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Computer Technologies For Postsecondary Students With Disabilities II: Resources and Recommendations For Postsecondary Service Providers

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Abstract

In this companion paper to our scientific findings (Fichten, Asuncion, Barile, Fossey, & Robillard, 2001b) we focus on applied issues associated with providing computer related services to postsecondary students with disabilities. We use the results of our series of empirical studies of the needs and concerns of students with disabilities and individuals responsible for providing services to them. The goal is to target evolving issues, provide an up-to-date, user friendly list of resources, and make practical recommendations about what postsecondary personnel responsible for providing services to students with disabilities can do to facilitate access to computer and information technologies at their colleges and universities.

Computer technologies are rapidly becoming a part of our professional, personal and academic lives. Because computer knowledge is a necessity for effective participation in the new North American economy, computer literacy and know-how are part of most postsecondary students' formal education. One need only look at North American colleges and universities to see this trend in action. North American college campuses are becoming increasingly "wired" and the technology is pervading all aspects of academic life (Bernstein, Caplan, Glover, 2001; EDUCAUSE Online Guide to Evaluating Information Technology on Campus, 2001). The integration of online courses and computer-mediated and web-based learning into curricula are top priorities at most universities and community/junior colleges. In parallel with this trend is evolution in the accessibility and affordability of both general use and adaptive computer

technologies (Adobe, 2001; Apple, 2001; Henter-Joyce, 2001; IBM, 2001; Microsoft, 2001). If these technologies interface smoothly the two trends have the potential to level the playing-field and provide students with disabilities access to the same skill-sets and opportunities as their nondisabled peers. This outcome is, of course, contingent on students with disabilities gaining timely access to the technologies and adaptations they need.

In this companion article to our scientific findings (Fichten et al., 2001b) our goal is to facilitate this process by providing an up-to-date, user friendly list of resources and by making practical recommendations about what postsecondary personnel responsible for services to students with disabilities can do to improve access to computer technologies.

Research and Projects of the Adaptech Project

The goal of the Adaptech Project is to provide empirically based information to assist in decision making that ensures that new software, hardware, and policies reflect the needs and concerns of a variety of individuals: postsecondary students with disabilities, the professors who teach them, and the individuals responsible who make technological, adaptive, and other disability related supports available to the higher education community. Since 1997 we have used focus groups, structured telephone interviews and questionnaires to collect data on computer and adaptive computer technologies used by university and community/junior college students with disabilities across Canada, a country where both English and French are official languages. Topics studied include: types of computer and adaptive computer technologies students with disabilities use (or wish they could use), advantages and disadvantages of the technologies, access to needed technologies both on and off campus, concerns of individuals responsible for providing services to students with disabilities, and views about training and about obtaining the necessary technologies to meet students' needs.

Our studies are funded by major Canadian federal and provincial research granting organisations. The research has had the involvement of many partners, including groupings of college and university personnel responsible for providing services to students with disabilities, consumer groups of postsecondary students with disabilities, as well as a distributor of adaptive technologies, a rehabilitation agency, and academic educational technology groupings. In addition, the research activities have been guided by an enthusiastic multidisciplinary and multisectorial cross-Canada Advisory Board.

Our recent research that has a bearing on the recommendations and resource lists that follow are based on the studies listed below. More information about each of these investigations is available on our Adaptech Project (2001) web page as well as in both non-refereed (Fichten et al., 1999; Fichten et al., 2000b) and refereed publications (Fichten, et al.,2001c; Fichten, Asuncion, Barile, Fossey, De Simone & Robillard, 2001b; Fichten, Barile, Asuncion, & Fossey, 2000), including the scientific companion to the present article (Fichten et al., 2001b).

Importance of Computer, Information and Adaptive Technologies in Postsecondary Education

In the U.S., the Americans with Disabilities Act (ADA, 1990) and related legislation have had a major impact on all aspects of living for people with disabilities. This includes accessibility of postsecondary educational institutions (Bausch, 1994) and of computer technologies (Department of Justice of the United States, 2001; United States Department of Justice, 1998; Waddell, 2000). A large scale demonstration involves the California Community College System. Here, in response to an ADA based investigation, a clear set of guidelines was developed to ensure access to distance education for all students with disabilities (High Tech Center Training Unit of the Chancellor's Office of California Community Colleges, 1999).

At most North American postsecondary institutions there is at least one designated person whose responsibility it is to provide disability-related services and accommodations to students. In many cases, ensuring that the computer technology needs of students with disabilities are met has become part of the job description. The background of many service providers, however, has not prepared them for this rapidly evolving "high tech" component of their job. Yet, the trend to incorporate technology as part of classroom teaching and learning will necessitate increasing involvement and expertise on the part of service providers.

Here we provide a listing of resources and a series of recommendations that are loosely based on our research data. The aim is to inform and assist individuals responsible for providing services to students with disabilities to become more conversant and comfortable with new developments in the educational use of computer, information and adaptive computer technologies.

Highlights of Adaptech Project Research Findings

Key findings from a series of 3 studies conducted between the fall of 1997 and the spring of 1999 are summarized in Table 1. In these investigations we explored the computer, information and adaptive computer technologies needs and concerns of Canadian university and community/junior college students. To obtain an overview of the important issues, we conducted focus groups with 6 postsecondary personnel responsible for providing services to students with disabilities and 12 postsecondary students with various disabilities. In Study 2 we obtained in-depth information from structured interviews with larger and more representative samples of these groups (n=30 and 37, respectively). In Study 3 we collected comprehensive information via questionnaire from a Canada-wide sample of 725 university and junior/community college students. Although the data were collected in Canada, the implications of the findings have broad-based applications to other countries.

Results from all stages of our investigations converge on a variety of important points. First, it is evident that computer technologies have incredible potential to facilitate the academic endeavors of students with all types of disabilities. Second, it is also clear that while the perceived advantages of computer technologies far outweighed the disadvantages, these technologies can act as either obstacles or facilitators for postsecondary students with disabilities. Postsecondary students with disabilities appear to have a high level of computer and Internet use and literacy. In fact, most participants in the research indicated that more, more up-to-date, better, and more user friendly technologies are needed both by students with disabilities as well as by institutions enrolling students with disabilities. What is also readily apparent from the data is that there are a variety of problems and issues regarding the availability of such technologies which need to be addressed. These include concern over inadequate funding for computer and adaptive computer technologies, both for the students themselves and for the institutions; lack of information about existing subsidy programs to help students acquire computer technologies; and the need for more information about adaptive technologies and enhanced training opportunities for students, individuals

Table 1

Highlights of Our Research Findings

Demographics
Community/junior colleges, in spite of smaller overall enrollments than universities, had similar numbers of students with disabilities
Almost half of the students had more than one impairment - this has implications for software and hardware incorporated into adapted work stations
Only about a quarter of the students used adaptive computer technologies (e.g., screen magnification, adapted mouse), although almost half indicated needing these - the reasons: cost and lack of information about what was available.
There were no gender differences and older and younger students did not differ on computer use or attitudes
Computer Technologies
Computer technologies have numerous important advantages for students with all types of disabilities
Virtually all students with disabilities use computers
Most use an IBM compatible
The overwhelming majority of students with disabilities use the Internet, mainly for research and e-mail
There was a clear tendency to "cross use technologies" (i.e., technologies intended for students with one type of disability used by students with a different disability)
Students used "general use" computer technologies, such as dictation software, spell-checkers and scanners, as disability accommodations
Most individuals responsible for providing services to students with disabilities were interested in having broad-based collaboration from their postsecondary institution (e.g., computer support services) and wished for better links with agencies and professionals who provide rehabilitation services to students
Barriers
There was an astonishing lack of information about existing Canadian subsidy programs to help students acquire computer technologies - this refers both to students with disabilities as well as to individuals responsible for providing services to students with disabilities
The high cost of acquiring and maintaining computer technologies was the single most important and common issue noted by computer users and non-users alike. This applied to technologies both for on and off campus use and was noted by both students and individuals responsible for providing services to students with disabilities

responsible for providing services to postsecondary students with disabilities as well as for faculty and computer services staff.

Our data also underscore the need for adapted work stations which accommodate the needs of students with various impairments and highlight the increasing importance of ensuring that different types of adaptive equipment be able to work together. In particular, the video card

requirements of magnification software, the heavy hardware and training demands of voice recognition programs, and compatibility between dictation software and voice technologies that read what is on the screen should be taken into consideration. Consistent with this trend is the "cross-use" of adaptive technologies by students with different disabilities (i.e., for students with one kind of impairment to use technologies intended for students with a different type of disability).

Computer Technologies for Students with Different Disabilities

Students in our studies indicated the types of computer technologies that could be useful in getting their work done and individuals responsible for providing services to students with disabilities noted the types of equipment they made available to students with different impairments. They frequently mentioned sophisticated features already available in popular general use software or equipment. For example, the most valued technology was spelling and grammar checking, followed by a scanner and a portable note-taking device that could be taken to class. Dictation software (voice recognition) and the availability of materials in electronic format (e.g., textbooks, course handouts) were also seen as especially helpful. While these are likely to be useful for all students, for many students with disabilities such technologies are a necessity.

In Tables 2 to 6 we list and describe computer technologies which are likely to be helpful for students with different disabilities. We provide some brand names. This is not necessarily because these are the "best" products but because these are the products the participants in our samples indicated they used. Also, we have no listing of Macintosh products because the tables are based on our findings and most of the students in our studies used PCs rather than Macs. These tables are adapted from a resource guide (Fossey, Fichten, Barile, & Asuncion, 2001a, 2001b) intended for distribution to students with disabilities and other concerned individuals. The guide is available, in English and French in both html and Adobe PDF formats on the Adaptech Project (2001) web site. The html version contains the web address for most products listed.

Students who are blind. Students who are blind use a variety of DOS and Windows-based software that use synthesized speech to read what is on the screen, specialized systems that incorporate a scanner and optical character recognition (OCR) software that turn a printed page into electronic text for speech or Braille output, portable note taking devices, and Braille printers as well as special hardware/software combinations that take a line of text on the screen and convert it into a line of text on a Braille display. Specific products and their descriptions are available in Table 2.

Students with low vision. Students with low vision frequently use a scanner and OCR software to turn the printed page into electronic text. They also use software that reads what is on the screen, as do students who are blind. Although costly, full-featured products are more versatile. An excellent demonstration of this type of technology is available by downloading the free ReadPlease (2000) screen reader. These students also use: magnification software, large screen monitors, and a variety of specialized software as well as built-in features of general use software packages to change the contrast and to enlarge and otherwise make text, cursors, and other visual elements more visible on the screen. Specific products and additional information are available in Table 3.

Students with learning disabilities. Not surprisingly, students with certain learning disabilities mentioned using the same technologies as students with visual impairments to help

them better process printed materials. In addition, dictation (speech recognition) software, document manag-

Table 2

Computer Technologies for Students Who Are Blind

Adaptation	Description	Brand Name	Free or Inexpensive
Screen reader	Sophisticated text-to-speech software that uses synthesized speech to read text, menus, buttons, dialogue boxes, etc.	• Jaws • Artic • Windows Bridge	Downloadable demos: • Http://www.hj.com/
Document reader	Text-to-speech software that uses synthesized speech to read what is on the screen or on the clipboard (but lacks many of the powerful features that a screen reader has)	• ZoomText (Level 2)	• ReadToMe • Clip&Talk
Voice synthesizer	Hardware - produces speech output for text-to-speech programs	• DECTalk	Contemporary screen readers do not need this because they use standard sound cards (e.g., Sound Blaster)
Reading machine	Standalone equipment that scans pages and reads content using synthesized speech	• Kurzweil	
Optical character recognition (OCR) software (used with a scanner)	Software - converts a printed page that has been scanned into electronic format (a text file) for speech output or storage	• OpenBook • Arkenstone Unbound	Mainstream products • OmniPage • PagisPro (Textbridge)
Text based browser, web and e-mail	Software		• Lynx • Opera (screen reader friendly) • Pine e-mail
Portable Braille note taking device	Hardware – portable note taking device with a Braille keyboard and speech output	• Braille'nSpeak • Braillemate	
Portable QWERTY keyboard note taking device	Hardware - portable note taking device with a QWERTY keyboard and speech output	• Type'nSpeak • Magnum	
Braille translation software	Software - converts electronic text into Braille code and formats text for printing in Braille	• Duxbury • HotDots	
Braille printer	Hardware	• VersaPoint • Romeo • BrailleBlazer	
Refreshable Braille display	Hardware - add-on to computer that gives a one line Braille display of what is on the screen	• Navigator • PowerBraille	

Table 3

Computer Technologies for Students Who Have Low Vision

Adaptation	Description	Brand Name	Free or Inexpensive
Document reader	Text-to-speech software that uses synthesized speech to read what is on the screen or on the clipboard (but lacks many of the powerful features that a screen reader has)	• ZoomText (Level 2)	• ReadToMe • Clip&Talk
Screen reader	Sophisticated text-to-speech software that uses synthesized speech to read text, menus, buttons, dialogue boxes, etc.	• Jaws • Artic • Windows Bridge	Downloadable demos: • Http://www.hj.com/
Reading machine	Standalone equipment that scans pages and reads content using synthesized speech	• Kurzweil	
Optical character recognition (OCR) software (used with a scanner)	Software - converts a printed page that has been scanned into electronic format (a text file) for speech output or storage	• OpenBook • Arkenstone Unbound	Mainstream products • OmniPage • PagisPro (TextBridge)
Document manager program	Software	• PagisPro	
Large monitor	Hardware	• 17-21 inch monitor • CCTV screen	
Screen magnification	Software - enlarges what is on the screen	• ZoomText (Level 1) • LPWin/DOS	• The Magnifier • Loupe • Microsoft Magnifier
Portable QWERTY keyboard note taking device	Hardware - portable note taking device with a QWERTY keyboard and speech output	• Type'nSpeak • Magnum	
Voice control of menus and toolbars	Software - allows voice commands such as "file," "open," "save"	• Dragon Dictate Classic Edition • Kurzweil VoicePad for Windows • Voice Direct • Aptiva computer	

ers (to help organize files), schedulers (to help organize time and activities), concept mapping/flow charting software (to help organize ideas), electronic dictionaries, grammar and spell checkers, and word prediction software (after typing several letters a listing of words that begin with these letters is presented, allowing the user to choose from a list) were used by these students. Details based on our findings are available in Table 4. There are also other popular full-featured (and full priced) adaptive products that combine a variety of functions in a single package ("OpenBook" and "Wynn," Freedom Scientific, 2001; "Read & Write," textHELP Systems, 2001)

Students with hearing impairments. It can be seen in Table 5 that these students use writing aids such as spelling and grammar checkers, e-mail and chat (instant messaging) programs (often used instead of the telephone), accessibility features built into the operating system of conventional software (e.g., visual flash instead of sounds), captions and subtitles for video clips (when available), and in-class versions of "real time reporting/captioning" (e.g., the C-Note System, CNS, 2001), a set-up that involves two joined laptop computers, permitting a hearing person who takes class notes to communicate what is happening in class, in real time, to a student with a hearing impairment. The student with a hearing impairment can ask questions and participate in class activities by typing on the laptop. This can be read aloud by the person who is the note taker. There are new technologies for students with hearing impairments that are in various stages of development. For example, Audisee (Audisoft, 2001) is a technology which permits students who lip read to maintain a constant view of the professor's face through a camera worn by the professor; the Liberated Learning Project (Atlantic Centre of Support for Disabled Students, 2001) is evaluating the

Table 4

Computer Technologies for Students with Learning Disabilities

Adaptation	Description	Brand Name	Free or Inexpensive
Document reader	Text-to-speech software that uses synthesized speech to read what is on the screen or on the clipboard (but lacks many of the powerful features that a screen reader has)	• ZoomText (Level 2)	• ReadToMe • Clip&Talk
Screen reader	Sophisticated text-to-speech software that uses synthesized speech to read text, menus, buttons, dialogue boxes, etc.	• Jaws • Artic • Windows Bridge	Downloadable demos: • Http://www.hj.com/
Voice recognition	Software - allows you to dictate (into a microphone) instead of typing on a keyboard	• Dragon • ViaVoice	
Spell checkers/grammar checkers	Software - usually built into word processors	• Franklin Language Master • Hugo 8+ • Keyspell	• Most word processing programs
Word prediction	Software - a menu box pops up as you type to give you several possible ways to complete a word that you have begun to type	• TextHelp! • Co-Writer	
Literacy software and tutorials	Software - helps improve grammar, math, and typing	• Plato	
Flow charting and concept mapping	Software	• Inspiration	
Portable note taking device	Hardware	• AlphaSmart • Palm Pilot	
"Shorthand" (macros) for frequently used words	Software - quickly "pastes" text		• HotKeyboard • Word "AutoText" feature

use of speech-recognition software (ViaVoice) which immediately converts the professor's voice to text which appears on a large screen at the front of the classroom.

Students with mobility and hand/arm impairments. Students with mobility and hand/arm impairments can benefit from a variety of ergonomic adaptations, dictation programs and voice control software that allows hands-free dictation and control of menus, word prediction software (described above), scanners, software based keyboard adaptations, software or hardware that allows for one handed typing, and a variety of alternative mice. These students can also use alternate input devices. See Table 6 for a listing of products and their descriptions.

Students with speech/communication impairments. Like their hearing impaired counterparts, these students often used e-mail and chat (instant mes

Table 5

Computer Technologies for Students Who Have A Hearing Impairment

Adaptation	Description	Brand Name	Free or Inexpensive
Spell checkers/ grammar checkers	Software - built into many word processors	• Franklin Language Master • Hugo 8+ • Keyspell	• Most word processing programs
Word prediction	Software - a menu box pops up as you type to give you several possible ways to complete a word that you have begun to type	• TextHelp! • Co-Writer	
Visual flash	Accessibility software usually built into the operating system - screen flashes (instead of sounds) to indicate changes such as error messages		• Windows built-in accessibility feature
Electronic encyclopedias and dictionaries	Software - CD-ROM or web based encyclopedias and dictionaries	• Encyclopedia Britannica • Encarta • WordView	• Web based
Subtitles/ captions	Some computer "multimedia players" allow you to turn closed captioning on and off		• RealPlayer
E-mail and chat programs	Software - instead of the telephone		• ICQ • AOL's AIM
Computer-based note taking systems	Note taking system involving 2 joined laptops - assistant types what the professor says. The information appears on the student's laptop – student can type questions or comments that are visible on the assistant's screen	• C-Note System (CNS)	
"Shorthand" (macros) for frequently used words	Software - that quickly "pastes" text		• HotKeyboard • Word "AutoText" feature

saging such as America On Line's, AIM, 2001) programs. They also used portable note taking devices (smart keyboards) to interact with others in face-to-face contexts. See Tables 5 and 6 for other possibilities.

Recommendations for Individuals Responsible For Providing Services to Students with Disabilities

In reviewing institutional information technology services, Wasser (1998) refers to six important criteria for good technology access in postsecondary institutions. Listed in Table 7, these are the same criteria that need to be considered when providing services to students with disabili-

ties. It is important to impress upon all levels of administration that it is vital that these goals are met.

Make technology for students with disabilities available on your campus. Some institutions, especially smaller colleges and campuses, have little or no computer equipment or support for their students with disabilities. To date, campus based disability service providers have felt that this has not posed significant problems because enrollments are still low enough so that human assistance is available instead of technological adaptations (Fichten, Asuncion, & Barile, 2001a). Thus, service providers in smaller institutions have been proceeding with an individualised, case-by-case approach. In this regard, however, it should be noted that Paul Grossman, in recapping a recent landmark decision by the U.S. Department of Education's Of-

Table 6

Computer Technologies for Students who have Mobility Impairments/Difficulty Using Their Hands or Arms

Adaptation	Description	Brand Name	Free or Inexpensive
Ergonomic adjustments	Adjustable work station (manual and electronic), desk and chair height and angles, accessible study carrel, ergonomic chair, keyboard location and angle, monitor and PC can be raised, rotated or lowered, document stand (to hold documents to be typed)		
Keyboard adaptations	Accessibility software usually built into the operating system: • One keystroke use of keys that require Shift, Control, CapsLock • Controls the repeat rate • Reconfigures keyboard to allow for one-handed typing	• Keyguard	Windows : • Sticky keys (to use Shift, Control, or Alt key by using one key at a time) • Filter keys (to ignore brief or repeated keystrokes or slow the repeat rate) • Mousekeys (allow mouse movements using only the

	Specialized "augmentative communication" systems • Place a "keyboard" on the screen • An extensive "smart" keyboard that allows students to combine words and phrases into sentences that are displayed or spoken using synthesized speech. Keyguards to prevent hitting 2 keys at the same time. Splints and wrist rests.		keyboard) Large variety of general use and adaptive keyboards
Mouse adaptations	Joystick type, trackball, foot mouse, touch pad, ergonomic, head mouse	• Kensington	Large variety of general use and adaptive pointing devices

Table 6 (continued)

Adaptation	Description	Brand Name	Free or Inexpensive
Voice control of menus and toolbars	Software - allows using one's voice rather than the keyboard and mouse to control menus and toolbars (such as "file," "open," "save")	• Dragon Dictate Classic Edition • Voice Direct • Aptiva computer • Kurzweil VoicePad for Windows	
"Shorthand" (macros) for frequently used words	Software - quickly "pastes" text		• HotKeyboard • Word "AutoText" feature
Voice recognition	Software - allows you to dictate (into a microphone) instead of typing on a keyboard	• Dragon • ViaVoice	
Sip and puff input device	Hardware and software - system to give computer commands by blowing or sucking through a straw - like device		
Mouth wand input device	Chop-stick like rod with rubberized tip for typing using one's mouth		
Morse input device	Hardware and software - allows typing and control of the computer using Morse code		
Optical character recognition (OCR) software (used with a scanner)	Software - converts a printed page that has been scanned into electronic format (a text file) for speech output or storage	• OpenBook • Arkenstone Unbound	Mainstream products • OmniPage • PagisPro (TextBridge)
Monitor and image	Hardware - multimedia projector connected to a computer allows a student to make presentations	• Proxima	

	without handling overheads		
Word prediction	Software - a menu box pops up as you type to give you several possible ways to complete a word that you have begun to type	• TextHelp! • Co-Writer	
Portable note taking device	Hardware	• AlphaSmart • Palm Pilot	

Table 7

Important Criteria for Good Technology Access

Access to the institution's systems and the Internet from a variety of locations at various times of day
Training on computers and the Internet
Technical support when and where students are using computers
Digital libraries which provide on-line access to catalogues and electronic texts
Faculty support and training *on integrating universal design of technology into courses*
Responsiveness to the needs of the community (e.g., on-line application, e-mail, course and institutional information on the web *in accessible formats*)

Note. Adapted from Wasser, 1998. Italics ours.

fice for Civil Rights, noted that providing human assistance in lieu of making computer adaptations available was not an appropriate accommodation (Hamilton, Grossman, Black, & Tate, 2001). Also, more students with disabilities are enrolling all the time. Campuses currently not offering computer supports for their students with disabilities need to carefully and continually examine this situation. As the findings clearly illustrate, computer technology is fast becoming a necessity in academic environments for all students. Institutions need to be responsive to this trend.

Provide off-hours access to computer technologies and arrange to loan computer technologies to students. Most students have academic work schedules that differ from those of the traditional "nine to five" working day (e.g., writing and doing research during the evenings and weekends). Some students also have transportation and health concerns (e.g., fluctuating levels of energy during the day, restrictive schedules of adaptive transportation). These make it critical that students with disabilities be given as much, if not more, access at school to computer technologies as their nondisabled counterparts receive. This is especially important in rural and outlying regions.

At many colleges and universities, general use computer labs and libraries have extended evening and weekend hours to meet the needs of their students. In recognition of this reality, and keeping in mind that some students with disabilities have no up-to-date equipment of their own to use off campus, individuals responsible for providing services to students with disabilities need to develop creative solutions to allow students to use adaptive computer equipment where it is currently housed (e.g., have students turn in their ID cards at security, have them "sign in,"

install a key card system). An alternative is to move computer equipment out of restrictive "nine to five" locations into less limiting ones, such as general use computer labs or libraries.

In cases where this is not possible the institution may wish to develop a program to loan equipment to students. Approximately half of the institutions we studied had a loan program for students with disabilities. There was no single model for loan programs. Duration of loans varied from, "a few hours or a day" to "duration of their studies." In most institutions equipment loans were flexible and based on individual need and availability of equipment. Generally, the loans were for a short (1-4 week) period. This was typically for a specific activity or for temporary replacement of students' own equipment, such as when waiting for an agency to provide approved equipment or when equipment is being repaired.

For example, students could benefit from being able to use laptops to work on assignments between classes, to take their own notes in class, give presentations, work in groups or communicate with other students. Such technological solutions could not only benefit students but could also be cost-effective.

Let students with disabilities know what is available to them on campus. If equipment is to be used, students with disabilities need to be made aware of its existence. At the start of every semester, new and old students alike should be acquainted with the types of technological supports available to them, where these can be found, and when they can be used. It is important to remember that some students with disabilities have little contact with service providers. Therefore, "open house" or other campus-wide publicity, in adapted formats, may be useful. As part of a web page on existing disability-related services, or printed literature, a listing of available computer equipment and hours of access could be provided. In the latter case, this needs to be provided in alternative formats.

There is sometimes an assumption that only certain students with disabilities will benefit from specific pieces of hardware or software. However as both the literature (Elkind, 1998; HEATH, 1999) and our own data show, students with disabilities do, in fact, "cross-use" technology. For example, students who are blind and those with specific learning disabilities both reported using screen readers. Rather than assume or prescribe computer supports for students, students must be allowed to choose for themselves the types of computer supports that might work best for them. Indeed, allowing students to become familiar with the types of equipment available and to try out new types of technologies may result in creative solutions to students' computing problems.

Educate professors about the importance of ensuring accessibility in their courses. While it is by no means clear that computer based learning is superior to traditional delivery of education, what is evident is that in the foreseeable future it will proliferate. Many faculty are scrambling to learn the basic skills need to function given the new realities (UCLA Graduate School of Education & Information Studies, 1999). Given a general lack of sophistication, it should come as no surprise that professors generally don't know what kinds of things to do to ensure that students with disabilities have full access to their electronic course materials (Roessler & Kirk, 1998). For example, they are typically unaware that Adobe Acrobat PDF files can have problems with accessibility for students with print and visual impairments, that PowerPoint is problematic for some students with visual impairments, that text (.txt) versions that work in Windows don't necessarily work in a DOS environment, that students with hearing impairments will probably miss audio clips on web pages and CD-ROMs, that some students have problems in computer labs when using a mouse, etc. (Banks & Coombs, 1998). They simply do not think of these

issues when they are developing their courses. This is especially true of online and web based distance education.

To help with this problem, we suggest that personnel providing services to students with disabilities consider holding a workshop or open house for professors concerning making electronic course materials accessible and useful for all of their students. Inviting sophisticated computer user students with different disabilities is likely to help drive the important points home. Inserting a module on issues related to students with disabilities into professional development and in-service training geared toward faculty that is related to the eductional uses of computers is also likely to be helpful. Of course, providing support for faculty in actually implementing needed changes is also important.

Making material available in an electronic format, whether it be by placing it online or on computer disk is an example of an adaptation, as is encouraging the use of e-mail in place of face-to-face office hours for those students who can not make it to the institution due to their disability.

Personnel responsible for providing services to students with disabilities can often advise professors about what kinds of problems exist and what kinds of solutions are available. Also, as noted earlier, some students themselves often know a great deal about what kinds of technologies are helpful. For those professors who are interested in "readable," minimally technical presentations, two resources are likely to be of interest: "W3C Checkpoints" by Chisholm, Vanderheiden, & Jacobs (1999) and "Universal design of a web site" by Cooper (1999). In addition, there are excellent "user-friendly" suggestions made by Burgstahler (1998), Campbell and Waddell (1997), and DO-IT (2001).

Make training a priority both for students and postsecondary personnel. Lack of knowledge about how to use specialized computer technologies on the part of both students and staff who oversee the technology is an important concern. If it is to be used effectively, systematic training must be seen as part of the overall investment in the equipment itself.

Some students are intimidated by computer technologies. Others are not given the appropriate support to use it to its optimum. Rectifying this situation starts with having knowledgeable staff at the school who know how to use the equipment. Where offices responsible for providing services to students with disabilities have adaptive technology "specialists" or technicians responsible for overseeing the equipment, time and opportunities must be provided to allow them to learn to use the technologies. Periodic "in-service" workshops, demos by students or colleagues from neighboring universities and colleges, professionals, or representatives of adaptive technology organizations and companies can provide a change of pace as well as information. Some vendors of adaptive computer technologies will "loan" their products on consignment to colleges and universities for evaluation and many software products have downloadable trial or demonstrative versions. Whether it is providing educational opportunities or allotting time to allow staff to learn on their own, learning about adaptive computer technologies needs to take place.

Where adaptive technologies are located at various points and campuses, other staff (e.g., library staff, staff in computer labs) need to receive at least minimal training to enable them to assist students. Then, and only then, can students with disabilities themselves be adequately trained.

Many institutions offer students one day or half day workshops and hand-outs on the use of campus computer facilities. The same must hold true for students with disabilities. This doesn't have to be an expensive undertaking. Some students on campus have probably developed

expertise in the use of specific hardware or software. Using a mentoring approach, these sophisticated students can be paired with other students who could benefit from their help. It makes sense that if there is equipment on campus, it is the responsibility of the institution to ensure that appropriate training takes place so that students can use the equipment. Putting a bunch of PCs in classrooms without offering students and faculty instruction in how to operate the equipment makes little sense for postsecondary institutions. The same goes for computer equipment for students with disabilities.

Include students with disabilities in all computer, learning, and adaptive computer technology acquisition decisions. To ensure that the computer technologies purchased will actually be used by students, it is vital that students with disabilities be included in the decision making process. This is particularly important since our findings indicate that needs and concerns of personnel responsible for providing services to students with disabilities are sometimes different from those of the students (Fichten, et al., 2001, Study 2). Because of the nature of their tasks, issues that are important to service providers frequently relate to institutional concerns, budgets, relations with other sectors of the institution, etc. Both student and service provider perspectives are valuable, and students can be involved in the decision making process whether the institution has a formal or an informal decision making structure for the acquisition of new technologies. What may seem "interesting" or "useful" may be "too complex" or "useless" to the students themselves. It is important to take advantage of this most important resource - the students themselves - because in many instances students have prior experience using the equipment that others do not have. They may also be more aware of the latest trends, and what works best for them.

Value the opinions of students with disabilities. If equipment sits idle, there is obviously a reason. Rather than assume "lack of interest" or "lack of knowledge" on the part of students, proactive steps should be taken to evaluate the views and opinions of students on the state of equipment and support available to them on campus. Candid, non-defensive discussions can be beneficial. Anonymous yearly "formative" evaluations can also be useful in providing honest feedback. If students are dissatisfied with the equipment and support currently available to them, what better argument to take to senior administration to lobby them for better funding for specialized computer technology and related support?

Make acquisition decisions that reflect the needs of all students with disabilities. Computer and adaptive computer technologies at colleges and universities should meet the needs of all students with disabilities. In this regard, it needs to be stressed that some adaptive technologies can be "cross-used" by students with different disabilities. Thus, "educated" acquisition decisions can, in the long run, prove to be more cost effective. For example, screen readers, as we found, can be beneficial not only to students who are blind or have low vision but also to students with specific learning disabilities. Similarly, scanners and voice recognition software can be useful to a host of students with disabilities. Table 8 provides information on possible cross-disability uses.

Become informed and share information on government programs offering technology-based assistance for students with disabilities. It is evident from our findings that the vast majority of students in Canada's colleges and universities are not aware of what programs exist to help them acquire computer technologies. Personnel responsible for providing services to postsecondary students with disabilities also were poorly informed. Many did not see this aspect of computer support for students with disabilities as part of their mandate.

Individuals responsible for providing services to postsecondary students with disabilities need to seek out information about funding sources and make this available not only to the students they serve, but also to individuals who work in other sectors of the institution which come into contact with students with disabilities (for example, financial aid offices, learning centers, counselling, and health services). Additionally, personnel responsible for providing services to students with disabilities should offer assistance and guidance to students in navigating through the maze of application requirements that often accompany such programs. After all, the more equipment students have for personal use, the lower the demand on institutional resources! In this regard, service providers should also insist that any program-related literature be made available to students in alternative formats.

Make Internet access for students with disabilities a priority. Our research indicates that many postsecondary institutions provide Internet access to their students. However, only some institutions have adapted computers (e.g., computers with screen readers and alternative input devices) that are capable of going online. The wealth of information available to students, the fact that course material and other school related information are increasingly being put on the web, and the usefulness of e-mail are three strong reasons why providing adapted Internet access is critical. We recommend that service providers advocate strongly to this effect to the computing professionals on campus.

Take advantage of the experience of others. Talking to your colleagues in the field, consulting other resources, and involving knowledgeable organizations as well as individuals with expertise on campus will make providing computer and adaptive computer resources in the future less daunting than expected. Lessons learned at postsecondary institutions that are of similar size to yours,

Table 8

Cross-Disability Uses of Adaptive Technology

Adaptation	Description	Used by Students:
Spell Checker/ Grammar Checker	Software - usually built into word processors	• All students
Screen Reader	Sophisticated text-to-speech software that uses synthesized speech to read text, menus, buttons, dialogue boxes, etc.	• Who are blind • Who have low vision • With learning disabilities
Document reader	Text-to-speech software that uses synthesized speech to read what is on the screen or on the clipboard (but lacks many of the powerful features that a screen reader has)	• Who are blind • Who have low vision • With learning disabilities
Reading Machine	Standalone equipment that scans pages and reads content using synthesized speech	• Who are blind • Who have low vision • With learning disabilities
Optical character recognition (OCR) software (used with a scanner)	Software - converts a printed page that has been scanned into electronic format (a text file) for	• Who are blind • Who have low vision • Who have mobility impairments/difficulty using their hands and arms

	speech output or storage	• With learning disabilities
Portable QWERTY Keyboard / note-taking device	Hardware - portable note taking device with a QWERTY keyboard and speech output	• Who are blind (with voice output) • Who have low vision (with voice output) • With learning disabilities • Who have mobility impairments/difficulty using their hands and arms • With speech impairments
Document management software	Software	• Who have low vision • With learning disabilities
Large monitor	Hardware	• Who have low vision • With learning disabilities
Screen magnifier	Software - enlarges what is on the screen	• Who have low vision • With learning disabilities
Voice control of menus and tool bar	Software - allows voice commands such as "file," "open," "save"	• Who have low vision • Who have mobility impairments/difficulty using their hands and arms
Word prediction	Software - a menu box pops up as you type to give you several possible ways to complete a word that you have begun to type	• With learning disabilities • With hearing impairments • Who have mobility impairments/difficulty using their hands and arms
"Shorthand" (macros) for frequently used words	Software - quickly "pastes" text	• With learning disabilities • With hearing impairment • Who have mobility impairments/difficulty using their hands and arms
Electronic encyclopedias and dictionaries	Software - CD-ROM or web based encyclopedias and dictionaries	• With hearing impairments • With learning disabilities • Who have mobility impairments/difficulty using their hands and arms
E-Mail		• All students
Chat programs	Instant messaging software - used instead of the telephone	• With hearing impairments • With speech impairments
Monitor and image control	Hardware - multimedia projector connected to a computer allows a student to make presentations without handling overheads	• With speech impairment • Who have mobility impairments/difficulty using their hands and arms
Voice recognition	Software - allows you to dictate (into a microphone) instead of typing on a keyboard	• With learning disabilities • Who have mobility impairments/difficulty using their hands and arms

to tap for funds, and strategies for dealing with administration doesn't have to be done in isolation.

In the future, more computer mediated learning activities and a greater role for general use computer labs will necessitate the active involvement of other sectors in the institution (e.g., consultation with intersectorial committees including students, academic computer departments, computing support services, audio-visual, the library, learning center, physical plant representatives, faculty, student affairs, and adaptive technologists). This has been recommended by others as well (Burgstahler, 1992, 1993).

Get involved in planning bodies responsible for institution-wide information technology purchases and systems development. Two trends are evident in postsecondary institutions. Colleges and universities are adopting policies to ensure that their campuses are networked for the new millennium. They are also experimenting with new methods of delivering education (e.g., adding computer lab components to courses, placing course materials on the web, interactive tutorials, communities of learners, WebCT, distance education and online admissions and registration). These trends have consequences that affect the types of accommodations students with disabilities will require in the near future.

Involvement with other areas of the school can have benefits both for the present as well as the future. Personnel responsible for providing services to postsecondary students with disabilities must actively make themselves aware of the institutional priorities concerning campus-wide information technology purchases and systems development. They must lobby, strongly, on behalf of and in partnership with students with disabilities to ensure that accessibility of new computer and information technologies is made a priority. This is also true for distance education courses, which are increasingly using computer and information technologies. Indeed, it is expected that by 2002, 15% of U.S. postsecondary students will be enrolled in online courses - a substantial increase over current levels (International Data Corp cited in Schofield, 1999). To ensure inclusion of all students in classroom activities, adaptive computer equipment will have to be available in general use computer labs and site licenses and server versions of adaptive software will need to be acquired in many instances.

Possible suggestions are: push strongly to ensure that all campus Internet servers and web pages meet the minimum requirements for universal accessibility (A-Prompt Toolkit, 2001; Cast, 2001; Cooper, 1999; W3C, 2001) make sure that a text-based browser is available; ensure that knowledgeable students and representatives of the Office for Students with Disabilities sit on committees that review and implement campus-wide computing decisions to ensure that accessibility is always on the agenda; work with professors and academic computing staff to educate them on access issues related to Internet and computer components of their courses; influence decision makers to ensure that electronic versions of textbooks, "course-packs," and other instructional materials are made available in conjunction with print versions of the same information. These issues must be planned for and dealt with from the beginning, and not on an "ad hoc" basis, when it may be too late to do something for the student. The key point here is to work alongside, rather than separately from the campus community as a whole in addressing computer accessibility.

Individuals providing services to postsecondary students with disabilities must lobby the government, rehabilitation centres, technology loan banks, etc., to provide easier application processes, to relax strict rules barring students with certain disabilities, and any other "red-tape" that may stand in the way of students receiving technologies they require.

Resources

Free and Inexpensive Computer Technologies

It is noteworthy that only about half of the students in our studies who indicated needing adaptations used these. The overwhelming reason cited was that these cost too much. Other reasons are: it is unavailable to students; they are uncertain where to buy the technology; they don't know how to use the equipment; and equipment is too expensive to maintain.

It is advisable to try some adaptive computer technologies before buying. Many products have downloadable "demos" which are usually available at a company's web site. There are also a variety of readily available free or inexpensive products that do part or all of what the full-featured products do (Fichten et al., 1999). Some of these are listed in Tables 2 to 6. These low cost products allow experimentation with technological solutions without having to make expensive purchases. These are not meant to replace the sophisticated, dedicated adaptive programs designed for individuals with specific disabilities or impairments. What makes these free or inexpensive technologies interesting is that they provide opportunities for students to test adaptations. These also provide "quick and dirty" solutions to frequent problems encountered by faculty such as having to make a last minute handout for a student who needs an audiotape. Similarly, when a professor wants a student who is blind to read material available on disk in his/her office, free or inexpensive document reading software can be accessed. Unless the material is scientific or highly technical, these free or inexpensive technologies can read the material to the student without the assistance of a reader. Similarly, free and inexpensive magnification software can allow students with low vision to see what is on the computer screen. For the web sites where these products are available as well as for new products, check out the "Downloads" section of the Adaptech Project (2001) web site.

Universal Design on Campus and Resources

A barrier-free learning community involves universal access to information (Ekberg, 1999). Guidelines for making programs and activities accessible have been proposed by several postsecondary educational institutions. Good examples are materials from Oregon State University (web accessibility guidelines, software access guidelines, hardware accessibility guidelines, 1999a, 1999b, 1999c, respectively) and Santa Monica College (1998, undated), and the distance education guidelines from Chancellor's Office of California Community Colleges (High Tech Center Training Unit, 1999). These resources, in addition to other well established North American organizations and web sites that are likely to have interesting, easily implementable solutions to common problems experienced in postsecondary education, are presented in Table 9. These resources provide information and tools to assist

Table 9

Useful References and Resources

Adaptech Project. Adaptech Project web site. Retrieved April 13, 2001 from http://www.adaptech.org

Adobe. Access.adobe.com Adobe Acrobat software and Adobe Portable Document Format (PDF) files. Retrieved April 13, 2001 from http://access.adobe.com/

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Cooper, M. (1999). Universal design of a Web site – CSUN '99 presentation. Retrieved April 13, 2001 from http://www.dinf.org/csun_99/session0030.html
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EASI (Equal Access to Software and Information). Retrieved April 13, 2001 from http://www.rit.edu/~easi/index.htm
HEATH Resource Center (American Council on Education - National Clearinghouse on Postsecondary Education For Individuals With Disabilities). Welcome to the HEATH Resource Center. Retrieved April 13, 2001 from http://www.acenet.edu/programs/heath/home.cfm
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Mates, B.T. (2000). Adaptive technology for the Internet. Chicago: American Library Association. Online version retrieved January, 2001 from http://www.ala.org/editions/openstacks/insidethecovers/mates/mates_toc.html
Microsoft Corporation. Accessibility & Microsoft. Retrieved April 13, 2001 from http://www.microsoft.com/enable/microsoft/default.htm National Educational Association of Disabled Students (NEADS). http://www.neads.ca/
NCAM (National Center for Accessible Media). Media access generator (MAGpie). Retrieved April 13, 2001 from http://ncam.wgbh.org/webaccess/magpie/
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you in ensuring that computer, information and learning technologies on your campus are universally accessible.

Conclusions

Computers are technologies that are enabling; they allow students with disabilities to prepare for and to participate in the economy of tomorrow. To plan for the future rather than catch up with the past, we recommend that the broadest based consultations take place at all postsecondary institutions and organizations and agencies which provide equipment and training for students with disabilities. Such consultations must involve students, who, of course, are ultimately the end-users. The complexity of the issues suggest that diverse sectors of the campus community need to collaborate to ensure that computer-based teaching materials and resources are accessible to students with different impairments. In this regard, we recommend that multidisciplinary computer accessibility advisory committees be constituted in postsecondary institutions with representation, at a minimum, by students with different disabilities, those responsible for providing computer related services to students with disabilities, professors, and someone from computer support services as well as administration. Such committees could benefit from the expertise of academic computer staff, adaptive computer technology specialists, librarians, audio-visual specialists, and rehabilitation professionals, among others. Creative partnerships and alliances are urgently needed.

In addition, we suggest better coordination and collaboration between disability service providers and federal and provincial/state agencies, programs, and departments which are responsible for providing equipment subsidies and computer and adaptive computer technologies to students for off-campus use. This would allow for better coordination and better information dissemination about what is really required to meet the forthcoming computer related needs of students with disabilities.

Planning for campus-wide information technology purchases and computer infrastructure improvements in community/junior colleges and universities are actively proceeding. The needs of students with disabilities are simply overlooked in much of the planning until it is discovered, often much too late, that the expensive new technology is inaccessible. This is not done through malice but through lack of forethought. Designing for accessibility always results in better, less expensive, and more timely solutions than retrofits. Implementing accessibility features in the initial design of information and instructional technology results in fewer design, construction and legal expenses. It is important to ensure that the needs and concerns of students with all types of disabilities are represented in planning decisions from their inception. Individuals responsible for providing services to students with disabilities can do much to ensure that the potential of computer, information and adaptive technologies to empower students with disabilities is realized.

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Author Notes

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