Computers in STEM (Science, Technology, Engineering and Math)

Read between the lines to see how this applies to ALL STUDENTS

PURPOSE

Now that computers are a standard part of both educational programs and the workplace, most people are required to use them on a daily basis. This is especially true in technical fields such as science, engineering and mathematics. The focus of this reading is to look at **adaptive computing technology and information access** as ways to provide access to educational programs and the workplace, especially in science, engineering and mathematics. First we will focus on general adaptive computing technology as a foundation for access, and then we will focus on issues that are unique to the science, engineering and mathematics fields.

INTRODUCTION

If a person cannot use a standard computer due to a physical or mental impairment, he or she has an "**access barrier"** to computer-use, and an adaptive device can be used to help the person use the computer.

Adaptive computing technology includes **both devices to provide access to computer**s, and it can also be used to **provide "compensatory tools**" for people with disabilities. Used as a compensatory tool, adapted computing hardware, software and peripherals allow disabled individuals to accomplish tasks that are not usually performed on a computer **--** tasks that a disabled individual might not be able to perform at all, without the use of the computer.

It is important to understand the difference between *computer access approaches* and *compensatory computing tools.* Simply, computer access approaches allow disabled individuals to use computers and peripherals. Compensatory computing strategies refer to the use of computing hardware and software **--** adapted or not **--** to accomplish tasks that individuals may find difficult or impossible, due to one or more disabilities.

For example, a blind person can't see a computer screen. A person without hand-movement can't type on a standard keyboard. The first purpose of adaptive computer technology is to provide approaches that will allow people with disabilities to get past those barriers and to use computers for tasks that are normally accomplished on computers.

In the other case, a disabled person might use a computer to read, write, research information, organize information, or communicate. So, besides providing access to computer systems that are available to all students on a campus, adaptive computing hardware and software can also be used as compensatory strategies that allow people with disabilities to use computers for tasks that would be difficult or impossible otherwise.

Compensatory computing strategies are a particularly important tool for individuals with disabilities who are studying, researching or working in the science, engineering and mathematics fields. And while many compensatory computing strategies employed in these fields are highly specialized and relate specifically to scientific and mathematical notation, graphics and charts, and specialized science lab equipment, disabled people who work in these fields will benefit from the adaptive technology that is commonly used by people in all fields.

The standard computer keyboard, monitor and peripherals provide several access barriers to people with various disabilities, and so it becomes imperative that schools and the workplace make available adaptive computing approaches that can help people get past those barriers to computer-use.

INPUT BARRIERS

There are **two potential access** problems that exist for individuals with disabilities. The first is putting information into the computer, and the second is knowing what has been displayed on the monitor or printed by the computer printer.

Access barriers exist for people who have trouble with **input devices -- the standard keyboard or mouse --** used to input characters or commands into the computer. Generally, input issues affect individuals who have limited or no control of hand movement. Input issues might also be a problem for people who have visual impairments or learning disabilities. **(visual problems, poor hand eye coordination, broken arm)**

Software that permits the user to **redefine keys on the keyboard** can help with some simple motor problems and may be useful in avoiding a repetitive stress injury.

Some computer users have begun to use **ergonomic keyboards** to reduce such repetitive stress. The Trace Research and Development Center has developed a public domain software, **Access DOS,** that permits a user to avoid having to depress two keys simultaneously. This software also allows the user to alter the repeat rate, which is useful for people who have limited fine motor skills that cause them to hold down a key for a longer period of time than is required.

Comment [DPM1]: This would be great for our Jason scenario case study

There are also a number of **alternate keyboards** to assist people with different mobility impairments. A **membrane keyboard responds to a light touch** and is beneficial for people who lack physical finger strength. **(Small hand size or large fingers—football players types)** this **Keyguards** help people keep from depressing multiple keys inadvertently. **Larger or smaller than normal-sized keyboards** may facilitate some people's keyboard usage, and there are one-handed keyboards for people who only have the use of one hand. The one-handed keyboard permits the user to depress several keys simultaneously. By using such keying techniques, users can input information into a computer without the use of a standard keyboard. **For ADD and ADHD, the process of depressing multiple keys at a time can become frustrating—often leading to the "banging the keyboard"-Keyguards are helpful.**

Manipulating a mouse is a problem for users with limited hand movement.

People who lack fine motor control in their hands also have problems using a standard mouse. A **trackball** might be a good alternative. It can be manipulated with smaller motions than a mouse, and it is also easier to control. There is also **software** known as **"mouse keys"** that allows the use arrow keys to move the mouse cursor around the screen.

There are still other adaptations for people who have no effective use of their hands. Some of these are simple and 'low tech," while others are more sophisticated and costly. Some mobility impaired individuals depress the keys of a traditional keyboard with the use of a **mouthstick**. Others use a **headwand,** which is a pointer attached to a headband. Still others make do with a **simple pencil** held in the mouth. One person, who has shoulder movement, but no finger movement, uses special **Velcro gloves** that he has made at a local shoe repair shop. Unsharpened pencils are inserted into the gloves, and he uses the muscles in his shoulder to move his arm up and down and strike the keys with the pencils that are in the gloves.

Most of these devices rely on head and neck motions to input data into the computer, and it's important that people get advice from an occupational or physical therapist before they use these techniques.

Morse Code is another input option for people with mobility impairments.

One of the ways to produce Morse Code without hand-use, is through a **sip-and-puff straw.** The sip-and-puff signals are created by the individual blowing or puffing into a straw, and they are translated through an interface device into the same electronic signals produced by depressing keys on the keyboard. The internal workings of the computer operates the same way as if the input had been through the keyboard. Morse Code can be input by any device that can produce a binary signal **--** a representation of a dot and a dash. A **simple set of switches** positioned near a controllable muscle would produce a similar result. Again, with this type of adaptive device, be aware of the possibility that using the adaptive device could injure the person, and you should always consult with a doctor, physical therapist or occupational therapist before recommending such a strategy.

Whether talking about traditional Morse Code or adaptive computing uses of this code, skilled users can frequently achieve speeds between 30 and 40 words a minute, and there are ways to increase that pace significantly.

The **on-screen keyboard** is one of the more sophisticated input devices. A picture of the standard keyboard is displayed at the bottom of the computer monitor and is controlled by special, adaptive software. The user points at the key to be input into the computer.

This may be done by a **infrared device worn** on the head that communicates with another infrared signal on the computer that does the pointing. Or, the computer could have the ability to "track" the gaze of the user's eyes and identify which on-screen key is being pointed to. In another configuration, the software moves a **blinking cursor** across the on-screen keys until it reaches the one the user wants to input.

At this point, by one of many devices, the user signals the computer to actually enter that data into the computer.

The newest and most rapidly evolving alternate input system is **voice recognition.** Only a few years ago, voice recognition software cost many thousands of dollars and required users to talk very slowly and with long, unnatural pauses between words. With newer technology, pauses are still important but the speaker can talk more quickly and pause for shorter spaces between words. When the software is trained to users' speech patterns and pronunciation, users are beginning to achieve input rates approaching those of a skilled keyboard typist. **Can be useful for ELL students if writing a problem also for dyslexic and dysgraphic students.**

OUTPUT BARRIERS

These affect people who cannot access the computer's output **--** either words on the monitor screen or the printed page. **Output barriers** exist for people who have difficulty reading the screen due to visual impairments or learning disabilities, people who cannot hear auditory cues, and people who have difficulty reading or handling a standard computer print-out.

Individuals with low vision benefit from an enlarged screen output.

Frequently, the ability to manipulate foreground and background colors is also useful. The ability to adjust the printer to produce documents in large type and to reformat the material to accommodate such enlargements is also important. Not only do these adaptations help individuals with low vision but they can also be useful to individuals with learning disabilities and various other cognitive processing problems as well.

Adaptive software will permit enlarging the size of the letters and graphics on the screen by as much as two to 16 times. The Apple Macintosh includes a utility, **CloseView,** which provides some enlargement. **inLARGE** is a good package for the Macintosh and **Zoom Text** is only one of several packages available for IBM and compatible computers.

Synthetic speech is another alternate output system for the computer. This requires both a speech synthesizer and specialized **screen-reading software.** Synthetic speech enables people who have no vision to get output from a computer. Synthetic speech may also be useful by individuals with learning disabilities who learn better by hearing information than by reading information.

The screen-reading software that functions with a synthesizer is important. The software must do more than merely capture the text going to the screen and send it simultaneously to the synthesizer. People with normal vision are able to scan a document they are reading, and a good screen-reading software program should offer similar options to people using synthetic speech. Screen-reading software allows the user to move an audible cursor around the screen re-reading what the synthesizer already has spoken. When the user is confused or needs more detailed accuracy, the software must permit reading the material a line, word or character at a time. While the user may normally listen to the speech synthesizer with the punctuation feature turned off, sometimes knowing punctuation is crucial to comprehension, and the computer user will need to control volume and speed as well as other speech attributes.

Refreshable Braille is another way for blind users to gain access to a computer display, and it can be particularly helpful for reading information in columns or charts. A device attached to the computer keyboard contains small pins that can be rapidly raised and lowered to make Braille characters.

This is normally one line of data either 40 or 80 characters wide, and essentially is a tactile window providing access to a portion of the monitor.

The user can move this Refreshable Braille 'window' around to provide access to the entire screen's display. This provides an accurate representation of the display content, whereas words spoken by a speech synthesizer can be misunderstood, and numbers are hard to manipulate aurally. Many blind programmers find the degree of reliability offered by Refreshable Braille essential for their work in spite of its being relatively expensive.

Braille embossers function similarly to a standard printer. The paper must be heavier and the embossing can be noisy. Some embossers produce output with Braille on both sides of the page. To make use of a Braille embosser, the user must take the word processor file and run it through a special translation program. This does several things. It will usually translate the text into Grade II Braille which is a kind of shorthand. The translation program also must reformat pages as the normal Braille page is only 40 characters wide.

Finally, an **optical scanner and optical character recognition software (OCR)** are important tools for blind individuals, especially students and professionals. A scanner is not an output device. Its normal function is to provide a convenient way to input data into a computer without having to keyboard it again. However, for a blind user, getting text from paper into the computer is only the first step toward displaying that text on the monitor and through the synthesizer. Most people who want to read a paper document will pick up the text and read it. For a blind person, the computer replaces a human reader, and the blind individual's interest in the scanner is as a means toward displaying the text in an accessible format.

COMPENSATORY TOOLS

Individuals using computing hardware and software as compensatory tools might be trying to accomplish tasks such as reading, writing, organizing information, researching information, taking tests and communicating.

In the past, students who were blind, low vision, or otherwise unable to handle printed material have been dependent on other people to read to them.

Now they can use an optical character reader that reads through a speech synthesizer. The person can also produce **ASCII files** and read them by reviewing the material on a computer screen or via a speech synthesizer. A blind individual can **scan material** into a computer and then use a **Braille embosser to print it out in Braille.** This strategy would be particularly helpful for a student who was writing a research paper to print out and proof the paper in Braille, make corrections, and then print out a regular paper copy for the professor.

An individual who has a disability that affects hand usage might normally have the services of a **note-taker or transcriber.** An alternate strategy would be for the individual to use a **laptop computer and input device to take notes in the class and then print them out in either normal or large-type print.** The student could also review notes on-line. Or, a blind student can use a laptop to take notes in class and then later read them with the use of a speech synthesizer. In these cases, it is quite possible that an individual's use of the laptop computer would cost a school or employer less money than if a note-taker had to be provided.

Individuals with learning disabilities would benefit from software outlining programs that help organize information efficiently, both for study and for producing written assignments.

Individuals with print handicaps (generally those who have visual or mobility impairments) benefit from the use of on-line information. Most libraries now have digitized card catalogs, databases on CD ROM, electronic journals, a few electronic books and accessible computers to allow disabled students to research the material they need. Most books are still not available electronically yet, but through organizations such as **Recording for the Blind and Dyslexic, audio and electronic versions** of many books are becoming more readily available.

Many campuses use computerized phone registration and most businesses have set up phones systems that give information through computerized phone systems. Individuals with hearing or physical impairments would need compensatory strategies to give them access to these systems.

Hearing-impaired individuals benefit from the use of a **TDD** (telephone device for the deaf).

SCIENCE, ENGINEERING AND MATHEMATICS ACCESS

Historically, people with disabilities have faced social and technical barriers that have deterred them from studying or working in the fields of science, engineering and mathematics. While the barriers can be daunting, researchers are developing new tools and methodologies that are allowing people with disabilities to study and work in these fields. In particular, the National Science Foundation is funding several projects that focus on these issues. There are three basic barriers that people with disabilities must confront.

First, individuals with disabilities have faced **negative social attitudes** from educators and from potential employers. Second, disabled individuals who are trying to study and work in the science, engineering and mathematics fields, encounter difficulty with physical barriers in laboratories and with standard lab equipment. Third, many disabled individuals have problems **accessing and manipulating information** that is specific to science, engineering and mathematics **--** such as charts, diagrams and scientific notation.

SOCIAL BARRIERS

Disabled individuals have faced negative attitudes **--** both in education and in the workplace **--** about their abilities to study and work in the fields of science, engineering and mathematics. Professors ask "how can I have a disabled student in my class without lowering my standards," and employers ask "how can a person who can't see tables and charts work with statistical material."

There are answers to both of those questions, and this overview will explain some of the technology and other compensatory strategies that are available to people with disabilities. In the process of introducing the technology, we hope to ease some of those attitudinal barriers.

PHYSICAL BARRIERS

The physical barriers that people with disabilities encounter in the fields of science, engineering and math are more easily identified than the attitudinal barriers. Individuals with disabilities face difficulties maneuvering in the traditional lab and classroom setting.

Generally, there are structural barriers that include **lab tables that are too high or low** for a person in a wheelchair, **instruments** that are difficult or impossible for a person with a mobility or vision impairment to manipulate, and **lectures and multimedia presentations** that are inaccessible to people with hearing or visual impairments.

SCIENCE, ENGINEERING AND MATH BARRIERS

Individuals with disabilities have difficulty accessing mathematical and scientific **notation, graphs, charts, drawings and three-dimensional models** that are prevalent in the science, engineering and mathematics fields.

SPECIFIC PROBLEMS BY DISABILITY CATEGORY

The specific problems and barriers that individuals with disabilities face are easier to understand and address if they're discussed by disability category.

MOBILITY IMPAIRMENTS

People with mobility impairments encounter difficulty using standard laboratory equipment, handling books and writing tools, and using computer equipment that has not been appropriately adapted.

HEARING IMPAIRMENTS

People with hearing impairments have problems getting information from traditional lectures, laboratory instruction, quiz sections, and other real-time oral communication. They also have difficulty **accessing videos, movies and other multimedia.** They may also have difficulty understanding mathematical and scientific abstractions because of language limitations.

SPECIFIC LEARNING DISABILITIES THAT INVOLVE VISUAL PROCESSING DISORDERS

Some people have learning disabilities that negatively influence visual processing. Such people would have problems understanding many materials that are presented in visual format, such as traditional text materials, videos and movies, graphs and charts. For people with visual processing disorders, there are barriers to understanding visual materials presented in lectures, labs, quiz sections and other real-time events, and problems completing homework assignments and exams.

LOW VISION

People with low vision have trouble reading traditional computer screens and computer print-outs. They also have problems reading printed materials. People with visual impairments have problems getting information from slides and overhead projections, videos and movies, and chalkboards.

Lab access barriers include encountering safety hazards while maneuvering throughout laboratories that aren't properly laid out or that don't have appropriate labels on equipment, substances and hazards.

BLINDNESS

People who are blind have problems with computer access, getting information from slides, overhead projections, videos, movies, board drawings and other real-time events. Significant problems are encountered with structured texts, tables, equations, charts, graphs, block diagrams and other graphic displays of quantitative information. There are also problems with writing and manipulating mathematical notation while taking lecture notes, and safety and usage barriers encountered in laboratories.

SOME SIMPLE SOLUTIONS

Many individuals with disabilities use adaptive computing technology in their classes and in the workplace. This technology can be particularly helpful in science, engineering and mathematics study and employment. There are many simple, inexpensive solutions already available that can help individuals get past barriers that keep them out of the science, engineering and mathematics fields.

***Information generated by biology laboratory instruments can be converted into ASCII files and then read by a voice synthesizer or converted into Braille.**

***Individuals with mobility disabilities can use word-predictive software to reduce the number of keys to type long physics-related words correctly.**

***Individuals with visual impairments or learning disabilities can use special computer screens that expand the size of the type so that mathematical equations or scientific formulae can be read more easily.**

***Mathematical information on computer monitors can be expanded or rever sed to white letters on black background or other color combinations for individuals with low vision or learning disabilities that affect visual processing.**

***Individuals studying or working in engineering and mathematics can use control codes in literal Braille to produce Nemeth Code.**

***Graphical information can be converted into a raised line format and then captioned in Braille to provide charts and graphics for people with visual impairments.**

***Special lighting can be used to allow individuals with hearing impairments to see the speaker during a slide show or computer presentation.**

***Videotapes can be close-captioned for individuals with hearing impairments.**

***Special computer input devices can be used by people with mobility impairments.**

MORE SOPHISTICATED SOLUTIONS

While there are simple solutions to remove many barriers facing individual work and study in science, engineering and mathematics, there are also more sophisticated techniques, systems and equipment being developed. A great deal of work is currently being done to solve many of the problems outlined above. Below are brief descriptions of some strategies that are being developed.

NEMETH CODE AND MATHEMATICAL/SYMBOLIC BRAILLE

Most students and employees with visual impairments use either Braille or electronic versions of text to access written material. However, math students and employees have special problems working with mathematical equations for two reasons. First, traditional Braille does not include mathematical symbols and second, most symbols used in higher mathematics are not part of the traditional ASCII character set, which makes it impossible to scan printed mathematical equations into an electronic format. To enable people with visual impairments to access certain technical information, Dr. Abraham Nemeth created a code that would represent the symbols necessary to create mathematical equations.

The most common type of Braille conversion is to **Grade II Braille.** Grade II Braille uses contractions and concatenations that greatly reduce the size of a finished document. The contractions are automatically done when a ASCII text is converted to Grade II Braille. If a mathematical equation is entered in Grade II Braille, there is a high possibility that the translation software will automatically contract and concatenate the equation, making it unreadable or misleading.

Another possibility is that the translator may replace a mathematical symbol with a word description or instruction. For example, "1 + 2 = 3" may be translated into "1 plus 2 equals 3." That may be acceptable in some cases, but it is not acceptable in other cases.

To prevent either of these translations from occurring, it is necessary that the Braille translation software drop out of Grade II Braille and begin using literal Braille, which is a character translation. Then the Nemeth Code, which substitutes usable ASCII symbols to represent the mathematical symbols, can be used.

Creating mathematical notation with Nemeth Code requires a software package that converts ASCII files to Grade II Braille and control codes that instruct the software translation package to drop out of Grade II Braille and to go to literal Braille. The Nemeth Code symbols are then inserted in literal Braille.

Arizona State University has been using the Nemeth Code and Duxbury Braille Translation software to efficiently create readable mathematical/symbolic Braille.

RAISED LINE DRAWINGS

Sometimes the best way to reproduce graphic information so that people with visual impairments can use it, is to create raised line drawings. This can be a relatively easy task that requires a software paint package such as **PC PaintBrush** and a software "capture" package that coverts images into **embossable ASCII format. VersaPoint Graphics from TeleSensory** is one package that performs this function well.

Creating usable raised line drawings depends on the proper use of textures, pixel density, definite boundaries and clear labels. It's also important to remember that although raised line drawings can be helpful for individuals with visual impairments; tactile images cannot represent as much detail as visual images.

AsTeR: AUDIO SYSTEM FOR TECHNICAL READINGS

Electronic documents make it possible to have information available in more than the traditional visual form. Electronic information can now be display-independent. The **Audio System for Technical Readings (AsTeR)** is a system that formats electronic documents to produce audio documents in a manner that allows the listener to either read an entire document or browse the internal structure of a document and read only selected portions. AsTeR can speak both literary texts and highly technical documents that contain complex mathematics.

Visual communication is characterized by the eye's ability to actively access parts of a two-dimensional display. The reader is active, while the display is passive. This active-passive role is reversed during aural communication, where information flows past a passive listener. This reversed relationship prohibits multiple views of the information being presented and makes it difficult for people to understand complex information. It is not possible for a listener to take an overall view of the information and then zoom in on the details. This shortcoming of audio information becomes more problematic when the information being presented is complex mathematics.

Audio formatting, which renders information structure in a manner attuned to an auditory display, overcomes these problems.

AsTeR is an interactive system that allows listeners to browse the information structure of a document, as well as the information being presented.

TeX is a typesetting system widely used in the mathematical and scientific communities to typeset technical documents from journal articles to text books. A TeX file is an ASCII file with embedded TeX commands to indicate mathematical symbols, for example, \alpha for the first letter of the Greek alphabet. AsTeR produces audio-formatted documents from the electronic source of the TeX documents. AsTeR works with several popular dialects of TeX. The combination of **TeX a**nd AsTeR makes it possible to use a command set that expresses the semantic content of a symbol as well as its typographical form.

The typographical features enable TeX to produce high-quality typeset output. The semantic content enables AsTeR to produce high-quality aural renderings.

AsTeR has parsing and expressive capabilities that aurally present the structure and content of a mathematical formula in ways similar to graphical displays. AsTeR also has hypertext facilities that allow a random search for information.

DOTSPLUS

Dotsplus is a method for producing hard-copy scientific literature that is usable by people with visual impairments and people with vision-related learning disabilities.

A Dotsplus document is laid out similar to its corresponding print document.

Dotsplus symbols are **larger** by a factor of **approximately 2.5**, but most of the mathematical and scientific symbols (plus, minus, equals, parentheses, brackets, integral sign, etc.) are raised images that look like their print equivalents. Some are emphasized to make tactile recognition easier, but all are instantly recognizable by sighted readers. Letters, numbers, and a few symbols that are difficult to recognize tactually are reproduced in an eight-dot Braille code. Symbol position is the same as it would be in an ink-print version of the document. In Dotsplus, Braille code must be one in which the cell shape, without reference to its position is sufficient for symbol identification. The lower case Dotsplus letters are standard Braille.

Dotsplus documents can be printed from TeX files and from some graphics-based word processor files. Original files may be viewed and edited on a graphics screen or printed for sighted viewers.

Dotsplus documents can be printed with the use of a modified wax-jet printer that produces tactile images, or they can be printed on special "**swell" paper** using most standard printers. The swell paper is then fed through a machine that heats the paper causing the black portions to swell.

NOMAD PAD

The **NOMAD pad is a "talking," touch-sensitive pad on which raised-line graphics** are placed. It is connected to a personal computer, into which files describing graphics have been loaded. When the appropriate file is selected, the user can touch various points on the graphic and NOMAD will describe the graphics through synthetic speech. The NOMAD pad is particularly useful describing geography, geometry, biology, physics, astronomy and other fields that make heavy use of charts, graphs, diagrams and spatial concepts.

The pad is 22 3/8 inches by 15 3/8 inches and weighs about six and a half pounds. It has an internal speech synthesizer that has both **English and Spanish** capabilities. The pad runs on electricity or battery.

NOMAD can be connected to any IBM compatible or Macintosh computer, although a special kit is required for Macintosh use.

LABORATORY ADAPTATIONS

Creating a laboratory for people with disabilities encompasses various requirements. For people with visual impairments, it's necessary to modify the laboratory equipment so that students and researchers can manipulate instruments and read data. For people with mobility impairments, it is necessary to configure labs so that people with wheelchairs, scooters and crutches can maneuver throughout the area and so that they can operate equipment. It is important to configure and label all lab equipment so that people with disabilities can safely maneuver in and identify all aspects of the laboratory.

Configurable accessibility for a scientific laboratory can be achieved through the use of **wide aisles, adjustable height tables, adjustable keyboards and monitors, easy-to-reach power strips and lighting, and lab documentation that is available in alternate formats.**

In addition to making the lab physically accessible, people working in the fields of science, engineering and math must be able to operate specialized equipment. IBM has introduced the **Personal Science Laboratory (PSL)**, a versatile, modular data acquisition system designed for performing computer-aided experiments in school laboratories. The PSL communicates with a host computer through a standard serial port, and reads its various sensor probes upon receiving commands from the host. It has sensors for pH, temperature, light intensity, and distance.

Sound cards that are compatible with the PSL are now available and make it possible to produce highly intelligible synthetic speech and other noises for a low price.

Researchers are currently writing software intended to make laboratory measurements more accessible to visually impaired students from the middle school through college, using a talking, whistling, musical, large-text laboratory work station assembled from widely available, moderately priced components. The work station hardware consists of an IBM-compatible personal computer, IBM's Personal Science Laboratory, a digital multimeter with computer output, a Creative Labs Sound Blaster sound card, and an electronic balance.

The documentation that IBM provides for the PSL has made it possible for researchers to develop software for reading the output of the PSL's temperature, light, and pH probes. The readings are spoken by the Sound Blaster. This software is not complete yet, but the core procedures for reading and controlling the PSL have been written, and new features are on the horizon.

The addition of an electronic balance to the PSL-computer system creates a lab work station where a visually impaired student can make independent measurements of the basic quantities mass, temperature, pH, and light intensity. With the further addition of a low-cost **Radio Shack Micronta digital multimeter (DMM)** equipped with a serial port, the ability to measure AC and DC voltages and currents, resistance, frequency, and capacity are available.

A separate program for the **Micronta DMM** (which operates entirely independently of the PSL) gives spoken readings through the Sound Blaster, and displays the readings in very large text on the screen. Readings can be stored in a disk file for later analysis. The program announces the meter's ranges as they are changed, and also tells the user if there is an overflow.

If the meter is in a hazardous range, the Sound Blaster makes obnoxious noises and gives the user a spoken warning.

MODEL PROJECTS

There are several organizations working on specific projects to increase the number of individuals with disabilities working in the fields of science, engineering and mathematics. Below are descriptions of a project that focuses on preparing high school students for post-secondary education and a project that focuses on making college and university science, engineering and mathematics programs accessible.

DO-IT (Disabilities, Opportunity, Internetworking & Technology)

The University of Washington is working on a project to increase the participation of disabled individuals in science, engineering and mathematics programs and careers. DO-IT began in 1992 and is primarily funded by the National Science Foundation.

The DO-IT Scholars program provides opportunities for high school students in their sophomore or junior years to study science, engineering and mathematics through an innovative program that combines a mentor program, on-line interaction and a short stint living on a university campus. The program is aimed at developing self-advocacy skills and using technology to pursue academic interests.

DO-IT scholars use computers and the Internet to explore academic and career interests. They are introduced adaptive technologies, establish local Internet connections and receive in-home training. Industry mentors work with scholars through electronic communications and personal meetings, and there is a summer study program in which scholars live in dorms at the University of Washington to get both a feel of campus life and participate in lectures and labs that use computers and the Internet. Subjects include oceanography, heart surgery, chemistry, virtual reality, geophysics, material sciences, civil, mechanical and electrical engineering, mathematics, bio logy, physics and astronomy.

RESOURCES FOR ADAPTIVE COMPUTING EQUIPMENT AND INFORMATION

TECHNOLOGY-RELATED ASSISTANCE ACT

The 1998 Technology-related Assistance Act and its 1993 amendments provide federal funding to help states establish programs that promote the provision of technology-related assistance. The purpose of the Tech Act programs is to, serve as statewide resources that will increase awareness of the need for adaptive technology, disseminate information about adaptive technology, and facilitate the availability of adaptive technology.