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Use of Computer Technology to Help Students with Special Needs

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Abstract

Millions of students across the United States cannot benefit fully from a traditional educational program because they have a disability that impairs their ability to participate in a typical classroom environment. For these students, computer-based technologies can play an especially important role. Not only can computer technology facilitate a broader range of educational activities to meet a variety of needs for students with mild learning disorders, but adaptive technology now exists than can enable even those students with severe disabilities to become active learners in the classroom alongside their peers who do not have disabilities.

This article provides an overview of the role computer technology can play in promoting the education of children with special needs within the regular classroom. For example, use of computer technology for word processing, communication, research, and multimedia projects can help the three million students with specific learning and emotional disorders keep up with their nondisabled peers. Computer technology has also enhanced the development of sophisticated devices that can assist the two million students with more severe disabilities in overcoming a wide range of limitations that hinder classroom participation—from speech and hearing impairments to blindness and severe physical disabilities. However, many teachers are not adequately trained on how to use technology effectively in their classrooms, and the cost of the technology is a serious consideration for all schools. Thus, although computer technology has the potential to act as an equalizer by freeing many students from their disabilities, the barriers of inadequate training and cost must first be overcome before more widespread use can become a reality.

Today's children are the first generation of the "digital age." They are being raised in a society that is changing rapidly as a result of the influx of new computer-based technologies that provide more pervasive and faster worldwide links to commerce, communication, and culture. The dramatic changes over the past decade have prompted the

Presidential Committee of Advisors on Science and Technology,[1] the U.S. Office of Technology Assessment,[2] and high-level government officials[3] to state that it is incumbent upon the public school system to prepare *all* students to use technology in ways that will allow them to compete in the increasingly complex technological workplace. Many people applaud the integration of computer-based technologies into the classroom for typically functioning students. Fewer individuals recognize the great number of benefits that computer-based technologies may afford children with disabilities.

This article focuses on the role that computer technology can play in promoting the education of children with special needs within the classroom. It begins with an overview of children's different types of disabilities and special needs, and an introductory discussion of how technology can help meet those needs. Several more detailed sections follow, describing how particular computer applications and devices make it possible for students with disabilities to be educated in a regular classroom alongside their nondisabled peers. The final section provides a discussion of the barriers to more widespread use of the promising technologies—barriers that must be overcome if schools are to provide greater opportunities for students with disabilities to learn more effectively in regular classroom settings.

Children with Special Needs-Who Are They?

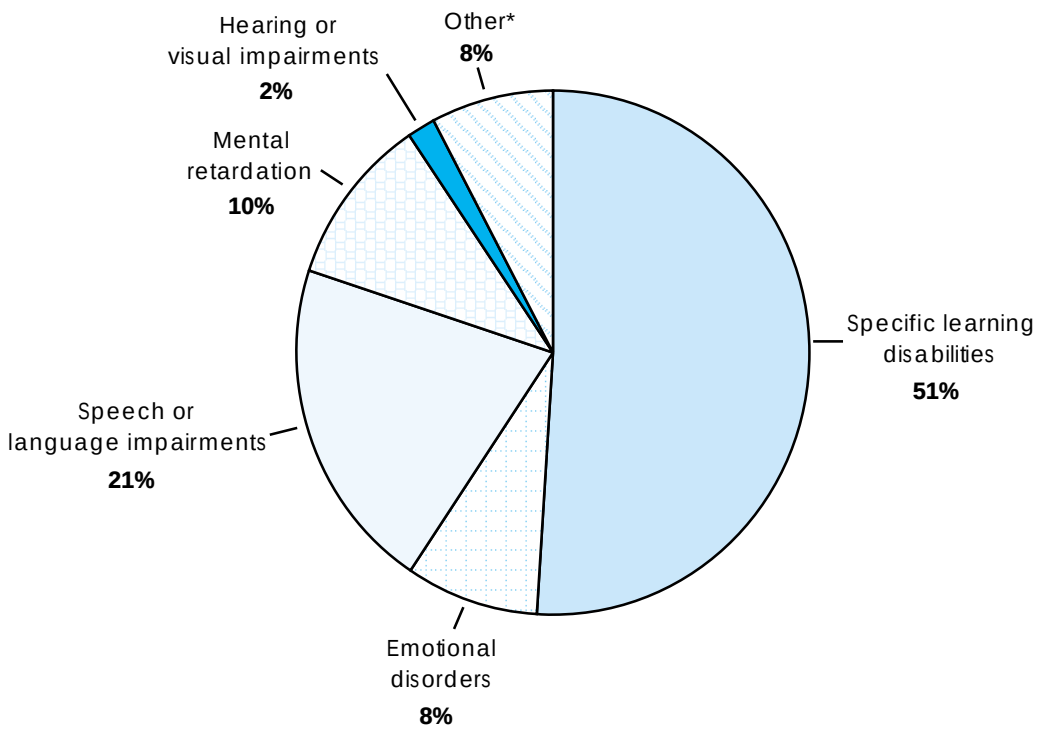
Over the past 20 years, the number of students with disabilities has been steadily increasing at a faster rate than both the general population and school enrollment.[4] Today, approximately one of six students in schools across the United States cannot benefit fully from a traditional educational program because they have a disability that impairs their ability to participate in classroom activities.[5] Federal law defines students with special needs as those who, because of a disability, require special education and related services to achieve their fullest potential.[6] According to the most recent government statistics, more than 5 million students ages 6 to 17 were receiving special education services during the 1997–98 school year.[7] As shown in Figure 1, students' disabilities ranged from speech and language impairments to mental retardation, and more than half were described as having a specific learning disability due to a psychological disorder.[8]

Children with disabilities vary with respect to the type and number of disabilities they have, and their disabilities vary in cause, degree, and the effect they have on the child's educational progress. Although children with disabilities are a very diverse group, data describing the demographic characteristics of students with disabilities suggest the following:

- More than half of all students receiving special services are males.
- Most are in elementary or middle school.
- Most have no obvious disability; they have problems that are primarily academic, emotional, social, or behavioral.

Figure 1

Percentage of Students by Disability (Ages 6 to 17)



* Other includes: Other health impairments — 3.60; multiple disabilities — 1.82; orthopedic impairments — 1.23; autism — 0.77; traumatic brain injury — 0.21; and developmental delay — 0.04.

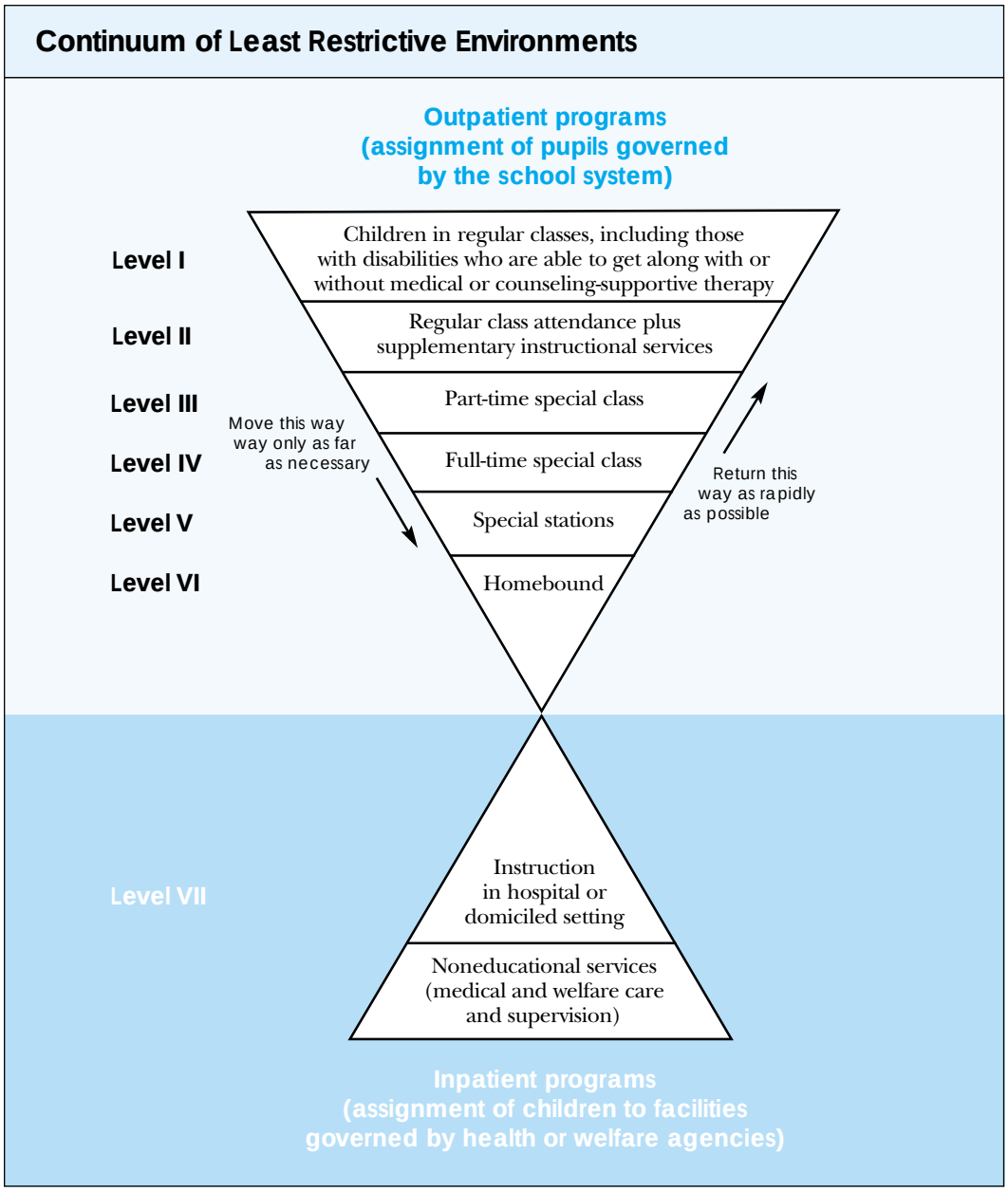
Source: Data summarized from the U.S. Department of Education. *To assure the free appropriate public education of all children with disabilities: Twenty-first annual report to Congress on the implementation of the Individuals with Disabilities Education Act (1999).* Washington, DC: U.S. Department of Education, April 10, 2000, Tables AA3 and AA4. The figure includes a total of 5,119,018 children ages 6–17 served under IDEA, Part B, during the 1997–98 school year.

Federal law mandates that all children with disabilities are to be provided with special education services. Students who qualify for special education services are entitled to a specially designed individual educational program at no cost to the parent.[9] This program must meet the unique needs of the child, including any needed modifications to the place of instruction—be it the classroom, a physical education setting, the child's home, a hospital, or another institution. In addition, special education certifications entitle students to receive all related services (such as occupational therapy and physical therapy) required to meet the individual learning needs of the youngster. (For more on this subject, see the spring 1996 issue of *The Future of Children*.)

Federal laws also specify that students with special needs are to receive their education in what is called the *least restrictive environment* (LRE), on a continuum with regular education classes on one end and residential institutions on the other (see Figure 2).[10] In recent years, demands have increased for serving all students with special needs in the regular classroom, no matter how severe the disability. This approach, called *full inclusion*, has placed more and more students with disabilities in regular classrooms, requiring teachers to find ways to make the education of these students as appropriate as possible.[11]

Teachers have found that technological innovations can help level the playing field for special needs students and enable these students to succeed in the regular classroom.[12] Technology for students with special needs is

Figure 2



Source: Adapted from Deno, E. Special education as developmental capital. *Exceptional Children* (1970) 37:229–37.

defined by federal law as "any item, piece of equipment, or product system, whether acquired commercially off the shelf, modified, or customized, that is used to increase, maintain, or improve functional capabilities of individuals with disabilities."[13] This broad definition encompasses a wide variety of both high-end and low-end technologies that have proven to be useful for improving educational options for students with disabilities. The following sections describe how various applications of computer technology can help meet the individual needs of students with disabilities and enable them to function effectively in the school setting.

Technologies for Students with Mild Learning and Behavioral Disorders

Students with learning disabilities and emotional problems account for nearly 60% of all children receiving special services in schools today, and their numbers are rising each year.[4] These students often have persistent problems learning and behaving appro-

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priately in school, problems that may become apparent only after teachers work with the students for weeks or months. Such students are likely to be given a broad label indicating only that their academic and social progress is unsatisfactory because of a disability,[14] and their problems often persist despite a teacher's efforts to meet their students' needs within the regular program. Most children with mild learning disabilities spend at least some portion of the school day in the regular classroom, even though many of these students find it difficult to keep up with their nondisabled peers[15] and their teachers often find it difficult to spend significant amounts of time providing them with individual attention. Technology has proven to be an effective method of giving such students opportunities to engage in basic drill and practice, simulations, exploratory, or communication activities that are matched to their individual needs and abilities.[16]

The research examining the potential benefits of computer-based instruction is grounded in basic learning theory and is the same for all students, including both those with and without mild disabilities. This research indicates that use of technology can enhance a student's acquisition of skills and content knowledge when the computer is used to deliver well-designed and well-managed instruction.[17] A teacher's ultimate goal is to help students develop skills and knowledge that can be used in real-world settings. Many computer-based applications—such as the Internet, communication technologies, CD-ROM reference materials, and multimedia presentation tools—can provide students with opportunities to use their skills to engage in projects that address real-world problems.[18] (For further discussion of these types of applications, see the articles by Becker and by Roschelle and colleagues in this journal issue.) The following sections examine several types of computer activities that, when integrated into classroom instruction, appear to have significant benefits for students with mild disabilities: word processing and word prediction software, communication and networking technologies, and the use of hypertext and multimedia projects.

Word Processing Software

The attributes of word processing that lead to its effectiveness as a learning tool for children with special needs are generally the same attributes that make it effective for children in general. For example, the ease of revising text, producing clean and readable text, and feeling a sense of authorship are frequently mentioned as attributes of word processors that lead to improved writing. Researchers have found that students are more willing to edit their work and to make necessary corrections on a word processor than on handwritten drafts. In addition, the word processor frees students from the more tedious duties related to the editing process,[19] enabling them to spend more time on the content of their written products. These benefits are significant for the many students with mild learning disorders related to deficits in

written language skills, who often need to spend a significant amount of time rewriting a passage to communicate an idea clearly.[20] Word processing is also especially helpful for those students who struggle with delays in fine motor skills that impair their ability to write legibly.[21] Thus, while teachers still must provide instruction in writing to make a difference, word processing software can have significant benefits for students with mild learning disabilities by allowing them to participate in the writing process with greater ease.

Word Prediction Software

Word prediction software is another example of a computer-based technology that can help students communicate with written language more easily. This software, when used in conjunction with traditional word processing programs, reduces the number of keystrokes that are required to type words and provides assistance with spelling for students of various ability levels. For example, in one application, a list of words appears that begins with the letter a student presses on the computer keyboard. As additional letters are added to the sequence, the list is updated to limit the words to the sequence that has been entered. When the desired word appears on the computer screen, the student simply selects the word to insert it into the written text. Some applications require that students be able to select the desired words from a list displayed on the computer screen; other applications enable the computer to read the words aloud. In addition, some word prediction programs provide words solely on the basis of the sequence of letters entered; others give consideration to the grammatical aspect of the words already present in the sentence. Still other applications limit the words provided to those that the student most often uses.

Students with mild learning disabilities benefit from the support that word prediction software offers as they attempt to produce written documents. Many times, students with communication deficits will avoid the use of longer words and complex thoughts to avoid frustration with the act of writing. But word prediction software allows students with mild learning disabilities, as well as those with mild communication and motor impairments, to express their words and ideas in the vocabulary that more closely reflects their thinking, rather than in the vocabulary that is easiest to spell. Thus, with the help of word prediction software, students with mild learning disabilities are better able to compete academically in regular classroom settings.

Communication Technologies

Use of computers for communication and networking activities via the Internet can expand the learning environment beyond the walls of the classroom and allow students with disabilities, just like other students, to access and send information literally around the world. Yet improved access and delivery systems do not necessarily bring improved instruction. To the contrary, improved learning is dependent upon the quality of instruction and not on the medium through which it is delivered.[22] Communication technologies become a powerful tool for learning only if they offer students opportunities to gather a wide variety of resources and information and then to exchange their thoughts and ideas with others in collaborative learning environments, networked through the Internet.

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The ability to collaborate on meaningful projects is especially beneficial for students with learning disabilities because they often have both academic and social needs to be addressed. Collaborative efforts can foster academic learning among these students by providing more "knowledge construction" activities, such as generating new ideas and building on the thoughts of others as a topic is analyzed, and by actively engaging them in the learning process.[23] Research has shown that students of all ability levels learn more when they are involved in such knowledge construction activities.[24] Research also has demonstrated that different types of discourse have been associated with different levels of thinking processes.[25] For example, questions that require students to simply restate or paraphrase information impose less complex cognitive demands than questions whose answers result in explanations,

inferences, justifications, hypotheses, and speculations. Thus, by providing more opportunities to communicate in different ways, communication technologies can help students with mild learning disabilities engage in more complex cognitive tasks and can result in powerful instruction for these students.[26] In addition, communication technologies can help meet the social needs of students with mild learning disabilities. For example, one teacher consultant found that hospitalized students with emotional disabilities valued opportunities to interact with other students via e-mail because their disability "disappeared" in these communication environments.[27] The hospitalized students became more willing to create written text, and their grammatical skills improved, when they were given the opportunity to communicate online with other disabled students who were enrolled in special education classes across the country. Over the Internet, the students shared descriptions of themselves and of their feelings, and were able to learn about others. Consequently, the technology facilitated the students' ability to make personal connections with others and provided opportunities to focus on writing skills within a context that they valued. Communication technologies can also foster social learning by connecting students one to one. Communications between even two individuals can enable students with learning disabilities to gain information or to practice communication skills in a real-world environment without fear of being stigmatized because of their disability.[28]

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Hyperlinks and Multimedia Environments

In addition to communication technologies that provide students with new ways to access information worldwide, other technologies help students make flexible connections between different text-based documents ("hypertext") and between different types of media, such as text, photographs, television, video, sound, graphics, and computing (commonly referred to as "hypermedia" or "multimedia"). Recently, educators have begun to examine the possibilities these technologies offer for students with mild learning disabilities.

Hyperlinks

The concept of hyperlinks is not new—in fact, speculation about such devices dates back more than 50 years.[29] Text with hyperlinks, or "hypertext," enables users to access electronically linked resources with the click of a mouse, leaping through vast amounts of textual information in a nonsequential manner. Hypertext is a web conceptually —somewhat like a dictionary or an encyclopedia—with complex interdependencies among units of information that users can jump between in ways that are similar to the way the human mind thinks.[30] Hyperlinks enable students to jump to electronic units of information with the speed and freedom of human thought, creating meaningful learning experiences through quick and easy links between new and previously learned information.

Hyperlinks are helpful for all students, but they can be especially helpful for students with mild learning disabilities. If a student is reading a book and encounters a reference to another work that would enhance understanding of the content, for example, normally it would be necessary to turn to the bibliography to get the complete reference and then visit the library to track it down. This process is cumbersome for all students, but students with learning disabilities who lack reading skills are especially likely to abandon the search in frustration. If a hypertext version of the book were available on a computer, however, students could simply use a mouse or other pointing device to click on the reference and instantaneously view the referenced article, or click on a word they don't understand to jump to a computer-based thesaurus and browse related words. Several studies have shown that students prefer to access reference material electronically rather than by using text-based resources.[31] In addition, while many students with mild learning disabilities relate a long history of failure and frustration with traditional print-based documents, few have experienced failure with these hyperlink technologies.

At the same time, some researchers caution that hyperlink technologies have the potential to overwhelm those students whose problems cause them difficulty in organizing information. For example, studies have demonstrated that many students with disabilities have significant difficulties retrieving requested information from both traditional and electronic versions of encyclopedias.[32] This research suggests that to ensure that students with disabilities have a positive experience using hyperlinks to conduct research electronically, teachers still must spend time teaching them how to locate and organize specific information from data sources, the same as would be required when using more traditional reference sources.

Multimedia Environments

Multimedia environments are a relatively new extension of the hypertext concept. The educational use of multimedia environments is best described as an electronic means of linking various media in new and different ways in activities that can facilitate fundamental learning and thinking. For example, multimedia can help deepen students' conceptual understandings by linking visual imagery and sound effects to information that is difficult to understand when presented in text alone. Research demonstrates that learning environments that incorporate dynamic images and sound are especially helpful for students who have limited background knowledge in a subject, which is often the case for students with learning disabilities.[33]

Multimedia applications also provide students with ways to express their knowledge other than in writing. As discussed above, many students with mild learning disabilities are reluctant writers. By providing these students with alternative ways to demonstrate what they have learned, multimedia applications can be very motivating. The technology provides a tool for students with disabilities to express themselves, and an opportunity for them to showcase unique abilities and talents that generally are not revealed in traditional school assignments. Multimedia projects can be especially important for students with disabilities who seldom have the opportunity to demonstrate their strengths in school.[24] For example, in a study in which students with mild learning disabilities were given a choice of formats for demonstrating their knowledge to others, all chose to create multimedia-based projects. They said they preferred the multimedia projects because the format allowed them to express themselves in ways that linear text did not.[34] Classroom teachers have also noted that students with mild learning disabilities often demonstrate higher-level performance and attention to detail working on multimedia projects than they normally exhibit.[35]

In addition, researchers report that the motivation of at-risk students and students with mild disabilities improves markedly when they work on projects that will be displayed in forums that include nondisabled students, parents, and community members.[36] And computer technology not only facilitates the creation of multimedia products, it can also facilitate the sharing of such projects. For example, after they complete their work, students can transfer the products to videotapes or CD formats, which can then be placed on a class Web page or in the school library as reference material. Such sharing of products has been shown to have significant benefits for students with mild learning disabilities because it offers them the opportunity to be the author of a "real" product, and to be seen—and to see themselves—as capable learners in school environments.

Students with mild learning disabilities often demonstrate higher-level performance and attention to detail working on multimedia projects than they normally exhibit.

Technologies for Students with Speech and Language Disorders

Communication with other individuals is one of the most important aspects of life. Certainly, effective communication is important in classrooms, where exchanges between teachers and students, or among peers, is a vital part of the learning process. But communication requires at least two individuals—one to send information and the other to receive it—and problems arise when a break occurs on either end of this chain, which is common among students with communication disorders.

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Two general types of communication disorders qualify a student for special education services: speech disorders and language disorders. A speech disorder occurs when the speaker's articulation, voice quality, or fluency patterns impair the listener's ability to understand the intent of the speaker.[37] A language disorder occurs when either the sender or the receiver of the message is unable to use the sounds, signs, or rules of the communication language. The U.S. Department of Education data indicate that more than 20% of all students with disabilities have speech or language disorders.[38] Consequently, technology addressing the needs of students with communication disorders could assist a significant proportion of students with disabilities to interact more normally within the classroom.

Fortunately, advances in computer technology have led to the creation of specialized devices—called augmentative and alternative communication (AAC) devices—that help make it possible for individuals with no speech, or individuals with poor speech, to overcome their communication problems. Augmentative devices are designed to support or enhance the speaking capability of a person. Alternative devices, on the other hand, replace speech as a means of communication. There are a variety of electronic AAC devices on the market, ranging from very low tech to very high tech, and ranging in price from a few hundred dollars to several thousand dollars.[39] Some devices are "dedicated," that is, their only purpose is to provide a means of communication. Other devices have been designed to work in conjunction with a computer that plays multiple roles (such as word processing or calculations). In addition, existing computers can now be modified for use as an AAC device through the addition of special communication software and hardware. These modifications are often less expensive and more flexible than many custom-built AAC devices.[40]

AAC systems vary in terms of their portability, complexity, input method, vocabulary representation format, and means of output delivery. Selecting an appropriate system must be tied to the needs and capabilities of the student. For example, students with physical or mental disabilities who cannot use a standard keyboard can use alternative input devices, such as touch-sensitive pads, selection switches, or optical pointing devices. (For a more detailed description of these devices, see page 117.) For students who have difficulty with vocabulary, AAC systems have been developed to allow communication through word selection devices or even devices using pictures and graphics. To assist students with disabilities in delivering a message, various speech and print output devices have been developed. Today, many communication devices have incorporated either synthetic or digital speech output. Synthetic speech is artificially generated by the computer, while digital speech is an actual recording of human speech stored in the memory of the device. (For a more detailed description of screen readers, see

page 115.) Written output can be provided by printers that are built into the communication device or attached externally, but this option is cumbersome because of the large amount of paper required. As a result, some devices use liquid crystal displays (LCDs) to show students' messages—some displaying a single line of text at a time, some displaying multiple lines of text, and some using both the LCD and speech output together.

Clearly, AAC systems can be extremely powerful tools for individuals with speech and language disorders. At a banquet for software publishers in 1998, a letter was read from a young man whose computer had been outfitted with a device converting text to speech output. In his letter, he talked about how technology had changed his life: "Until now, I have never had a voice or a way to communicate. Until this year I was in a special education classroom. Now I am in the regular school in eighth grade. My computer has been the best thing that has ever happened to me in my life. Now people do not have to read my words. They can listen like everyone else." While an AAC device can enable some students with severe communication disorders to participate in instructional activities alongside their nondisabled peers, the rate of message transmission is still quite slow compared with normal speech. As computer-based technologies advance and AAC devices become smaller, more flexible, and less expensive, they will likely help even more students with communication disorders in the future.

Technologies for Students with Hearing Impairments

Students with hearing impairments are those who have a hearing loss that interferes with their ability to process linguistic information through auditory channels with or without amplification.[41] The most recent data available from the U.S. Department of Education indicate that 1% to 2% of students ages 6 to 17 enrolled in special education programs in the United States have hearing impairments, and that a small fraction (0.02%) of these are both deaf and blind. In all, about 66,000 students have been diagnosed with some type of hearing impairment that interferes with their ability to function without some type of assistive device.[38]

Any device that is used to enhance a person's residual hearing is referred to as an assistive listening device (ALD). Beyond ALDs, telecommunications devices have been created to assist students with severe hearing impairments by making use of other abilities, such as sight and touch. ALDs have been used since the 1800s. At that time, horns were held to the ear to collect and focus sound waves. Certain pitch ranges were amplified, depending on the dimensions of the horn, and no external power supply was used. One of the first high-tech devices designed for persons with hearing impairments is something we take for granted—the telephone. Alexander Graham Bell originally invented the telephone for the purpose of helping his sister, who had a hearing disability. Today, advances in computer technology and medicine have led to the development of a wide range of high-tech ALDs and telecommunication devices that assist students with severe hearing impairments, enabling them to participate more effectively in the classroom (see Box 1).

AAC systems can be extremely powerful tools enabling some students with severe communication disorders to participate in instructional activities alongside their nondisabled peers.

Two telecommunication devices that assist students with severe hearing impairments and that have become commonplace in American society are the Telecommunication Device for the Deaf (TDD) and "captioning." TDDs allow users to use a keyboard to type and receive messages over the phone lines; captioning refers to the addition of text to a visual display, where the words that are spoken are seen as text. Although TDDs are devices that primarily enhance the lives of students with hearing impairments outside of school, captioning has been found to be especially helpful in promoting the inclusion of students with hearing loss in the regular classroom environment. For example, video captioning and captioned educational programs have proven to be very helpful in motivating students with hearing disabilities to learn to read. Because the nature of a hearing loss tends to cause language and

Box 1

Devices to Assist Students with Hearing Impairments

- ***Hearing Aids:*** The hearing aid is a miniature public address system worn by the user (listener). It works best in quiet, structured settings, where the speaker is no more than a few feet away and extraneous noise is minimized. Hearing aids are generally available in four styles: body-worn, behind-the-ear, eyeglass, and in-the-ear. School-age children most often use *postauricular* hearing aids, which are designed to fit unobtrusively behind the ear. Almost all people with hearing loss, including "nerve loss," can benefit to some extent from hearing aids.

- ***Frequency-Modulated (FM) Amplification Systems:*** Also known as an auditory trainer, the FM transmission device creates a direct link between the teacher, who wears a microphone, and the student, who wears a hearing aid. In this system, background noise is reduced and the teacher and students are free to move around the room. For more than 40 years, FM systems have been used by teachers and students in the classroom, and they are still one of the most commonly used auditory enhancement devices in schools because of their versatility and portability for use in or out of the school building.

- ***Audio Loops:*** The audio loop is another type of amplification system. It was introduced in an attempt to meet the need to control the sound level of the teacher's voice, to maintain consistency in auditory cues between home and school, to deal more effectively with background noise, and to provide maximum mobility within a classroom. An adaptation of the FM device described above, the audio loop directs sound from its source directly to the listener's ear through a specially equipped hearing aid. Sound may be transmitted through a wire connection or by using radio waves. Audio loops can be built into the walls of a room or created to surround only a certain section of seats in a room.

- ***Infrared Systems:*** Infrared systems transmit clean, clear sound invisibly to hearing impaired listeners. They provide better hearing in public places without the hassle of wires and cords, and they suffer less from interference emanating from pagers and other outside radio signals, but they may have limited accessibility because of issues related to line-of-site or distance between the emitter and the transceiver. Nevertheless, as costs come down, the popularity of infrared systems is increasing.

- ***Cochlear Implants:*** A cochlear implant is a relatively new device designed to provide sound information for people with profound hearing impairments. While hearing aids and other assistive devices are designed to amplify sound, an implant can actually enable the wearer to hear sounds that were previously indistinguishable. The implant, which is surgically placed beneath the skin, bypasses the damaged parts of the inner ear and stimulates nerves that have not been stimulated before. Signals are sent continuously when sound is present in the environment, but special circuitry in the speech processor reduces unwanted background noise.

Box 1 (continued)

Devices to Assist Students with Hearing Impairments

- ***Telecommunication Devices for the Deaf (TDDs):*** The TDD, which enables a person with no hearing to make or receive telephone calls, is the most widely known telecommunication device used today. The TDD is attached to a telephone and resembles a small keyboard with a screen to display the incoming or outgoing messages. Some TDDs have a paper printout to record a permanent copy of the conversation. To use a TDD, the user types a message on the keyboard that is automatically converted into tones and transmitted over the phone line to another TDD, which converts the message back into text form. In this system, both the sender and the receiver of the message must have access to the technology. Although these technologies are not typically used in the classroom environment, they enable students with disabilities to interact with each other outside of the school environment for both academic and social reasons, just as their nondisabled peers do.

- ***Captioned Television:*** Captioning refers to the addition of text to a visual display, where the words that are spoken are seen as text. The early form of captioning was seen primarily as subtitles for translating foreign films. There are two kinds of captions, open and closed. Open captioning is seldom used, because it cannot be turned off and is consequently unpopular with the general public. Conversely, closed captioning is very common and it can be turned on or off by the user on all modern televisions. Since 1993, all television manufacturers have been required to place built-in decoders in their products to provide individuals with hearing impairments with access to closed captioned television programs and videos for educational and recreational purposes. Given that consumers purchase more than 20 million televisions each year, the majority of classrooms and private homes in this country have access to this technology.

- ***Live Speech Captioning:*** Live speech captioning is another variation of this technology that allows individuals with hearing impairments to access words as they are being spoken. This technology works much like steno keyboards that are used to record judicial proceedings. When captioning is used in educational settings, a stenographer typically enters information as the teacher talks and the text is displayed on a computer monitor. This technology has proven to be very helpful for students with hearing disabilities who are enrolled in college courses or who attend public lectures.

communication problems, particularly in understanding situations, conversations, and written materials, studies indicate that the average reading levels of students who are deaf are considerably lower than the levels of their hearing peers of similar intellectual ability.[42] Research has demonstrated, however, that captioned video and television programs can help deaf students improve their vocabulary and reading comprehension, and promote deeper levels of understanding of what is taught in the classroom.[43]

Today, a large percentage of broadcast television is captioned, providing individuals with hearing impairments equal access to public information and entertainment. But while most programs on national networks and cable television channels—as well as thousands of movies and documentaries—are captioned, fewer than 10% of educational videos were captioned as of 1998.[44] Increased captioning could expand classroom opportunities and enhance reading instruction for students with hearing loss.[45]

Technologies for Students with Visual Impairments

According to the most recent data available, about 24,000 school-age children have visual disabilities that make them eligible for special education services.[38] Although it is difficult to classify or label the varying degrees of visual acuity succinctly,[46] most students with visual impairments find that they need some type of device to help them to be effective learners in school settings. Students who are visually impaired but have at least some useful vision are often able to rely on large-print materials, specialized magnification lenses, or electronic enlargement for the assistance they need. Even those with no useful vision, who traditionally have had to rely on tape recordings or translations into Braille, now have access to many other devices that can help them become independent learners (see Box 2).

For example, descriptive video services (DVS), which provide narrative verbal descriptions of visual elements, have proven useful in helping students who are blind or have low vision to use educational programs in regular classrooms.[47] Synthetic and digital speech synthesizers, mentioned earlier as output devices to assist students with communication disorders, are also helpful to those with visual impairments. With these text-to-speech applications, sometimes referred to as "screen readers," students who are visually impaired can have any text found on the computer screen read aloud. Text-to-speech technologies also facilitate the rereading and editing of previously written text, thus providing opportunities for students with visual impairments to participate in such tasks alongside their nondisabled peers. These applications range in price from about $700 to $2,000.[48]

Another computer-based application, optical character recognition (OCR) technology, can scan and read text aloud, allowing individuals with visual impairments greater access to all types of print materials and enabling them to "read" the materials independently.[49] OCR software is now available for most computers and scanners, and several dedicated portable devices have also been developed, making them more user-friendly. Although current OCR technology cannot read handwritten materials accurately, this barrier will likely fall by the wayside in the very near future. Finally, advances in computer technology have made even the use of Braille more useful. A number of software applications have been developed that combine Braille with computer technology, such as Braille notetakers—small, portable devices that can store Braille characters and read text aloud—to assist students with visual impairments in the classroom. Such devices range in price from about $1,000 to $6,000. Higher-end devices using refreshable displays are considerably more expensive, however, costing as much as $10,000.[50]

Technologies for Students with Severe Physical Disabilities

Students with severe physical disabilities are a heterogeneous group. For some, mobility is the greatest barrier they face. For others, caring for their personal needs is a tremendous challenge. Still others face overwhelming obstacles in communication. The data indicate that approximately 63,000 students with orthopedic impairments were served in the public school system during the 1997–98 school year, slightly more than 1% of all students with disabilities who are currently receiving special education services.[38] Fortunately, a variety of new technologies have been developed to help individuals with physical disabilities overcome their challenges and function well in school, work, and home environments (see Box 3).

For example, switches can be activated by almost any part of the body, allowing students with physical disabilities to control many aspects of their environment independently—from using a toy or radio for their own entertainment, to communicating with their nondisabled peers in the classroom, to controlling a computer or other high-tech or AAC device.[51] Today, switches can be used with a number of adaptive devices that enable students with severe physical disabilities to successfully operate a computer independently, including turning the power on and off, inserting and removing a disk or CD from a drive, copying files, accessing a modem, and using a keyboard. A number of alternative input devices can be connected to a standard computer to assist or replace the use of a traditional keyboard, which is often the greatest barrier to computer use

Box 2

Devices to Assist Students with Visual Impairments

- ***Closed-Circuit Television Magnification (CCTV):*** CCTV is designed to enlarge any type of text or graphic material by using a small vertically mounted video camera with a zoom lens directly connected to a monitor for displaying the image. The text or graphic material is placed under the camera lens on a sliding reading stand and the image is projected on the attached video monitor. CCTVs allow the user to adjust the magnification, contrast, brightness, and focus, and to change the background display to either black or white, or in some cases, color. Older CCTVs, while still useful for many classroom applications, are expensive and cumbersome to move. But the newer, smaller versions of this technology are portable, and thus much easier for students to use.
- ***Computer Screen Magnification:*** Most computers sold today allow for the magnification of the screen through the use of special software. Typically, the user can select a portion of the screen and then enlarge that section up to 16 times the original size. Although the user is somewhat inconvenienced by having to view a smaller portion of the original screen as the magnification increases, this technology makes it possible for students with visual impairments to use computers in ways similar to their nondisabled peers.
- ***Descriptive Video Services (DVS):*** DVS technology inserts a narrative verbal description of visual elements—such as sets and costumes, characters' physical descriptions, and facial expressions—into pauses in a program's dialogue. The majority of television sets and VCRs manufactured in the past six years have been designed with a "second audio program" (or SAP) switch that can be turned on so that the user can automatically hear descriptive video. DVS is available for both standard VHS and DVS formatted videotapes. DVS technologies help students by providing them with access to information, and through the increased opportunities to discuss programs and movies that are part of the popular culture, by providing them with opportunities for increased socialization and knowledge building.
- ***Screen Readers:*** Screen reader software represents what is known as a text-to-speech application, which analyzes letters, words, and sentences and converts them into synthetic or digital speech. Today, text-to-speech software is common in many software packages, including many word processing and educational software programs in math, reading, and spelling. In some instances, the student can adjust the volume, pitch, and speed of reading, and even choose between a male or a female voice. With synthetic speech, the computer reads text passages, analyzes the phonetic structure of words, and attempts to reconstruct the words by putting together a string of synthetic phonemes that are then "spoken" by the computer. However, when the words are not phonetically predictble, the results can be difficult to understand. In contrast, digital speech is composed of actual recordings of human speech. While digital speech is much easier to understand, it requires a large amount of storage because each word that the computer may encounter must be prerecorded. Consequently, its use is often not feasible for classroom instruction. As more low-cost options for storing electronic information become available, however, this technology will likely be used more extensively to assist students who have communication disorders or visual impairments.

Box 2 (continued)

Devices to Assist Students with Visual Impairments

- ***Optical Character Recognition (OCR):*** OCR technology enables blind students to place books or other print materials on a scanner and have the text interpreted and read using synthetic or digital speech. The first OCR system for individuals with visual impairments was introduced in 1976, when Ray Kurzweil invented the Kurzweil Reader. The early Kurzweil Reader was about the size of a small photocopy machine and was considered to be a truly remarkable advance for students with visual disabilities. While the device was often found in libraries, it was too bulky and expensive to be available to students in the classroom. Today, there are portable stand-alone OCR devices and devices that can attach to other computers and scanners.

- ***Braille Notetakers:*** Braille notetakers are small, portable devices that enable students to enter and store Braille characters in the form of words and sentences. The notetakers use the same six keys found on a traditional Braille writer used for making a paper copy of Braille. However, most notetakers allow users to review what they have written by listening to the text-to-speech function of the device. In addition, software translators allow the Braille to be converted into text. The stored files can then be used with a standard word processor or a screen reader. To get a hard copy of the information that was entered, the user can connect the notetaker directly to a standard printer for text output or a Braille printer for Braille output. Similarly, a paperless Braille display can be attached to a computer or a personal notetaker that can display up to 80 characters simultaneously. Devices such as the Braille notetaker that combine Braille with computer technology have made Braille much more useful than it was in the past.

for students with physical disabilities. Adaptive keyboards, infrared sensors, and voice recognition systems, described in Box 3, all have proven to be highly effective in helping students with severe physical disabilities use computers to participate in many educational activities that would not be available to them through other means. These devices range in price from less than $100 for some switches to as much as $9,000 for higher-end, voice-activated systems.[52]

The previously mentioned technologies have grown increasingly sophisticated and are becoming more familiar in classroom settings, and still other technologies are being developed for use in the near future. For example, a number of research labs are examining the use of devices such as robotic arms, which can help individuals who are physically disabled accomplish such daily activities as eating, retrieving objects, turning pages in books and magazines, and even playing cards. Although it may be years before these technologies become commonplace, some robotic devices are already in use, and more sophisticated devices are continually under development. In time, they too may be commonplace, and technologies that have yet to be envisioned for use by students with severe physical disabilities will be moving into the limelight.

Barriers to Effective Use of Technology for Students with Disabilities

Many technologies described in this article are readily available for use by individuals with different types of disabilities and are already providing many students with special needs an opportunity to be educated alongside their nondisabled peers. However, several barriers inhibit more widespread use of these applications and devices, especially inadequate teacher training and cost.

Box 3

Alternative Input Devices for Students with Physical Disabilities

- ***Switches:*** Switches control the flow of electrical power to a device that the user wants to turn on or off. Switches can be activated by almost any part of the body a person is able to voluntarily and reliably control—for example, switches are available that can be activated by the use of an arm, hand, finger, leg, foot, head, or chin. They also may be controlled by less obvious movements of the eyebrow, or the rib cage with access through controlled breathing. While the movement does not have to be big, it must be controllable and reliable, and often considerable training is required before the use of the switch is reliable.
- ***Basic Adaptive Keyboards:*** Basic keyboard adaptations that assist physically disabled students to use computers include replacing standard keys with larger keys that are easier to see and touch, reducing the number of keys on the keyboard, placing letter keys in alphabetical order, and providing keys that are brightly colored and easy to read. Other keyboards are much smaller than their traditional counterparts and have keyboard surfaces that are much more sensitive to touch. These keyboards are excellent for individuals with a limited range of motion or for individuals who have a difficult time applying pressure to keys.
- ***Touch-Sensitive Screens:*** Touch-sensitive screens are very popular with young computer users and with individuals who have severe developmental or physical disabilities. This technology allows the user to simply touch the computer screen to perform a function. Many touch-sensitive screens come complete with multiple screen overlays that can be used to perform a variety of tasks. Similarly, many companies provide additional software that enables the users to create their own overlays.
- ***Infrared Sensors with Pneumatic Switches:*** Use of an infrared sensor worn on the head, along with use of a pneumatic switch, can enable physically disabled students to interact with the computer. As the user looks at the computer screen, the cursor follows the user's head movement. Moving the head to the left moves the cursor in the same direction on the screen. Thus, users can position the cursor anywhere on the screen by moving their head left, right, up, or down. The pneumatic switch, which is activated by inhaling or exhaling through a plastic tube, enables the user to use the mouse. When the user sips or puffs on the switch, the computer responds as if the mouse button had been clicked. In this manner, the user can move a cursor and click on items displayed on the computer screen. Special software is used in conjunction with these movements to allow the user to type out information on a facsimile of a keyboard that is displayed on the computer monitor.
- ***Voice Recognition:*** Using voice recognition software, the user can bypass the keyboard and just speak to the computer. By programming the computer with a set of predefined instructions, the user can control the computer by verbally issuing commands into a microphone. In most cases, the reliability of the system can be enhanced by having the user "train" the computer to recognize his or her speech patterns. Voice recognition systems allow students to operate a variety of application programs, to dictate to a word processor, and to enter data into spreadsheets.

Lack of appropriate technology training in preservice and in-service teacher education programs is the most commonly cited barrier to use of technology in the classroom.[53] For example, communication technologies such as e-mail and the Internet represent a relatively inexpensive, yet very powerful, form of instructional technology that could be used more in instructional settings for all students, with and without learning disabilities.[54] But a 1997 report from the President's Committee of Advisors on Science and Technology found that few teachers feel they have the skills to integrate use of the Internet effectively into the curricula,[1] and even as of 1999 it was reported that only 20% of the teachers in this nation's schools feel "very well-prepared" to use technology in their teaching.[55]

Lack of adequate teacher training has an especially strong impact on students with disabilities because technology is often a critical component in planning and implementing an educational program for these students. In addition, use of technology for multimedia projects, for example, can be very motivating for students with disabilities. But classroom teachers must have a deep understanding of what they are trying to accomplish and how technology can help them achieve their goals.[56] Thus, to meet the needs of students with disabilities within regular classrooms, all teachers, both those in regular education and those in special education programs, need training in how technology can be used, and the technical skills to carry out a plan of action.[57]

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The cost of the technology needed to help students with disabilities participate in regular classroom settings, especially the computer systems needed for students with more severe disabilities, is also a serious consideration for all schools. Such systems often must be tailor-made for each student and can be quite expensive, costing tens of thousands of dollars. Funding for technology can be obtained from a variety of sources, but these sources are not always adequate. For example, two federal acts attempt to address the needs of students with disabilities, but their goals exceed their funding levels. The Individuals with Disabilities Education Act, for example, mandates that each state must provide a free and appropriate education for all students regardless of their ability level.[58] Thus, school administrators, teachers, parents, and others involved in planning the student's individualized educational program must consider technologies that would be necessary to meet the student's educational needs. In addition, the Technology-Related Assistance for Individuals with Disabilities Act enables states to conduct needs assessments, identify appropriate technologies, and provide assistive technologies as needed for individuals to function in their homes, in school, and at work.[59] However, because of limited funding, school districts are not obligated to purchase a specific computer technology, even if it is identified as potentially beneficial.

Individual schools are often hesitant to provide the necessary technology because they must fund these purchases themselves rather than rely on the school district's resources.[60] Consequently, those attempting to assist students with disabilities must seek out alternative funding sources.[61] In addition, requirements attached to some funding sources can restrict the use of technology, especially for those students who have more severe disabilities and require more complex technical systems to help them communicate or interact with others. For example, in some school districts, "limited-use policies" prohibit the use of district-funded technology outside the classroom. Such policies make it impossible for technology-dependent students with disabilities to participate in educational or social activities during after-school hours unless the equipment is purchased with nonschool funds.[62]

Conclusion

The barriers of inadequate teacher training and high cost are problematic—significantly inhibiting the use of technology in classroom settings—but are not insurmountable. There is no doubt that technology has the potential to act as an equalizer by freeing many students from their disability in a way that allows

them to achieve their true potential. More widespread use of technology would meet both the legal requirements and the spirit of the laws calling for students with special needs to be educated in the least restrictive environment. Thus, it is important for all individuals who are involved in policy decisions regarding the placement of students with disabilities, teacher training, and the funding of educational technologies to become familiar with the issues surrounding the use of technology for students with disabilities. Working together, parents, teachers, administrators, and school board members, as well as both students with disabilities and their nondisabled peers, can help create classroom environments in which *all* students have opportunities to learn.

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