $40 for three years. Local Easter Seals organizations offer many services to the disabled.

National Organization on Disability (NOD)
910 Sixteenth Street NW
Washington, DC 20006
(202)293-5960 (Voice)
(202)293-5968 (TDD)
(202)293-7999 (Fax)

NOD is a nonprofit organization serving as an information clearinghouse for the disabled.

Prentke Romich Company
1022 Heyl Road
Wooster, OH 44691
(216) 262-1984

Prentke Romich makes the augmentative communication systems TouchTalker and LightTalker, as well as computer access equipment and environmental control systems.

TASH (Technical Aids & Systems for the Handicapped, Inc.)
Unit 1, 91 Station Street
Ajax, Ontario
Canada L1S 3H2
(416) 686-4129

Affiliated with the Canadian Rehabilitation Council for the Disabled, TASH sells hardware and software products including ability switches, environmental controls, keylocks, keyguards, keyboards, keyboard emulators, and disk guides.

Trace Research and Development Center on Communication Control and Computer Access
University of Wisconsin-Madison
S151 Waisman Center
1500 Highland Ave.
Madison, WI 53705
(608) 262-6966

The Trace Center provides information on development of communication and computer access for people with disabilities, including HyperAbleData, a desktop version of the AbleData database of more than 17,000 products designed for the disabled user.

Resource Guide

North Carolina

NC Assistive Technology Project Demonstration Center
1110 Navaho Drive, Suite 101
Raleigh, NC 27609
(919) 850-2787

One of four demonstration centers in the state, the center has an extensive variety of assistive technologies on display, including many for the disabled computer user. Consumers can try out the devices, and also use the resource library and AbleData database to obtain more information on products. The center is open to groups or individuals by appointment.

Telephone numbers for the other demonstration centers are:

Charlotte:	(704) 355-2703;
Greenville:	(919) 830-8575;
Winston-Salem:	(919) 761-2290.

North Carolina Library for the Blind and Physically Handicapped
1811 Capital Boulevard
Raleigh, NC 27635
(919) 733-4376
(800) 662-7726 (NC only)

Operated by the state, the North Carolina Library for the Blind and Physically Handicapped is a public library service that circulates books and magazines to those who cannot use standard reading materials because of a visual or physical disability. Large print, Braille, records, and cassette tape versions are available to qualified readers throughout the state.

North Carolina Department of Human Resources
Services For The Blind
Division of Rehabilitation
Rehabilitation Center for the Blind

305 Ashe Ave.
Raleigh, NC 27606
(919) 733-5897

A demonstration center at the Rehabilitation Center for the Blind in Raleigh contains perhaps the most comprehensive collection of assistive technology for the blind and low-vision computer user in the state. Clients with visual impairments can use and compare many different technologies in the same place. Reading systems, screen reading programs with voice synthesizers, screen magnifying systems, tactile Braille screen reading hardware, and pocket Braille computers are all on display.

The center also offers a variety of summer programs to help teenagers and young adults develop the skills they need to prepare for college and adult life.

- a pre-college assessment program for high school students undecided about attending college;
- a personal skills program for high school sophomores and juniors;
- an adolescent evaluation to assess visual functioning, travel ability, communication skills, and academic status for ages 15 and older; and
- a college preparatory program for the college-bound student. Training during the program, which will be held during the 1993 summer session at North Carolina State University in Raleigh, will cover note taking and study skills, use of library resources, and how to hire and fire a reader.

Electronic Resources

Internet:

Educom's Project EASI
"Adaptive Computing Evaluation Kit for Colleges and Universities" is designed to help colleges and universities complete the self-evaluation required by the ADA. The kit is available electronically or on paper, and includes an overview of legal issues, a background checklist for self-evaluation, and a user-needs survey.

Contact CSMICLC@MVS.OAC.UCLA.EDU, or call (310)640-3193.

Internet/Telnet:

Handicap News Archive
The archive is a comprehensive source of information for those with an interest in disabilities. Information on the ADA and related legislation is available, as are listings of national and local support groups, newsletters, and sources of state and federal assistance. Shareware for the disabled computer user can be downloaded .

Anonymous ftp site: log on as anonymous to HANDICAP.SHEL.ISC-BR.COM or (129.189.4.184), or call Bill McGarry at (203)337-1518.

Bitnet List Servers:

Americans with Disabilities Act List
ADA-LAW@NDSUVM1

Alternative Approaches to Learning List
ALTLEARN@SJUVM

Autism and Developmental Disabilities List
AUTISM@SJUVM

Computer Use for and by Persons Who Are Blind
BLIND-L@UAFYSYB

Blind News Digest
BLINDNWS@NDSUVM1

List on Speech Disorders
COMMDIS@RPITSVM

List on Deafness
DEAF-L@SIUCVMB

Disa lity Research List
DISRES-L@RYERSON

Handicap Digest
L-HCAP@NDSUVM1
