For disabled students in post-secondary education, the future of adapted computer technology is filled with both promise and peril. Advances in computer technology open some doorways and close (or, more accurately, never really open) others. Over the coming years, careful consideration will be required in the following areas.

Adapted Computer Access to Campus-Wide Networks

In order to harness and organize the vast processing power represented by the array of micro, mini and mainframe computers found on many campuses, colleges are rapidly implementing complex networks which link widely dispersed computer systems into one coordinated assemblage whose resources can be shared by all. At their best, such networks become an integral part of the culture of a college or university. Well-designed and functional networks can provide improved student/faculty communications, access to valuable research data, computer assisted or augmented instruction, electronic bulletin board and mail services, a forum for the exchange of information and ideas, access to computerized class registration and much more. Such networks point squarely at the future of information access, not just on college campuses, but in our society as a whole. We are again at a turning point, a critical moment in time at which those with the capacity and opportunity to access vast networks of computerized knowledge will become information rich; those who do not will be information poor. Knowledge, as the saying goes, is power. In our ever-

more-complex world, instantaneous computer access to accurate information is the key to knowledge.

It is vitally important that colleges and universities consider the adapted computer access requirements of their disabled students when planning such networks. Failure to do so could inadvertently exclude such students from a major component of campus life and culture.

A number of important questions must be asked:

If campus networks are accessed via personal computers, what special equipment and/or software will be required to connect the PC to the campus network?

How will the hardware/software which allows the PC to access the campus network affect the operation of adapted computer access hardware/software?

11.2

Will screen displays of text, on-line card catalogues for example, be consistently formatted to enhance access for blind computer users?

If the campus network makes extensive use of computer graphics, how will access be provided for blind students whose screen reading systems are unable to interpret a graphic display?

What provisions can be made to provide remote access to the network via phone modem by disabled students who may find it more practical to carry out some assignments at home?

If the network can only be accessed with dedicated computer terminals, what provisions will be made to accommodate the special access requirements of blind, low vision or orthopedically disabled students?

Adapted Access Requirements and Computerized Educational Testing

Most major testing companies (College Board, McGraw/Hill, etc.) now have or are actively developing computerized versions of most tests. Each of these companies shares a common vision of a time in the not-too-distant future when a majority of testing will be conducted in a computerized format. How disabled individuals will be afforded fair and equitable access to such testing environments is an issue which will require careful consideration.

Advanced Computer Graphics and Blind Computer Users

Recent advances in the technology of extremely high resolution computer displays could have devastating consequences for blind computer users. The trend in the computer industry is toward the development of highly graphic program designs which make extensive use of the display capabilities of advanced computer systems. Such systems replace traditional text oriented program menus and options with graphic symbols called icons. An icon shaped like a computer printer might represent the option to print a document, a tiny trash can the option to erase a program, a small wrist watch the "please wait" prompt. Typically, these options are accessed by directing an on-screen pointer with a pointing device called a mouse. The mouse is rolled about on the surface of the desk or work station until the onscreen pointer is positioned at the desired icon. Pressing a button on the mouse selects the option and typically displays an additional list of icon symbol

options. For a sighted computer user struggling with the sometimes cryptic commands used by various programs, such graphically oriented systems can be helpful. For blind computer users, such systems are only now becoming accessible. Given the fundamental methodology screen reading systems employ to translate a visual text display into speech, making graphically oriented computer systems fully accessible to blind users represents an immediate and essential challenge to computer manufacturers and programmers alike.

As the trend in the computer industry appears to be toward the development of such graphically oriented systems, blind computer users are facing the devastating possibility of being denied access to a whole new generation of advanced computer technology. In order to prevent such disasters, it is vitally important that colleges and the computer industry be aware of the access requirements of blind computer users. If high resolution, graphically oriented computer systems are the wave of the future, and there are many indications that is indeed the case, an industry-wide standard must be developed to provide access for non-sighted computer users.

11.4

How do such design oversights occur? Certainly they do not come about by deliberate action. In most instances, they simply occur through benign neglect. As an example, at a recent conference sponsored by the United States Department of Education, a major university proudly demonstrated a graphically oriented word processing system which they had developed and were proposing as the standard word processor to be used by a consortium of colleges and universities from several states. When asked how they proposed to provide access to blind students the college representative replied "Gee, I guess we didn't think of that." "I guess

we didn't think of that" is an all too common refrain which only education and a persistent demand for equal access will begin to remove.

Several major computer manufacturers have already begun to monitor the development of new products with the special access needs of the disabled in mind. IBM, Digital Equipment Corporation and Apple Computer all maintain departments employing specialized staff who oversee new product development with an eye to including product features which assist the disabled computer user and remove those aspects of product design which act as barriers. In many instances, such design modifications benefit the non-disabled user as well. The recent addition by Apple Computer Corporation of access systems for low vision and orthopedically disabled persons to the basic operating system files of Macintosh computers is an outstanding example of responsible leadership on the part of computer manufacturers.

Access to Publicly Funded Computer Databases

A vast amount of publicly available information is stored in computerized databases established and maintained by federal dollars. These databases are, in effect, enormous public libraries of an entirely new order. They are the future of information storage and retrieval. Access to these resources will clearly separate the information-rich members of our society from the information-poor. It is very important that the computer access requirements of disabled persons be clearly understood and responded to in order to maintain equal access to this wealth of computerized information.

Although of an entirely new order, computerized libraries are in many respects much like traditional libraries. There users may still browse through titles, opening an electronic book here and there to scan an area of interest. The fundamental difference is the incredible speed with which such electronic browsing can be carried out. A complete literature search for a doctoral thesis might be completed in less than one hour.

These are indeed public libraries, funded by federal dollars, intended for the use of all citizens and therefore subject to the provisions of the Architectural Barriers Removal Act of 1968 which states that access for disabled individuals must be provided to any building maintained through the receipt of federal dollars or to buildings used by organizations receiving federal dollars. The advent of advanced technologies will require reevaluation of our traditional view of access in light of the creation of federally funded "electronic environments" which may only be entered via computer.

11.6

Emerging Technologies and Adapted Computer Access

At least three research areas have begun to produce results which hold enormous potential benefit for disabled computer users: optical character recognition, speech recognition and direct visual selection.

Optical character recognition is a process through which a printed document, a business letter for example, can be automatically converted to a computerized text file editable by any standard word processor. For blind, low vision and learning disabled individuals, this would be most useful. Optical character readers, often called OCRs, are external hardware devices about the

size of a typical computer printer. A sheet of paper containing the written materials to be converted is fed into the OCR. Printed content is examined letter by letter and converted to a computerized text file. On average, the process requires two to four minutes per page and is generally around 98% accurate. During the conversion process, if the OCR encounters a symbol it doesn't recognize, the user is notified and given the opportunity to insert the correct choice. Alternately, most OCRs will also substitute a previously agreed upon character, a question mark for example, in place of any character or symbol in the printed document it is unable to recognize. The majority of OCRs recognize a variety of type styles and sizes, and several can be "trained" to recognize a good many more. Currently, recognition accuracy is significantly affected by quality, style and size of printed characters as well as page formatting. As an example, a document com

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posed in block paragraph style using a 10 pitch Courier type font printed on a laser or letter quality printer would probably be read by the average OCR with no errors. The same document printed on a dot matrix printer would probably be read by the OCR with a 3% error rate. The improvements in OCR technology have been rapid and dramatic. It is reasonable to expect that within the next year or two, continuing advances in the accuracy and reliability of OCRs coupled with continued price reductions will make this device an important tool for providing adapted computer access.

Although speech recognition technology has been commercially available for several years, fundamental limitations in accuracy and reliability of even the best speech recognition systems produced by lack of microcomputer processing speed and memory access have rendered such devices impractical for use by orthopedically disabled, learning disabled or blind individuals. The ideal adaptation for such individuals, the mythical "talking typewriter," may finally be on the technologi-

cal horizon. Such a device would accept spoken input at a normal rate of speech, convert everything it "heard" into a computerized text file, insert punctuation marks, correct spelling, suggest grammatical alterations and finally, if desired, print the document. With the advent of new, very high speed microcomputers capable of performing millions of tasks per second and addressing billions of bytes of internal memory, a computer environment now exists which is capable of supporting the dual requirements of such systems: raw processing power and memory. Because such a device would be of great interest to the general public, it is well within the realm of possibility that highly reliable, entirely speech activated word processing systems will be commercially available at a reasonable price within the next two to three years. Such systems will revolutionize computer access for orthopedically disabled, learning disabled and blind individuals.

Work in the area of direct visual selection could be of unprecedented benefit to severely orthopedically disabled persons. Individuals who because of the scope and severity of their disability are unable to produce intelligible speech and have no gross or fine motor control; individuals who have been virtual prisoners within their own bodies may soon have access to some extraordinary new access technologies. Direct visual selection allows such persons to "type" by simply looking at the letter they wish to select.

There are two major lines of development in the area of direct visual selection. The first involves the use of a keyboard-like device, specialized video camera and infrared reference beam; the second incorporates a system which reads selection data directly from the optical cortex of the brain.

The system, incorporating an on-screen keyboard, specialized video camera and reflector, is a commercially available product. Although it has requirements which make it unusable by many severely orthopedi-

cally disabled persons, it points the way toward development of much more broadly effective devices incorporating the same basic technology. A particular liability of the system is its requirement that the user be able to hold his/her head very still while selecting characters from the on-screen keyboard. If the user is able to meet this requirement, the system behaves exactly like the computer's keyboard and can be used with either Macintosh or PC type computers.

A second line of development takes an entirely different approach and may be much more broadly applicable to the computer access requirements of the severely orthopedically disabled. Not yet a commercially available product, this system reads the electrical activity of the brain's optical cortex. In use, tiny sensors are placed on the scalp over the optical cortex. The user looks at a keyboard-like device, each "key" of which has a small, bright light which blinks at a different rate. The user simply looks at the key he/she wishes to select. The system reads the blink rate of the light directly from the electrical activity of the optical cortex, identifies the key associated with the blink rate and sends the correct character to the computer. The system is much more tolerant of head motion and nastagmus (a rapid, involuntary, horizontal movement of the eye). Although still experimental, the technology appears to be quite reliable and hopefully will appear as a commercially available product within the next year or two.

Adapted Computer Access and the 1986 Amendments to the Rehabilitation Act of 1973

With the 1986 amendments to the Rehabilitation Act of 1973, new language was included which will have a dramatic effect on the future of computer access for

hundreds of thousands of disabled persons. Broadly referred to as "electronic curb cut legislation," when fully implemented, the impact of these new access requirements will be of enormous benefit. Although initially referenced in Chapter 8, because of its importance to the future of adapted computer technology, it seems **only fitting to conclude this** work with the language of the amendment in its entirety:

> Title V. Miscellaneous
>
> A new section (508) Electronic Equipment Accessibility has been added.
>
> Sec. 508.(a) (1) The Secretary through the National institute on Disability and Rehabilitation Research and The Administrator of the General Services, in consultation with the electronics industry, shall develop and establish guidelines for electronic office equipment with or without special peripherals.
>
> (2) The guidelines established pursuant to paragraph (1) shall be applicable with respect to electronic equipment, whether purchases or leased.
>
> (3) The initial guidelines shall be established not later than October 1, 1987, and shall be periodically revised as technologies advance or change.
>
> (b) Beginning after September 30, 1988, the Administrator of General Services shall adopt guidelines for electronic accessibility established under subsection (a) for Federal procurement of electronic equipment. Each agency shall comply with the guidelines adopted under this subsection.
>
> (c) For the purpose of this section, the term special peripherals means a special needs aid that provides access to electronic equipment that is otherwise inaccessible to a handicapped individual.

The committee, formed under the auspices of the National Institute of Handicapped Research to establish

access guidelines for electronic office equipment is called The White House Committee for Equal Access to Standard Computers and Information Systems.