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AUTHOR	Heiner, Donna
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ABSTRACT

This booklet provides information about access to computers through alternate keyboards used by students who have physical impairments. Part 1 describes a typical technology team and the alternate keyboard selection process. Part 2 discusses the practical aspects of everyday teaching and living with an alternate keyboard user and includes suggestions on the following topics: information needed about the device and the student, strategies for enhancing students' independence, and implementation of alternate keyboards in the classroom curriculum or in the home. Part 3 discusses how to prevent problems and includes a troubleshooting checklist. Appendices include descriptions of alternate computer keyboards, such as miniature keyboards, touch screens, and augmentative communication devices; a glossary of terms; and a list of resource materials and addresses of information sources. (JDD)

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Center for Special Education Technology
The Council for Exceptional Children
1920 Association Drive
Reston, Virginia 22091
703/620-3660
800/873-8255

Center for
Special Education
Technology

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Introduction

Since the advent of Public Law 94–142, The Education for All Handicapped Children Act, increasing numbers of children with physical impairments have left segregated educational settings and joined their peers in the school and classroom. Recent trends in educational practice will result in the placement of even more children with physical impairments in the regular education setting. Many of these children will require microcomputer technology to support their education in less restrictive environments.

Microcomputer technology allows students with physical impairments to participate in regular classes, to maximize their educational potential, and to exhibit their knowledge. With a computer, a student can write an essay, answer workbook questions, draw a picture, sing a song, work arithmetic problems, practice a foreign language, create a banner, compose music, or design a building. For the student with a physical impairment, computers provide the potential of overcoming physical barriers in the previously "inaccessible" academic environment. The computer can enhance educational, vocational, and personal independence.

Many students, however, are unable to manipulate the standard computer keyboard. In order to experience the potential of computer technology, these students may require an alternate keyboard. Such a keyboard replaces the standard one and has specially designed keys and input methods for students with physical disabilities.

Directed toward the facilitating adult – professional, parent, or paraprofessional – who works with students with physical impairments, this booklet provides answers to questions most frequently raised by those working with the student who accesses the computer through an alternate keyboard. The facilitating adult is assumed to have knowledge of computer operation, but little or no experience with enabling technology specifically designed for individuals with physical impairments.

Part 1 of this booklet briefly describes a typical technology team and the alternate keyboard selection process. Part 2 discusses the practical aspects of everyday teaching and living with an alternate keyboard user and includes suggestions on the following topics: what you need to know about the device and the student, strategies for enhancing students' independence, and implementing alternate keyboards in the curriculum – in the classroom or in the home. Part 3 discusses how to prevent problems and includes a troubleshooting checklist.

Appendix A describes alternate computer keyboards, including miniature keyboards and augmentative communication devices. Appendix B is a glossary of terms that are frequently used. Appendix C lists resource materials and addresses of information sources.

Part 1

Selecting an Alternate Keyboard: The Technology Team

When a student enters the classroom or home with a computer system that includes an alternate keyboard, a significant event in the process of selecting and using an alternate keyboard has already occurred. Many times, the individual who will be responsible for helping the student use the keyboard to achieve academic objectives was not involved in its original selection. It is important for the teacher or other person who works with the student to understand the decision-making process that took place.

The selection of the most appropriate alternate keyboard for the student depends on input from a team of individuals who know both the student and the academic environment. The number of people on the team often depends on the age and capabilities of the student; the more physically impaired the student, the more complex the decision. The professionals involved usually include:

- An occupational or physical therapist who can provide information on the student's physical capabilities.
- A classroom teacher – either regular or special education – who is aware of the academic tasks to be accomplished with the computer.
- A technology specialist with knowledge of the variety of technological alternatives available.
- A special educator with expertise in how one or more physical impairments affect academic learning.

Depending on the student's individual characteristics and academic needs, other people, such as a school psychologist, medical doctor, speech-language pathologist, rehabilitation engineer, or vocational counselor, may also be called upon to participate directly or indirectly in the decision-making process.

Not all members of the technology team are professional educators or ancillary personnel. Parents or guardians of the student also have an active role to play. As the "first teachers" of the student, parents have knowledge of how their child has functioned over time and have the final responsibility for the welfare of the student. Caregivers or paraprofessionals who live or work with the student at home or during the school day have much direct contact with the student. The student, regardless of his or her physical or cognitive functioning, is a sometimes overlooked, but extremely important, member of the team. A student's input – verbal or nonverbal, a cry, or a well-expressed statement – must be treated as significant information. A student who is able to comprehend and to take part in the discussion frequently has specific requirements for computer access.

The results of the team's effort may be a recommendation of one or more alternate keyboards that will fit the student's physical, cognitive, and academic needs. If the student cannot touch the keyboard with fingers or hands, another decision must be made about how the student will access the keyboard. Most teams could easily come up with a description of an "ideal" keyboard for each individual student; however, in reality, a compromise must usually be made between the ideal, and what is available commercially, including the inherent limitations of a particular keyboard or access method.

Once the technology team has reached a consensus and obtained the desired equipment, team members assemble the components in a way that meets the student's needs and then teach the student to operate the keyboard. At this point, many team members assume a consultative role. The people who work closest with the student – classroom teachers, the paraprofessionals, and the parents – will determine how and to what extent to implement the use of the alternate keyboard in the learning environment.

Part 2

The Student-Computer Team

What You Need To Know About The Device

If an alternate keyboard is to be an effective tool for a student with a physical impairment, the individual supervising the use of the system must possess certain knowledge about both the device and the student. Although one or more members of the technology team have installed the device for student use and have trained the student, these team members will probably not be responsible for the ongoing operation of the device in the student's school or home environment. (See Appendix A for more information about alternate keyboard "systems.")

The team members should provide the facilitating adult (the person who works with the student) with the following information and instructions.

Functions and Limitations of the Device

What is the device supposed to do? What can't it do? Brochures and other information from the vendor provide a foundation for understanding the purpose of the device. (See also the glossary in Appendix B). Written information, however, is no substitute for observation and hands-on experience. Visit another student who is using the device or watch a videotape demonstration of the device in use. Put yourself in the student's place and use the device yourself to perform an actual task. Type a letter using a single switch or a headstick. Even the most sophisticated technology requires additional cognitive or physical effort from the student. You need to understand the device well enough to have reasonable expectations of what the student will be able to accomplish.

Information About Software

Depending on the specific keyboard and on the capabilities of the student, the device may allow the operation of: (a) any software that runs on the student's computer system; (b) most software that runs on the student's computer system, providing that a customized setup for a keyboard emulating interface has been designed (see the glossary in Appendix B); or (c) a limited set of software that has been specifically written for that alternate keyboard.

As the student's academic needs and abilities change, additional setups may be needed. You can participate in the customizing process by selecting appropriate software and by giving information to the technology team or the vendor regarding the keyboard input needed to run the software.

Preparing the Keyboard for Student Use

Activating the keyboard may be as simple as turning on the computer, or it may involve the cabling of equipment together and the loading of a specialized software setup. Even procedures that appear complicated require only that you carefully follow directions in a specific order. Anyone who will be assisting the student should participate in a short training session taught by a member of the technology team.

Request a demonstration; take careful notes if no simplified, written instructions are available. Then, using your notes, perform the sequence yourself under supervision. Revise your notes, including each detail, and post a copy of them next to the student's workstation or on the device itself. If it is necessary to attach or cable components of the system, label or color-code the components so they can be matched up easily. Mark cables "this side up" if there is a right and wrong way to attach them. Request a copy of the user documentation or manual for your reference.

Ask questions, even if they seem insignificant or silly. It is easy for someone very familiar with enabling technology to forget to mention an important aspect of using the device. Take time to learn about common problems that others have experienced and what you can do to prevent or solve those problems. (See Part 3 for help in preventing problems and for troubleshooting hints.)

Because a student's ability to operate the device may vary because of fatigue or a temporary change in physical capability, you also need to know if the rate at which the student accesses the device can be changed and how to change it.

Power Source Considerations

Although many alternate keyboards and control interfaces only require attachment to the computer to operate, others also require a separate source of power. Several kinds of keyboards must be plugged directly into an electrical outlet. Augmentative communication devices, designed for portable use, usually have internal rechargeable batteries. When the device, by means of an auditory or visual warning, indicates a "battery low" state, the device will soon inactivate itself to prevent loss of stored information. Although most of these devices can operate on 120 AC current, recharging will take place only when the device is turned off and "on charge" for a specified number of hours. Optical headpointers also require regular charging; "battery low" status is usually not directly indicated.

When and How to Call for Help

Where can you reach a technology team member or other "expert" if you have additional questions or need help? Are there specific times during the day when such a person can be easily reached? Vendors of devices often have toll-free "Help Lines" staffed by technicians who can often solve problems quickly and easily over the telephone.

Other resources include user groups, which are composed of parents and professionals interested in sharing information on a specific device, or enabling-technology (SIGs), which are special interest groups that are often part of local computer clubs. Many states now have enabling-technology resource centers. These centers, which are operated by state agencies or by a group of consumers such as members of the Alliance for Technology Access, can provide technical assistance and training. (See Appendix C for available resources.)

How to Involve the Student

A long-range goal for the adult facilitator is to pass the responsibility for the day-to-day operation of the computer system to the student. Depending on the age and cognitive ability of the student, his or her involvement in the operation, maintenance, and troubleshooting aspects of the device may be appropriate. An experienced user of enabling technology needs to understand how the computer and alternate keyboard work together. Even though the student may not be physically able to attach components or load disks, the student should be able to direct others to do those tasks when it is necessary.

What You Need To Know About The Student

The most important component of the system is not the computer or the alternate keyboard—it is the student.

How the Student Feels About the Device

If the student had input into the selection of the device—or if he or she is very young—acceptance may not be a problem. However, both children and adults may resist change. Any new way of performing a task brings with it additional demands and apprehension. For example, a student who has always been dependent on others for writing tasks may value the human contact more than the independence provided by a computer. Some young people, in their desire to "be like everyone else," may decide against using enabling technology in favor of a less efficient method or no method at all.

During the excitement of learning about a new technology, remember to listen to and observe the student. An ongoing problem may require the selection of another device or consultation with a school counselor or psychologist.

How the Student Has Been Taught To Use the Device

If the student is a young or novice technology user, it may be your responsibility to maintain and reinforce the input skills taught by a member of the technology team. Learning about the device will be of great value, but your ability to continue with the techniques that were initially taught will benefit the student even more.

Observing several teaching sessions and noting what the consultant says and does with the student provides additional knowledge not found in any manual or user documentation. Role playing the student's part in a teaching session and learning to use the device as the student did, presents another view of the process.

How to Position the Student with the Device

Positioning is a crucial factor that affects the student's ability to use an alternate keyboard. Proper positioning, which facilitates normal movement patterns, makes functional use of head and arms possible. The well-positioned student is in a comfortable position that offers necessary support to designated parts of the body.

Students may access a keyboard from a lying, seated, or standing position; in any of these positions, the student's body must be adequately supported. In the classroom, the majority of students with significant physical impairments will employ a seating system that fits their specific requirements. Because accessing a keyboard, with or without a control interface (see the glossary in Appendix B), requires the student to perform new tasks, the student's positioning or wheelchair components may change as the computer system develops. Input from an occupational therapist is essential to the arrangement of the components of the system and the student. The physical relationship among student, computer, alternate keyboard, and control interface determines how efficiently the student uses the computer.

Once the student is correctly positioned, the placement of the control interface is determined. A keyboard or switch must be placed so that the student can activate it without unnecessary fatigue or interference with therapeutic goals.

The computer and peripherals (monitor, printer, and disk drive) may also be part of the complete system. Placed to eliminate glare from windows or overhead lighting, the monitor should be easily viewed by the correctly positioned student. Operation of the printer or disk drive may necessitate additional adaptations or specialized furniture.

If the student has complex positioning needs, request that the occupational therapist provide photographs or diagrams of the complete arrangement of student, chair, device, and control interface for easy reference by all who work with the student. To maintain consistency, use pieces of tape or other markers on the table or work surface as visual reminders of placements.

Positioning is an ongoing process. Changes in the student's physical condition, the seating system, or the classroom setting may require a reassessment from the therapist. Changes in a student's positioning should be made only with the guidance of a qualified occupational or physical therapist.

Strategies for Enhancing Independence

One reason for providing students with enabling technology is to develop their independence—both in academic tasks and in future vocational and personal activities. The process begins with the appropriate involvement of students in the selection of the computer, alternate keyboard, and control interface. Providing necessary physical adaptations and training in maintenance and upkeep make it possible for students to begin assuming responsibility for their own equipment.

Most students who can operate a computer can also turn it on. With the touch of a button or toggle, standard power strips arranged with a surge protector turn on all components of a system simultaneously and can be positioned on the edge or leg of a table for convenient access. For students who require a larger or more sensitive target area, adapted power bars turn on with the press of a switch or the pressure of a wheelchair on a floorpad.

Disk guides and holders enable students to select and place programs and data disks into the drive. The semi-rigid 3.5 in. disks are usually easier to manipulate and insert than the more flexible 5.25 in. disks. The addition of a hard drive eliminates much disk handling; disk management programs automate the loading of programs and files.

Because students who require alternate keyboards may also have difficulty expressing themselves in speech, consultation with a speech-language pathologist will help determine the need for additions to the student's expressive vocabulary. Both the student who signs and the student who uses an augmentative communication device must be able to ask questions, offer suggestions, and alert others to problems. Students need the ability to communicate statements such as:

- "Is it time to use the computer?"
- "I need to use the computer."
- "That's not the right disk."
- "The printer won't print."
- "The battery is low."

Adults and students in the home and classroom signing environment will need to learn the new signs and how to respond to them. The augmentative communication device may require additional programming of words and phrases, which the student must learn to retrieve at the proper time. If the student is using the communication device as the alternate keyboard, provisions must be made for the student to move between "communication" and "computer" mode. When control interfaces prevent the student from accessing both the communication device and computer, the student must have a method of indicating a desire to communicate and a backup communication system, such as a communication board, with which to communicate.

Using Alternate Keyboards with Academic Instruction

Because of the effort involved in the selection, acquisition, and setup of an alternate keyboard and computer system, it is easy to overlook the most important aspect – how the student will use the keyboard to meet academic objectives. Although the same general principles of software selection apply for students with or without physical impairments, the task of selecting instructional software that can be used with the alternate keyboard sometimes challenges even the most experienced educators. To do so effectively requires that one have in-depth knowledge of: (a) available software, (b) the capabilities and limitations of the alternate input device, and (c) the student's physical and cognitive functioning.

Educators working with students using the standard keyboard have the luxury of many software programs from which to choose. When a student has a physical impairment, the first consideration is often "What is the student able to do with the alternate keyboard?" If the student is unable, physically or cognitively, to access all the keys of the standard keyboard, software must be selected with these limitations and the student's educational objectives in mind.

Successful implementation of an alternate keyboard calls for consideration and possible modification of the academic objectives specified in the curriculum. The following examples illustrate how a combination of enabling technology, software, and curriculum modifications can support educational objectives for students. The examples illustrate four major categories. Each is based on the amount of curriculum modification required and differences in academic objectives.

No Modification of the Academic Task

- In a high-school word processing class, Bob, a proficient Braille writer and reader, inputs and edits text with his Braille keyboard and display. At the end of the session, he sends his work to the printer, prints the assignment, and hands it in.
- Kathy, whose plans after high school include a career in computer-assisted drafting, directs the on-screen cursor with a foot-controlled expanded keyboard placed on the floor.
- Eight-year-old Juan receives A's on his arithmetic worksheets. Each weekend, his parents use an optical character reader to scan the next week's worksheets into the computer. Using his joystick and an alternate keyboard, Juan enters his answers and turns in his completed worksheet.

Some Modification of the Academic Task

- Sally operates her computer through a switch-controlled alternate keyboard. She is an excellent student whose "handicap" is the time and effort necessary for her to complete her schoolwork. Her teachers have shortened lengthy assignments for her; if she can do the most difficult questions correctly, she need not complete the easier ones.
- While the first-grade class completes a workbook lesson on matching upper-and lower-case letters, Fred, with the help of a mini-keyboard, accesses a software program. To progress through the alphabet, he must select the letter on his keyboard that matches the one displayed on the screen.
- In a preschool special education class, the goal is for the children to learn to associate the name of an object with the object itself. Cassandra uses an alternate keyboard and software with an overlay that has been designed for this task.

Modification of the Academic Task with Similar Educational Objectives

- As part of a middle-school biology class, the students must demonstrate the ability to use a simple microscope. In the resource room, Jim, using an expanded keyboard and customized setup, simulates the physical manipulation of the microscope with a software program.
- A second-grade teacher has decided to focus her efforts on developing her students' reading comprehension. The workbook for the students contains short stories and a series of questions about the content of each story. Anne can access the computer through her communication device, but is presently limited to eight selections. Her teacher has found a software program that closely parallels the textbook. Because the program requires the use of only the return key, spacebar, and five numbers, Anne can operate it independently.
- Jake and his classmates are required to research a topic in the encyclopedia and to turn in a summary of their notes. Although he cannot manipulate the pages of a book, Jake performs his research with a telecommunications program and an on-line encyclopedia, and dictates his notes into a tape recorder.

- After a particularly successful field trip, the students are writing thank-you notes to the parent chaperones. Amy's expanded keyboard has been programmed with the words she needs for her note. The overlay on the keyboard contains pictures that correspond to the programmed words. When she touches a picture, an entire word, spelled correctly, appears on the screen. When she touches the square with a picture of a printer, the keyboard sends a "print" command to the computer, and her thank-you note prints out.

Modification of the Academic Task with Different Educational Objectives

- The fourth-grade project for the semester is "dinosaurs." Each of the students has been assigned a type of dinosaur and the task of finding out what that dinosaur ate, when it existed, how large it was, and so forth. Tyrone, who has a physical impairment and whose reading ability is several years below grade level, enters the results of his classmates' work into a simple database he and his teacher created.

- John, enrolled in a computer class with age-appropriate peers, has neither the physical nor cognitive ability to follow the standard *Introduction to Computers* curriculum. Instead, he uses an alternate keyboard and software designed to teach beginning computer skills to younger children.

Arranging the Environment for Computer Use

The physical arrangement and placement of the student's computer system in the home or classroom will affect the ability of the student to use it effectively and with maximum independence.

Laptop Computers

The laptop portable systems of nonambulatory students may be carried under or behind the wheelchair seat, embedded in a laptray, or mounted to the side of the chair. The power jack receptacle should be located for convenient recharging or operation off the electrical outlet. The angle-dependent LCD screens of laptop systems necessitate careful positioning and diffuse lighting to prevent glare and to increase visibility.

Stationary Computers

The needs of the student, as well as the purpose and frequency of use, determine the placement of a stationary computer system. Some children may find it easier to access computers placed on or low to the floor. In the home, resource room, or computer lab, computers arranged against the wall maximize use of space, conceal unsightly cables, and provide access to electrical wall outlets.

A student who frequently uses a computer throughout the school day may need a system on his or her classroom desk to participate in classroom activities. Enclosing power cords in protective floor strips and bundling cables lessens the possibility of accidents involving computers or students. Avoid traditional wheelchair computer furniture with high backs and sides; these make it difficult for the student to see and be seen. To decrease distracting printer noise, enclose the printer in a soundproof printer cover.

When a stationary computer must move from class to class with a student, additional safety precautions are necessary. A trolley that is specifically designed for transportation of computer systems and that allows the secure fastening of system components protects computers and students. Protective inserts are available to insert into the disk drive, and the drive door is closed before moving the computer. If the computer has a hard drive, you may need to enter a command that protects the delicate mechanism from possible damage.

Conclusion

Facilitating the effective use of computers for students with physical impairments requires knowledge of computer equipment and the students' capabilities and needs, and a large dose of creativity. Most of the alternate keyboard and interface systems result from the creative energies of people who were looking for ways to enhance the communication skills of individuals with disabilities. We hope that you may discover uses, positions, and applications that will in turn enable other students—and teachers—to meet their own educational and personal objectives.

Part 3

Precautions and Troubleshooting

Preventing Problems

As you increase the complexity of a computer system to improve its functionality for a student with a physical impairment, you increase the chances of potential problems. Fortunately, simple precautions can prevent the most frequent problems from occurring.

Increase Your Knowledge of the Device

Profit from the experiences of other users. Professional magazines and other publications feature articles on how particular devices operate. Inservice training workshops and conferences focusing on technology for students with physical impairments frequently include workshops for beginning and experienced users.

Keep Step-by-Step Directions Current and Visible

You will soon outgrow the need for a detailed set of instructions on how to activate the student's system. However, you may not always be there. Other adults in the classroom or family members may need to assist the student in your absence. Include with the instructions a copy of the Troubleshooting Checklist from Page 11 of this guide.

Backup Computer Programs and Setups

Professional computer users make it a practice to maintain a backup copy of data and programs. Disks can be accidently erased, bent or destroyed. If the student requires customization through a software setup program for an alternate keyboard, store a copy of the current version clearly labeled with the title, student's name, and date in a safe place. If the original is damaged, make a copy of the backup and use that. Make a backup copy of any student work that cannot be easily redone.

Write-protect floppy disks to prevent inadvertent changes in a customized setup by: (a) placing a tab over the notch of a 5.25 inch disk or (b) sliding the write-protect tab of a 3.5 inch disk to the "closed" position.

Although they are not as vulnerable as floppies, hard drives can also fail or be accidentally erased. To be safe, back up information on the hard drive to floppy disks or to an external backup.

Take Care of Cables

Cables, groups of wires covered with a flexible rubber coating, carry information between components of the computer system. When they become damaged, the system will operate erratically or not at all. Avoid removing or replacing cables whenever possible. Screw down permanently placed cables to prevent them from coming loose.

Cables with pins on either end are fragile and prone to damage. Label or color-code connections and mark cables "this side up." Attempting to insert a connector upside down or otherwise incorrectly will bend or break a pin. Bent pins may sometimes be manually straightened, but they eventually break off. Order duplicates of frequently handled cables to prevent interruption of the student's access to the computer.

Store cables carefully, particularly cables that are attached to battery chargers. Loop the cable in a circle or figure eight and fasten it with a twist-tie to prevent bending or breaking the internal wires.

Eliminate Static and Power Problems

Make it a rule to turn off the computer before plugging or unplugging anything. Even inserting a switch into a switch interface may generate enough static to interfere with the operation of the computer.

Some environments, especially in the winter months, are static prone. Antistatic mats and sprays help to control static in the vicinity of the computer.

Avoid opening the computer unless you know what you are doing. Before touching anything inside the computer, you must ground yourself by touching the power supply box first to discharge static electricity from your body and to prevent serious damage to the internal circuitry.

Accessories such as fans and surge protectors (sometimes combined in one unit) prevent problems.

Heat buildup inside the computer can cause the computer to operate incorrectly. If the alternate input device necessitated the addition of internal circuit boards, an internal or external fan is necessary. Surge protectors protect the computer from wide variations in electric current.

Troubleshooting Techniques

When, despite all your care and precautions, something does go wrong—the scan won't scan or the keyboard doesn't respond—don't panic. Most of the problems that occur with computers are easily remedied.

Sometimes there is no discernible reason for a problem. Remove the software from the disk drive and turn off the computer. Wait a minute, cross your fingers, and repeat the start-up procedure. If the problem remains, before seeking expert help, perform your own troubleshooting procedure (see the following checklist). In the majority of cases, apparent malfunctions are caused by something as simple as a loose cable or electrical connection.

For more serious computer malfunctions, the most efficient solution is to isolate the problem—the problem can't be solved until it is defined. Because the computer system is composed of separate components, all of which are interrelated, a problem with one component affects the entire system. If possible, place components one at a time from a system that does work into a system that is malfunctioning, and that will eventually identify the problem.

As you troubleshoot, take notes on what you observe, both for your own use and for the use of others who may be assisting. If you change equipment or software settings, write down the original setting for later reference.

Troubleshooting Checklist

Computer

- ☐ Is the computer on? If power cords are plugged into a common power strip or surge protector, power must be turned on at the computer and on the strip or protector.
- ☐ Is the monitor on? Have the brightness and contrast been altered?
- ☐ Are power cords attached firmly? Power cords may pull away slightly and interfere with power to the computer and still appear securely attached.
- ☐ Are all cables secure? Check cables, particularly those with prongs, and reattach carefully. Cable problems cause equipment to function erratically. Check the problem by substituting a similar cable that works.
- ☐ Is the computer itself working properly? Failure of the computer is not usually the problem, but can be easily checked by running a self-test for a malfunction in its internal circuitry.
- ☐ Has the computer been recently moved or bumped? It is possible for chips or expansion cards to become loose. If you are familiar with the inside of the computer, turn off the computer (but don't unplug it) and ground yourself. Keeping one hand on the power supply, gently push down on the chips and circuit boards.

Software

- ☐ Has the correct software been loaded?
- ☐ Have the disks been loaded in the correct order?
- ☐ Does the software run in another computer?
- ☐ Do copies of your backup disks run?

Please keep a copy of this checklist in a convenient location!

Alternate Keyboard or Other Enabling Device

- ☐ Is the device on?
- ☐ Does the device or its control interface require charging? If so, has it been recently charged?
- ☐ Does the device utilize batteries? Have they been replaced recently? Even rechargeable batteries must be replaced eventually.
- ☐ Are all components of the device securely cabled together? Turn off the computer and check all the physical connections.
- ☐ Has the angle of the visual display been changed?
- ☐ Are there any settings that could have been altered? Some devices have controls on the side (small switches arranged in rows) that may have jarred during transport. Write down the existing setting (e.g., up, down, down, up, up) and reset the switches.
- ☐ If the device is switch-operated, does another switch work?

When to Call for Help

If you need to call the vendor for assistance, it helps to have the telephone near the computer, alternate keyboard, and control interface. Have the following information available:

- The computer type.
- Name, version, and serial number of the device.
- The software and version number.
- What happened, or what didn't happen.
- The steps you have already taken or tried to solve the problem.
- Any error messages displayed.

Keep serial numbers and names of equipment, as well as lists of software and their version numbers, in a loose-leaf notebook near the computer, with blank pages for recording problems and solutions.

Appendix A

The Alternate Keyboard "System"

The alternate keyboard itself is usually only part of the student's computer system. Other possible components include keyboard emulating interfaces, control interfaces, and specialized software programs. Although the devices and software are designed for use by nontechnically trained individuals, it is useful to have a general understanding of their operation.

Most computers are designed to recognize incoming information from a single source—the keyboard. If the student's alternate keyboard does not send information in a form that the computer recognizes, the alternate keyboard will require a keyboard emulating interface (KEI) to "talk" to the computer. The KEI changes the signals from the alternate keyboard into standard keyboard input "code" and sends them to the computer. It operates in much the same way as a translator listens to a conversation in one language and repeats it in another. The computer "translator," the KEI, is attached or cabled to both the alternate keyboard and the computer.

A student who cannot touch a selection on a keyboard with his or her hands or with a pointing device, such as a headstick or mouthstick, must use control interfaces to select. Control interfaces, such as a joy-stick, optical headpointer, or switch, allow the student to select an item without making contact with the keyboard. With the appropriately selected and positioned control interface, even the student who has only one consistent movement can operate a computer without touching a keyboard.

The last necessary part of the student's "alternate keyboard system" is software. Some alternate keyboards require special software, which is purposely written to accept nonstandard keyboard input. These keyboards will not run the majority of educational software programs and may not be useful for students who require access to the same educational software used by their classmates. In addition, some KEIs have their own special software that must be loaded into the computer. These programs, called "setup" or "configuration" programs, customize the operation of a particular program or access method for an individual student.

The following is an example of one student's setup program. Rachel, an elementary school student with cerebral palsy, drives her wheelchair, speaks through an augmentative communication device, and accesses a computer by moving her head to touch switches placed on the headrest of her chair. When Rachel needs to use the word processor to write a story, her teacher, Mr. Baker, attaches the augmentative communication device to a KEI cabled to the computer. Mr. Baker turns on the computer, and, in seconds, loads Rachel's individual setup program (which tells the augmentative communication device and the computer how they will send information to each other), then a word processing program. When Rachel begins to enter her story, she touches her switch (the control interface) and selects a letter on her augmentative communication device (the alternate keyboard). The device sends a message to the KEI, which, in turn, sends a letter to the computer.

How Alternate Keyboards Vary

Alternate keyboards differ in a number of significant characteristics.

- Some attach to the computer directly; others require a KEI.
- Some have flat, touch-sensitive surfaces; others have separate keys.
- Some require the student to touch the surface with a finger; others require a control interface.
- Some operate with standard software; others require specialized software.

Alternate keyboards also differ in the keyboard arrangement and in the features that improve access by students with physical impairments. The arrangement and nature of items on the alternate keyboard depend on the characteristics of that keyboard, the student, and the educational task. Some keyboards may be easily customized; symbols, pictures, or even real objects may be used to simplify the physical or cognitive requirements of the software. Students who require the ability to produce written work need access to the letters, numbers, punctuation, and functions of

the standard keyboard arrangements. Possible arrangements of the keyboard may include:

- QWERTY – the standard typewriter or computer keyboard.
- Alphabetical – for younger children.
- Frequency of use – key arrangements that increase efficiency.

Alternate keyboards are specifically designed for students with physical impairments and frequently include additional options. Because a student may be able to activate only one key at a time, a "latching" feature enables the student to perform operations requiring multiple keystrokes (such as "shift" "a") with sequential (one at a time) rather than simultaneous keystrokes. Visual, auditory, or tactile feedback lets the student know that he or she has successfully made a selection. Some keyboards include the option of altering the rate of selection to prevent accidential or incorrect keystrokes. For students who cannot lift their fingers from the keys quickly, altering the key-repeat feature of the keyboard eliminates the unwanted production of multiple, identical keystrokes. Keyboards that activate with only a small amount of pressure benefit students with decreased strength. Through software or a KEI, it is possible to direct how the control interface and the keyboard will work together and select customized features for a particular student.

Types of Alternate Keyboards

Alternate keyboards come in a variety of shapes, sizes, and forms. Except for their function, alternate keyboards may be very different in appearance. Following are some examples of alternate keyboards.

Detached Keyboards

Detached keyboards may resemble standard-sized keyboards accessed directly or they may be specifically designed for use with one or more switches. Standard-sized keyboards require good fine-motor skills, but allow for alternate positioning of the keyboard or the use of specialized options. Switch-operated keyboards allow students who do not have the physical skills to directly access the keyboard to utilize the capabilities of the computer.

Examples:

ComputAbility Corp. – *Membrane Keyboard II*

Compute Able Network – *Toteboard*

EKEG Electronics Co., Ltd. – *Remote Keyboard*

Keytime – *Dvorak Keyboard*

Key Tronic – *Key Tronic Touch Pad Keyboard*

Polytel Computer Products Corp. – *Keyport 60, Keyport 300*

Prentke Romich Co. – *Computer Entry Terminal*

Sunburst – *Muppet Learning Keys*

TASH, Inc. – *Membrane Keyboard, MOD Keyboard*

Typewriting Institute for the Handicapped – *Dvorak One-Handed Keyboard*

Venture Technologies, Inc. – *TurboSelect*

ZYGO – *TETRAscan II*

Expanded Keyboards

Expanded keyboards, larger than a standard keyboard, offer large target areas and keys that are spaced more widely apart. Students with limited fine motor skills or visual impairments frequently use expanded keyboards. On some expanded keyboards, it is possible to group keys together to form even larger target areas. Other keyboards are arranged for efficient use by one-finger or headstick users.

Examples:

Cacti Computer Services – *Expanded Pressure Sensitive Keyboard*

Dunamis, Inc. – *PowerPad*

EKEG Electronics Co., Ltd. – *Expanded Keyboard*; *Expanded Keyboards for Apple II+, IIe, IIgs*, and *Mac*; *Expanded Keyboards for Garid Personal Communicator*; *Expanded Keyboards for IBM PC, AT, XT*, and *PS/2*; *Expanded Keyboards for Learning Aids*; *Expanded Keyboards for the AFC*; *Expanded Keyboards for Trace Center's Blissapple Program*; *Narwhal Board*; *TenKey Board*

Exceptional Computing, Inc. – *Florida Expanded Keyboard*

TASH, Inc. – *Membrane Keyboard*; *King Keyboard*; *Learning Pad*; *PC King*

Unicorn Engineering, Inc. – *Unicorn Expanded Keyboard*

Mini Keyboards

Miniature keyboards are appropriate for some students, such as some mouthstick users, who have excellent fine-motor skills, but a limited range of motion. The closely spaced keys of miniature keyboards may be arranged so that frequently-used keys are found in the center of the keyboard.

Examples:

Computability Corp.—*Mini Membrane Keyboard*

inTouch Systems—*Magic Wand Keyboard*

TASH, Inc.—*Bloorview Miniature Keyboard*; *Mini Keyboard*; *PC Mini*

Unicorn Engineering, Inc.—*Model 510*

Augmentative Communication Devices

Augmentative communication devices, with the appropriate keyboard emulating interface (KEI), allow the user to access the computer through the device.

Examples:

AdamLab—*Wolf*

Adaptive Communication Services, Inc.—*Eval PAC*; *Real Voice*; *Scan PAC*

Phonic Ear—*VOIS 160*

Prentke Romich Co.—*LightTalker*; *TouchTalker*

ZYGO—*scanWriter*; *ZYGO Model 100*

Chordic Keyboards

Used with one or both hands, chordic keyboards have a limited number of keys and require the student to depress two or more keys simultaneously, much like playing chords on a piano. Each combination of keys represents a key on the computer keyboard. The six-keyed Braille keyboard is a familiar example of a chordic keyboard. Other chordic keyboards permit students with one usable hand to enter information rapidly.

Examples:

TASH, Inc.—*Optima Keyboard*

TeleSensory—*Braille Interface Terminal*; *Navigator*; *VersaBraille II+*

Touch Screens

In this adaptation, touch screens fit over the computer monitor. The student indicates selections by touching a corresponding area on the touch screen. Software must be specifically written to accept touch-screen input; the documentation or software package will specify touch-screen compatibility.

Example:

Edmark Corp.—*TouchWindow*

Keyboard Emulating Interfaces

A keyboard emulating interface (KEI) makes possible the use of an alternate keyboard, augmentative communication device, or switch as an access device to the computer. The KEI receives the information from the alternate access device and sends it to the computer.

Examples:

Adaptive Communication Systems, Inc.—*Emulator for Apple IIe*: Apple IIe family; *Emulator for IBM and Compatibles*: MS-DOS and PS/2 computers.

ComputAbility Corp.—*Aid + Me*: Apple IIe family, MS-DOS computers, PS/2, and Macintosh.

Don Johnston Developmental Equipment, Inc.—*Adaptive Firmware*: Apple IIe family; *KE:NH*: Macintosh.

Prentke Romich Co.—*AKI-2E*: Apple IIe family; *KII*: MS-DOS computers.

Regenesis Development Corp.—*Regenesis Keyboard Expander*: MS-DOS computers.

TASH, Inc.—*PC A.I.D.*; *PC Serial A.I.D.*: MS-DOS computers.

TeleSensory—*BIT+*; *Soft BIT*: MS-DOS computers.

Words+—*Expanded Keyboard Emulator*; *Software Keyboard Emulator*: MS-DOS computers.

ZYGO Industries, Inc.—*ZYGO Emulator*: Apple II+, Apple IIe family.

Control Interfaces

Control interfaces allow the student who cannot touch a keyboard to select an item by operating a switch, joystick, or optical headpointer.

Examples:

Don Johnston Developmental Equipment, Inc.—*Multiple Switch Box*; *Porter*

Dunamis, Inc.—*PowerPort*

Switches

Switches, or on/off devices, are used by very young students or students with severe physical impairments. To use a switch, the student must be able to make a consistent, controlled movement of some bodypart. Although some switches detect movement or sound, in most cases the student is in direct contact with the switch and must make a movement, however slight, to activate it. Switches may be used singly or in groups of two or more.

Matching the student with the correct switch requires a team effort and trial use over a period of time. Switches vary widely according to how they are

accessed, the feedback provided, the type of movement required, and the amount of pressure necessary for activation. The active involvement of an occupational therapist is essential to determine the type of switch and switch placement that will allow the student efficient access without causing undue fatigue or interfering with therapeutic objectives.

The large number of different types of switches permits the selection of a specific switch to meet an individual student's need. The following companies market a variety of switches.

Examples:

ComputAbility

Creative Switch Industries

Don Johnston Development Equipment, Inc.

Prentke Romich Company

TASH, Inc.

Scanning

The most common switch access method is scanning—a selection technique whereby the student indicates a choice from a sequential presentation of selections.

As do other alternate input devices, switches require software written specifically to accept switch input or a KEI to access standard unmodified software programs. The specialized software or the KEI allows customization for individual students. The scan method, rate, speed, or the selections themselves may be altered to meet the requirements of the student or the software. For example, a preschooler might access an unmodified early learning software program with a KEI, single switch, and a customized setup which includes only the few selections necessary to operate the program.

On an alternate keyboard that uses scanning as input, each possible selection is associated with a small light-emitting diode (LED). When the light comes on next to the desired selection, the student indicates his or her choice. In a typical scanning situation, selections are automatically presented on the alternate keyboard, from left to right and top to bottom, one at a time, or in groups. One selection or group is visually singled out by the device. The student activates the switch when the desired selection is reached.

When the selections are presented sequentially, in a fixed order, the scan is referred to as a *linear scan.* Using the standard typewriter layout as an example, a linear scan would present "Q," then "W," "E," "R," "T," "Y," and so forth, and then proceed to the next row of keys. The LED would light up under each letter in turn. To enter the letter "M," the student waits for the other 25 letters to be presented, then presses the switch when the LED under the "M" lights.

In a *row-column scan,* an array of selections is presented. The device scans by rows; when a row is indicated, the device then scans by column. Using the familiar typewriter layout, in a row-column scan, the LED lights under the letters "QWERTYUIOP," then "ASDFGHJKL," then "ZXCVBNM." When the student selects a row, each letter in the row is presented in turn.

The student may use one of several different methods to choose the item. The method chosen largely depends on the student's physical abilities. How quickly can the student press or release a switch? Can the student operate one or several switches? Does the student fatigue quickly? The following are four different methods of scanning:

- *Automatic scan*— the student presses the switch to begin the scan, then waits as the selections, individual or group, are presented. When the LED light(s) reach the desired selection, the student presses the switch.
- *Step scan*—uses the same presentation format as the automatic scan, but the student does not depend on the device to present the next selection. The student activates the switch repetitively to move the light from selection to selection. When the LED under the desired selection is lit, the student then waits a predetermined time or presses a second switch.
- *Inverse scan*—the student presses and does not release the switch until the LED reaches the desired selection. Releasing the switch indicates a choice.
- *Directed scan*—the student who can use two or more switches may access the keyboard with this method. The student directs the LED (up-down, left-right) to a selection with two or more switches and selects with another switch.

Because scanning is a time-consuming method of access, alternate keyboards that include scanning as an option have selections arranged for greater efficiency. The placement of frequently-used letters in the upper left-hand row decreases the amount of time the student must wait until the LED reaches a selection.

Morse Code

For some students, single-or double-switch Morse code input offers an efficient means of entering data. Morse code is an option for students with limited movement, but who have good control over switch presses. The codes, which indicate letters, numbers, and punctuation marks, are the same as those used by ham radio operators. The student presses one or two switches to produce a combination of "dits" and "dahs."

Joysticks

Joysticks, similiar to those used in computer games, operate on the same type of alternate keyboards as do switches. As on a scanning keyboard, an LED below each selection indicates the active choice. As the student moves the joystick, the light moves from selection to selection. The student may indicate a selection with the joystick "firebutton" or by waiting for a set period of time. The speed at which the light appears to move is adjustable, as is the "wait" time. Adapted joy-sticks allow the student who can move the lever, but not press the firebutton, to indicate a selection through a switch press.

Because the joysticks used to operate alternate keyboards are equivalent to five switches, an array of switches sometimes substitutes for a joystick. Four of the switches indicate the directions "up," "down," "left," and "right"; the fifth switch represents the joystick firebutton.

Examples:

Don Johnston Developmental Equipment, Inc.—*Modified Joystick*

Prentke Romich Co.—*Armslot Control*; *Joystick*

TASH, Inc.—*Joystick with Pad*; *Micro Joystick with Push*; *Mini Joystick with Pneumatic*; *Mini Joystick with Push*; *Penta*; *Star*; *Wafer*

Optical Headpointers

Resembling small flashlights, optical headpointers are used to directly indicate a selection on an alternate keyboard. The headpointer may be fastened to the student's glasses or headband; the student controls the keyboard through slight head movements. On several alternate keyboards, the keyboard choices are each associated with one or more LEDs. The headpointer contains a photo diode that senses when it is directed at an LED. As the student moves his or her head, LEDs under possible selections light in turn. Selection is made either by pressing a switch or by leaving the cursor on the target selection for a set period of time.

Examples:

Adaptive Communication Systems, Inc.—*Light Pointer*

Prentke Romich Co.—*Optical Headpointer*

Words + —*Long Range Optical Pointer*

Other Assistive/Adaptive Products

Customized and Authoring Programs

Computability Corp.—*Computability PowerPad System*

Dave Schmidt (Public Domain)—*Talking PowerPad.*

Dunamis, Inc.—*Control Without Keyboards*; Power *for IBM-PC*; *Power Pad*; *PowerKey Software*; *PowerPad Programming Kit*; *PowerPad Tool Kit*; *TouchCom*

Edmark Corp.—*IBM TurboTouch Programmer's Toolkit*; *LessonMaker*; *Talking TouchWindow*; *Touch Window*; *TouchWindow Toolkit.*

Hartley Courseware, Inc.—*E-Z Pilot II Authoring System*

Madalaine Pugliese Associates, Inc.—*Me Too!*

Sunburst—*Muppet Learning Keys*; *Muppet Learning Keys Toolkit.*

Unicorn Engineering, Inc.—*Start Talking*; *Unicorn Keyboard*; *Up and Running*

Troubleshooting Programs

Dunamis, Inc.—*Nikrom Master Diagnostics Disk*: Apple II+, IIe, and IIc computers. Tests system and assists with computer maintenance.

Don Johnston Developmental Equipment, Inc.—*Peripheral Tester*: Apple IIe family computers. Troubleshoots adaptive computer hardware.

Disk Guides

Extensions for Independence—*Disk Guide*

Prentke Romich Co.—*Disk Guide*; *Dual Disk Guide*

TASH, Inc.—*Disk Guide*

Adapted Power Bars

Regenesis Development Corp.—*Power Bar*

TASH, Inc.—*Ultra Power Bar*

Appendix B

Glossary

Augmentative communication device: An electronic device used by students who are not independent verbal communicators.

Circuit card: An electronic circuit board ("card" or "board") containing add-on features for a computer or peripheral.

Control interface: The component of the alternate input system that is closest to, and usually in physical contact with, the student's body.

Customizer setup: Special software or optional routine within a program that customizes the operation of a particular program or access method for an individual student.

Direct selection: A selection technique by which the student directly indicates a desired symbol, letter, or character by touching or pointing.

Emulation: When a computer or a device mimics the characteristics of another device.

Firmware: A programmed microcomputer chip that is sometimes attached to a circuit board or card.

Input device: Any device that sends operational signals to another device.

Interface: A device that transmits information between two systems or parts of a system; the means by which two physical objects interconnect.

Joystick: A lever, usually mounted in an upright position, that is capable of motion in several directions.

Keyboard emulating interface (KEI): A device that accepts data from particular types of alternate input devices and converts the data to signals that will be understood by the computer as standard keyboard input.

Morse code: A system by which a combination of two signals represents a specific character.

Optical headpointer: A remote pointing device containing a photo diode that activates the LEDs of an alternate keyboard.

Scanning: A selection technique in which characters are singled out on a display and selected by switch activation or a "wait" period. Scans may be linear or row-column.

Special software: Software written to accept non-keyboard input from an alternate keyboard.

Standard software: Software that expects standard keyboard entry of data or information. Depending on the computer type, it may require a KEI if it is used with alternate keyboards.

Appendix C

Resources

Videotapes

Access (Office of Special Education and Rehabilitation, Apple Computer)

Adapted Computer Input (Assistive Device Center)

Adaptive Firmware Card for the Apple IIe (Pennsylvania Assistive Device Center)

Adaptive Firmware Card for the Apple IIGS (Pennsylvania Assistive Device Center)

Computer Use: An Introduction (Macomb Projects)

Equal Opportunity at the Keyboard: A Video Featuring the IIe Adaptive Firmware Card (Access Unlimited)

Epson SpeechPAC/Eval PAC (Pennsylvania Assistive Device Center)

Independence Day (Office of Special Education and Rehabilitation, Apple Computer)

Introduction to the Adaptive Firmware Card Model G32e (Don Johnston Developmental Equipment, Inc.)

Just Regular Kids (North Okanagan Handicapped Association)

Special Friends and Computers: Adapting the Computer (United Cerebral Palsy Association of Western New York)

Touch Talker/Light Talker with Minspeak (Pennsylvania Assistive Device Center)

We Have Something to Say: Children, Computers, and Special Education (Access Unlimited)

Books

Behrmann, M. M. (1988). *Integrating computers into the curriculum: A handbook for special educators.* Boston: Little, Brown and Co.

Bennett, R. E., & Maher, C. A. (1984). *Microcomputers and exceptional children.* Binghamton, NY: Haworth Press.

Bowser, G. (1989). *Computers in the special education curriculum.* Roseburg, OR: Technology Access Project, Oregon Department of Education.

Budoff, M. (1985). *Microcomputers in special education.* Cambridge, MA: Brookline Books.

Church, G., & Bender, M. (1989). *Teaching with computers: A curriculum for special educators.* Boston, MA: College-Hill Press.

Enders, A., & Hall, M. (Eds.). (1990). *Assistive technology sourcebook.* Washington, DC: RESNA Press.

Johnson, D. L., Maddux, C. D., & Candler, A. (1987). *Computers in the special education classroom.* Binghamton, NY: Haworth Press.

Lewis, R. B., Dell, S. J., Lynch, E. W., Harrison, P. J., & Saba, F. (1987). *Special education technology in action: Teachers speak out.* San Diego, CA: California State Department of Education, Special Education Division.

Male, M. (1988). *Special magic: Computers, classroom strategies, and exceptional students.* Mountain View, CA: Mayfield Publishing Company.

Russell, S. J., Corwin, R., Mokros, J., & Kapisovsky, P. M. (1989). *Beyond drill and practice: Expanding the computer mainstream.* Reston, VA: The Council for Exceptional Children.

Stainback, S., & Stainback, W. (1985). *Integration of students with severe handicaps into regular schools.* Reston, VA: The Council for Exceptional Children.

Taber, F. (1983). *Microcomputers in special education.* Reston, VA: The Council for Exceptional Children.

U.S. Congress, Office of Technology Assessment. (1988). *Power on! New tools for teaching and learning, OTA-SET-379.* Washington, DC: U.S. Government Printing Office.

Organizations

Alliance for Technology Access (formerly National Special Education Alliance), 1307 Solano Avenue, Albany, CA 94706-1888; 415/528-0747.

Center for Special Education Technology, The Council for Exceptional Children, 1920 Association Drive, Reston, VA 22091-1589; 703/620-3660 or 800/873-8255.

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

IBM National Support Center for Persons with Disabilities, P.O. Box 2150, Atlanta, GA 30301-2150; 800/IBM-2133.

National Technology Center, American Foundation for the Blind, 15 West 16th St., New York, NY 10011; 212/620-2080 or 800/AFB-LIND.

Office of Special Education and Rehabilitation, Apple Computer, Inc., 20525 Mariani Ave., MS 43S, Cupertino, CA 95014; 408/974-7910.

RESNA, Suite 700, 1101 Connecticut Ave., NW, Washington, DC 20036; 202/857-1199.

Vendor Addresses

Access Unlimited, P.O. Box 7986, Houston, TX 77270-7986; 713/461-0006 or 800/531-5314.

AdamLab, Wayne County Intermediate School District, 33500 Van Born Rd., Wayne, MI 48184; 313/467-1415.

Adaptive Communication Systems, Inc., 354 Hookstown Grade Rd., Clinton, PA 15026; 412/264-2288 or 800/247-3433.

Assistive Device Center, 6000 J St., Sacramento, CA 95819-2694; 916/278-6422.

Cactl Computer Services, 130 9th St., S. W., Portage la Prairie, Manitoba R1N 2N4 Canada; 204/857-8675.

Compute Able Network, P.O. Box 1706, Portland, OR 97207; 503/645-0009.

ComputAbility Corporation, 40000 Grand River, Ste. 109, Novi, MI 48375; 313/477-6720 or 800/345-1267.

Dave Schmidt, Colorado Easter Seal Society, 5755 W. Alameda, Lakewood, CO 80226; 303/233-1666.

Don Johnston Developmental Equipment, Inc., P.O. Box 639, 1000 Rand Rd., Bldg. 115, Wauconda, IL 60084-0639; 800/999-4660.

Dunamis, Inc., 3620 Hwy. 317, Suwanee, GA 30174; 800/828-2443 or 404/932-0485.

EKEG Electronics Co., Ltd., P.O. Box 46199, Sta. G. Vancouver, BC V6R 4G5, Canada; 604/273-4358.

Edmark Corp., P.O. Box 3903. Bellevue, WA 98009-3903; 800/426-0856 or 800/422-2118.

Exceptional Computing, Inc., 415 NW 58th St., Gainesville, FL 32607; 904/374-8847.

Extensions for Independence, 757 Emory St., 514, Imperial Beach, CA 92032; 619/423-7709.

Hartley Courseware, Inc., P.O. Box 419, Dimondale, MI 48821; 800/247-1380 or 517/646-6458.

Key Tronic, P.O. Box 14687, Spokane, WA 99214; 509/928-8000 or 800/262-6006.

Macomb Projects, Western Illinois University, 27 Horriban Hall, Macomb, IL 61455; 309/298-1634.

Madalaine Pugliese Associates, Inc., Suite 175, 5 Bessom St., Marblehead, MA 01945; 617/639-1930.

North Okanagan Handicapped Association, 3300 37th Ave., Vernon, BC V1T 2Y5 Canada; 604/542-7605.

Pennsylvania Assistive Device Center, 150 South Progress Ave., Harrisburg, PA 17109; 800/222-7372 or 717/657-5840.

Phonic Ear Inc., 250 Camino Alto, Mill Valley, CA 94941-1466 or 415/383-4000.

Polytel Computer Products Corp., 1250 Oakmead Pkwy, Suite 310, Sunnyvale, CA 94086; 408/730-1347 or 800/245-6655.

Prentke Romich Co., 1022 Heyl Road, Wooster, OH 44691; 216/262-1984.

Regenesis Development Corp., 1046 Deep Cove Rd., N. Vancouver, BC V7G 1S3 Canada; 604/929-6663.

Sunburst Communication, 101 Castleton St., Pleasantville, NY 10570-3498; 914/747-3310 or 800/628-8897.

TASH, Inc., 70 Gibson Dr., Unit 12, Markham, Ontario L3R 4C2 Canada; 416/475-2212.

TeleSensory, 455 North Bernado Ave., P.O. Box 7455, Mountain View, CA 94039-7455; 415/960-0920.

Typewriting Institute for the Handicapped, 3102 West Augusta Ave., Phoenix, AZ 85051; 602/939-5344.

Unicorn Engineering, Inc., 5221 Central Ave., Suite 205-A, Richmond, CA 94804; 415/528-0670.

United Cerebral Palsy Foundation of Western New York, Children's Center, 4635 Union Road, Buffalo, NY 14225; 716/633-[illegible]40.

Venture Technologies, Inc., 304-134 Abbott St., Vancouver, BC V6B 2K4 Canada; 604/684-9803.

ZYGO Industries, Inc., P.O. Box 1008, Portland, OR 97207-1008; 503/297-1724.

About the Author

Donna Heiner is the director of the Living and Learning Resource Centre, a Michigan-wide information, demonstration, and consultation center supporting the use of microcomputer-related assistive technology. Involved in education for 25 years, Donna has an Ed.S. in special education from Michigan State University. She has written and presented on adapted computer input for education and vocational education purposes at state and national conferences.