Accessibility of e-Learning and Computer and Information Technologies for Students with Visual Impairments in Postsecondary Education

Catherine S. Fichten, Jennison V. Asuncion, Maria Barile, Vittoria Ferraro, and Joan Wolforth

Abstract: This article presents the results of two studies on the accessibility of e-learning materials and other information and computer and communication technologies for 143 Canadian college and university students with low vision and 29 who were blind. It offers recommendations for enhancing access, creating new learning opportunities, and eliminating obstacles.

The use of information and communication technologies, including the Internet, on campus and in distance education is ubiquitous. To succeed in college, students must adapt to the extensive use of e-learning (that is, technology used by instructors to support the learning process), including PowerPoint presentations in class, web-based discussions to further in-class dialogue, and the full range of information and communication technologies that faculty use when teaching courses entirely in the classroom, entirely online, or in a combination of both. In the modern learning environment, students are expected to download course materials from dedicated course web sites; access course-management systems, such as WebCT and Blackboard; and make presentations using PowerPoint.

E-learning has the potential to facilitate the inclusion of students with visual impairments in classrooms of higher learning. In traditional classes, for example, students can access class notes and handouts on course web sites without assistance, assuming the course web sites are designed to be accessible and the students have access to needed information and computer communication technologies, including adaptive software for screen reading and magnification.

The experiences of students with visual impairments while using information and computer communication technologies and e-learning materials have changed over the years for a variety of reasons, including: increasing use of such electronic technologies and e-learning materials in all

Funding for this research was provided by SSHRC, Dis-IT, and the Canadian Council on Learning. The assistance and collaboration of the project's partners is also gratefully acknowledged: Adaptech Research Network, NEADS, AQEIPS, CADSPPE, SAIDE, and AQICEBS.

aspects of postsecondary teaching and learning, increasing use of computer-based testing materials and tutorials, increasing presence of adaptive technologists on campus, the maturing of adaptive hardware and software, and the increasing compatibility of such software with general-use information and computer communication technologies.

Another change in the postsecondary environment is the increasing popularity of universal instructional design. At its core, this approach suggests that the designs of instructional strategies, products, and environments be usable by all students, to the greatest extent possible, without the need for adaptation, specialized design, or extra cost (McGuire, Scott, & Shaw, 2003); and that e-learning materials need to be created with the inclusion of students with different disabilities in mind (Burgstahler, 2006). Nevertheless, the poor availability and accessibility of information and communication technologies, as well as some specific forms of e-learning, can pose problems even when students use adaptive software (Burgstahler, Corrigan, & McCarter, 2005).

Asuncion, Draffan, Guinan, and Thompson (2009) surveyed adaptive computer technologists in junior or community colleges and universities in seven countries, including the United States and Canada, and their use of adaptive computer technologies. Although Asuncion et al. performed an extensive investigation of policies and practices regarding the use of such technologies, the study did not evaluate the views and experiences of the students themselves. To obtain students' views, in the studies presented here, we explored the types of information and communication technologies that students with visual impairments indicated using on and off campus.

Some Canadian government programs that provide adaptive computer technologies to students with visual impairments for off-campus use offer only one type of technology—text-to-speech screen readers, for example. As Argyropoulos, Sideridis, and Katsoulis (2008) noted, there has been little research on the extent to which postsecondary students with visual impairments use one type of adaptive computer technology or several. Therefore, we examined the adaptive computer technologies used by students who indicated that they were blind and those who indicated that they had low vision.

To evaluate issues with access to e-learning in postsecondary education, we investigated the following in two studies involving junior or community college and university students who identified themselves as being blind or as having low vision. In Study 1, we examined the adaptive computer technologies used by students and the extent to which the information and communication technologies met their needs on and off campus. In Study 2, we surveyed students on their views of the accessibility of 18 types of e-learning materials used by professors. We also asked them about the problems they encountered with these materials and how these were resolved.

Study 1

Method

Participants

A convenience sample of 139 students from 52 Canadian universities and junior or community colleges participated in the first study. Of the 139 participants, 24

(11 men and 13 women, mean age = 31, range = 20–56, median = 28) identified themselves as being "totally blind" and 115 (46 men, 68 women, and 1 with an unspecified gender; mean age = 32, range = 19–59, median = 27) indicated they had a "visual impairment that is not adequately corrected by wearing glasses or contact lenses." The participants had attended within the past year or were currently attending a postsecondary institution. All were participating in a larger investigation to develop the POSITIVES Scale, a psychometrically sound instrument to evaluate how well the information and communication technology–related needs of students with various impairments is being met at home and at school (Fichten, Asuncion, Nguyen, Budd, & Amsel, 2009).

Procedure

In 2007, an online questionnaire was developed and administered to more than 1,000 Canadian college and university students with various disabilities. The participants were recruited through e-mail discussion lists dealing with Canadian postsecondary education. The project's partners publicized the study to their members, and students who had participated in our previous investigations were contacted. The research protocol was approved by Dawson College's Human Research Ethics Committee.

Potential participants were asked to e-mail us for more information. Those who indicated an interest were directed to the study's web site, where they read the consent form that provided information about the study, including the honorarium of $10. Clicking the "I consent" button brought participants to the online questionnaire.

The questions, which were adapted from the POSITIVES Scale, asked the students to provide demographic information, identify their disabilities or impairments, and indicate the types of computer technologies they used (Fichten, Nguyen, Barile, & Asuncion, 2007). Students also rated, on a 6-point Likert scale (from 1 = strongly disagree to 6 = strongly agree), how well their computer-related needs were met on and off campus in a variety of contexts. Item-by-item test-retest correlations showed acceptable reliability for all items (all correlation coefficients were higher than .50, $p < .001$), and validation showed significant and meaningful results (Fichten et al., 2009).

Results

Computer technologies used

Table 1 shows the most popular types of computer technologies used by the participants. Software that is designed to read what is on the screen (text to speech) or convert hardcopy print to electronic text with optical character recognition (OCR) scanning technology were noted by the participants in both groups. Close to 100% of those who were blind and 50% of those with low vision reported using screen-reading technologies. Scanning with optical character recognition (OCR) was used by close to 90% of students who were blind and a third of those with low vision. Refreshable braille displays were used by slightly more than two-thirds of the students who were blind and 4% of those with low vision. The most popular form of adaptive software mentioned by the participants with low vision was screen magnification, used by more than

Table 1
Adaptive computer technologies used by students, in rank order.

Software used	%	Number
Students who are totally blind[a]		
Software that reads what is on the screen	96	23
Scanning and optical character recognition	88	21
Refreshable braille display	71	17
Software that improves the quality of writing (such as grammar and spell check, colors, and highlighting)	42	10
Alternative mouse (such as track ball and mouse keys)	8	2
Students with low vision[b]		
Software that enlarges what is on the screen (such as magnification and zoom)	70	81
Software that improves the quality of writing (such as grammar and spell check, colors, and highlighting)	55	63
Software that reads what is on the screen	50	58
Large-screen monitor	46	53
Scanning and optical character recognition	34	39
Alternative mouse (such as track ball and mouse keys)	10	12
Dictation software	8	9
Adapted keyboard (such as large keys and an on-screen keyboard)	6	7
Refreshable braille display	4	5

[a] 16 of the 17 students who used a refreshable braille display also used text-to-speech technology.
[b] All 5 students who used a refreshable braille display also used text to speech and 2 used screen magnification as well. Among the 58 students who used text-to-speech technology, 45 also used screen magnification.

two-thirds of this group. Almost half the students with low vision also indicated that they used a large-screen monitor.

The participants in both groups felt comfortable using needed information and communication technologies in the classroom; those who were blind felt significantly more comfortable ($M = 5.50$ on a 6-point scale, $SD = 0.93$) than those with low vision [$M = 4.58$, $SD = 1.71$, $t(119) = 2.54$, $p < .001$] in using this technology.

How adequately students' technology needs are met

Table 2 presents comparative information about the views of the participants in the two groups on how well their information and communication technology needs were met. The two-way between-within analysis of variance (ANOVA) [2 groups x 2 locations (home, school)] on four dependent variables (technology needs are met, technology is sufficiently up to date, technical-support needs are met, and technology-training are needs met) indicated that, overall, the participants' needs were significantly better met at home than at school. The results also showed that the information and communication technologies the participants used at home were significantly more up to date than those at school, especially for the participants who were blind. There were no significant findings on training or technical support, although the means indicate that these aspects posed difficulties for both groups.

Table 2
How well students' needs were met at home and at school: students with low vision versus students who are blind.

	Mean	*SD*	*n*	ANOVA	*F*	*df*	*p*
In general, my computer technology needs at my school are adequately met							
Students with low vision	4.39	1.64	107	Group	1.07	1,128	.304
Students who are blind	4.57	1.67	23	Location	6.88	1,128	.010
				Interaction	0.32	1,128	.572
In general, my computer technology needs at home are adequately met							
Students with low vision	4.84	1.52	107				
Students who are blind	5.26	1.32	23				
At my school, computer technologies are sufficiently up to date to meet my needs							
Students with low vision	4.41	1.76	102	Group	0.04	1,123	.834
Students who are blind	3.87	1.79	23	Location	7.28	1,123	.008
				Interaction	3.58	1,123	.061
My personal computer technologies are sufficiently up-to-date to meet my needs							
Students with low vision	4.62	1.52	102				
Students who are blind	5.04	1.36	23				
The technical support provided at my school for computer technologies meets my needs							
Students with low vision	3.91	1.75	86	Group	1.42	1,106	.236
Students who are blind	3.64	1.97	22	Location	0.03	1,106	.859
				Interaction	0.71	1,106	.402
The availability of technical support when I am not at school meets my needs							
Students with low vision	4.12	1.70	86				
Students who are blind	3.50	1.99	22				
Training provided by my school on how to use computer technologies meets my needs							
Students with low vision	3.90	1.79	63	Group	0.29	1,79	.594
Students who are blind	3.33	2.09	18	Location	0.22	1,79	.643
				Interaction	1.51	1,79	.222
Training available off campus on how to use computer technologies meets my needs							
Students with low vision	3.41	1.81	63				
Students who are blind	3.56	1.95	18				

Note: The numbers in boxes are significant. Scores range from 1 (strongly disagree) to 6 (strongly disagree).

The scores of the two groups were compared on 17 items related to how adequately their technology needs were met in a variety of contexts. Table 3 presents means and *t*-test results. Because of the number of comparisons, a Bonferroni correction to the alpha level was applied. The results show that the technology needs of the participants with low vision were reasonably well met in most areas that were surveyed. There were four exceptions: the availability of adaptive computer technologies in both specialized and general-use computer labs, use of e-learning for testing (such as online quizzes), and the school's technology-loan program. The

Table 3
How well students' information and communication technology needs are met.

Item	Group of students	N	Mean	SD	t-test	df	p
The availability of computer technologies in my school's general-use computer labs meets my needs	Low vision	109	3.50	1.97	3.10	128	.002**
	Blind	21	2.10	1.51			
I have no problems when professors use e-learning for tests and exams (such as quizzes in WebCT)	Low vision	77	3.96	1.93	2.01	92	.047*
	Blind	17	2.94	1.71			
My school's loan program for computer technologies meets my needs	Low vision	52	3.48	1.98	0.73	63	.466
	Blind	13	3.92	1.80			
There are enough computer technologies in my school's specialized labs or centers for students with disabilities to meet my needs	Low vision	99	3.85	1.95	0.50	118	.619
	Blind	21	3.62	1.75			
Distance education courses offered by my institution are accessible to me	Low vision	60	4.37	1.68	2.47	74	.016*
	Blind	16	3.19	1.76			
Informal help is available at my school to show me how to use computer technologies if I need it	Low vision	100	4.07	1.71	0.39	121	.695
	Blind	23	3.91	1.78			
The accessibility of the library's computer systems meets my needs (such as catalogs, databases, CD-ROMs)	Low vision	108	4.68	1.47	3.65	126	.006**
	Blind	20	3.30	1.95			
When professors use e-learning (such as PowerPoint in the classroom, course notes on the web, CD-ROMs, WebCT), it is accessible to me	Low vision	101	4.61	1.49	2.41	121	.017*
	Blind	22	3.77	1.45			
Funding for computer technologies for personal use is adequate to meet my needs (such as from the government, foundations, rehabilitation centers, or loan programs)	Low vision	95	4.27	1.82	0.06	117	.954
	Blind	24	4.25	1.59			
My school has enough computers with Internet access to meet my needs	Low vision	108	4.56	1.65	1.24	129	.218
	Blind	23	4.09	1.65			
When I approach staff at my institution with problems related to the accessibility of computer technologies on campus (such as I cannot see a PowerPoint presentation), they act quickly to resolve any issues	Low vision	98	4.46	1.57	0.45	117	.654
	Blind	21	4.29	1.76			
The hours of access to computer technologies at my school meet my needs	Low vision	107	4.42	1.77	0.03	127	.978
	Blind	22	4.41	1.65			
The availability of electronic-format course materials (such as Word, PDF, and MP3) meets my needs	Low vision	108	4.58	1.73	0.11	130	.913
	Blind	24	4.54	1.50			
There is at least one person on staff at my school who has expertise in adaptive hardware and software (for example, is knowledgeable about software that reads what is on the screen)	Low vision	106	4.86	1.58	1.42	128	.158
	Blind	24	4.33	1.86			
My school's interactive online services are accessible to me (such as registering)	Low vision	111	5.19	1.16	3.70	132	.011*
	Blind	23	4.09	1.86			

(cont.)

Table 3
(cont.)

Item	Group of students	*N*	Mean	*SD*	*t*-test	*df*	*p*
My school's web pages are accessible to me	Low vision	114	5.11	1.29	2.43	135	.017*
	Blind	23	4.35	1.70			
If I bring computer technology into the classroom, I am able to use it (for example, I can plug it in)	Low vision	98	4.67	1.43	1.81	118	.073
	Blind	22	5.27	1.24			

Note: Numbers in boxes are significant after a Bonferroni correction to the alpha level. Scores range from 1 (strongly disagree) to 6 (strongly disagree).
* $p < .05$; ** $p < .01$.

technology needs of the participants who were blind were consistently (on 15 of the 17 comparisons, 7 of which were significant before and 2 after the Bonferroni correction) less well met than were those of the participants with low vision. In addition to the problem areas indicated by the participants with low vision, the participants who were blind also indicated that their technology needs were not especially well met in the following situations: when taking distance education courses, when seeking informal help related to information and communication technologies at school, when attempting to access the library's computer systems, and when their instructors used e-learning materials. Items rated by both groups as being reasonably accessible included the ability to use needed adaptive technologies in class, the school's web pages, and technical expertise on campus.

Study 2

Method

Participants

A convenience sample of 33 students from 26 Canadian universities and junior or community colleges participated. Of the 33 participants, 28 (11 men, 16 women, and 1 unspecified; mean age = 30, median = 26, range = 18–61) identified themselves as having a "visual impairment: low vision" and 5 (3 men and 2 women, mean age = 36, median = 23, range = 20–59) indicated they were "totally blind." The students had taken at least one course in the past three years that used some form of e-learning. All were participating in a larger investigation to evaluate perceptions of the accessibility of e-learning by students with different impairments.

Procedure

The study began with 22 interviews with key informants: students with various disabilities, faculty, individuals who provided disability-related accommodations on campus, professionals who supported or implemented e-learning on campus, and vendors of e-learning materials to the postsecondary community. On the basis of these interviews, web-based surveys were developed, pretested, and administered in the first half of 2006. The participants were recruited as in Study 1, but instead of an honorarium, a drawing was held for a $100 gift certificate to a large online computer store. The research protocol was approved by Dawson College's Human Research Ethics Committee.

Closed-ended items collected demographic and disability data and information on the accessibility of 18 specific types of e-learning materials (such as course web pages and PowerPoint in the classroom) on a 6-point Likert-type scale (from 1 = completely inaccessible to 6 = completely accessible). Open-ended questions, each accompanied by a text box in which the participants typed their responses, asked the participants to indicate three key problems they encountered with e-learning materials and to state how each was resolved. Responses were categorized by coders who were trained to a minimum of 70% interrater reliability using a coding manual consisting of 28 problem and 18 solution categories.

Results

Most and least accessible forms of e-learning

Table 4 shows the accessibility of the 18 forms of e-learning that we studied. The results indicate that both groups found e-mail, course web pages, web-based discussion forums, and course-related files in Word to be generally quite accessible. On the other hand, both groups indicated that videoconferencing technology, online tests and quizzes, CD-ROM tutorials, and online content using Flash (a multimedia platform that is used to add animation and interactivity to web pages) were poorly accessible. Many forms of e-learning that the participants with low vision found moderately accessible were not accessible to the participants who were blind.

Problems and solutions related to e-learning

All 5 participants who were blind and 25 of those with low vision specified at least one problem with e-learning materials. Figure 1 shows problems reported by a minimum of 8% of each group. Inaccessibility of web sites and course management systems posed problems for all the participants who were blind, but substantially less so for the participants with low vision. Both groups commented on the inaccessibility of some course notes and materials, including those in PDF (portable digital format). The participants also indicated that the lack of needed adaptive computer technologies was a problem, as was their own inadequate knowledge about how to use e-learning materials effectively. Time limits for online examinations and the inaccessibility of PowerPoint and data projection during lectures posed problems for the participants who were blind, while technical difficulties and the lack of technology and software required for home access were problems for the participants with low vision.

Figure 2 shows solutions to the problems experienced with e-learning that were reported by at least 8% of each group. Although the most common response indicated by both groups (more than half the participants with low vision and 40% of those who were blind) was that their e-learning problems remained unresolved, a number of solutions were commonly cited, including using alternate formats, devoting more time and effort to learning how to use e-learning materials, and taking an examination at a different time from the rest of the class (non-e-learning solution).

Discussion

Limitations

Although the samples of students with visual impairments were large and represent a wide age range of students from 62 different universities and junior or

Table 4
Accessibility of e-learning materials according to students with visual impairments in rank order.

Group, rank, and item	Mean
Students who are blind	
1. Course-related files in Word, PowerPoint, et cetera	4.60
2. E-mail	4.50
3. Course web pages	4.20
3. Web-based threaded discussion forum or bulletin board	4.20
5. WebCT, Blackboard, First Class, or other course- or learning-management system	3.60
6. Audio clips or files (such as recorded class lectures)	3.50
7. Course-related files in PDF	2.80
8. Video clips or DVDs	2.67
9. Additional content or resources that are included with course textbooks (such as CD-ROMs or URLs)	2.50
9. Online tests, quizzes, examinations, or other forms of online evaluation	2.50
11. In-class presentations using PowerPoint	2.00
12. Live online chat (such as MSN Messenger)	1.50
13. PowerPoint presentations viewed online using a browser	1.00
13. Videoconferencing	1.00
13. CD-ROM tutorials used in class or computer labs	1.00
13. Online content that uses Flash	1.00
Web-based lectures or presentations	NA
Live online voice-based chat (speaking and listening)	NA
Students with low vision	
1. Course-related files in Word, PowerPoint, et cetera	5.46
1. E-mail	5.46
3. WebCT, Blackboard, First Class, or other course- or learning-management system	4.86
4. Live online chat (such as MSN Messenger)	4.78
5. Course web pages	4.71
6. Web-based threaded discussion forum or bulletin board	4.48
6. PowerPoint presentations viewed online using a browser	4.38
8. Course-related files in PDF	4.31
9. Audio clips or files (such as recorded class lectures)	4.29
10. Additional content or resources that are included with course textbooks (such as CD-ROMs or URLs)	4.14
11. In-class presentations using PowerPoint	4.08
12. Video clips or DVDs	4.00
13. Videoconferencing	3.92
14. Online tests, quizzes, examinations, or other forms of online evaluation	3.89
15. CD-ROM tutorials used in class or computer labs	3.81
16. Web-based lectures or presentations	3.70
17. Online content that uses Flash	3.63
18. Live online voice-based chat (speaking and listening)	3.00

Note: Scores range from 1 (completely inaccessible) to 6 (completely accessible).

community colleges across Canada, the research had some limitations. The samples were neither random nor fully representative of the populations that were studied. Given self-selection biases, students who read online discussion lists,

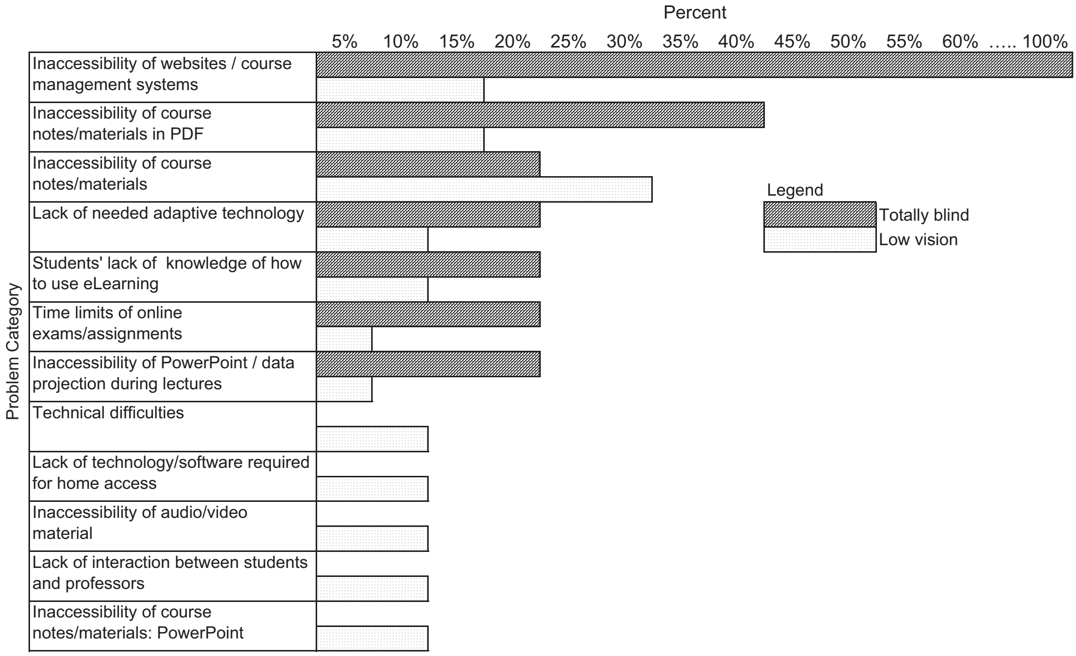

Figure 1. Percentage of students reporting each problem category.

had experience using e-learning materials, or were proficient users of information and communication technologies were overrepresented. The number of participants who were blind in Study 2 was small, leading to concerns about the generalizability of the findings for this group. It was especially troubling that we could not calculate a return rate because of the manner in which the participants were recruited.

Yet, available indices suggest that the characteristics of the participants resemble those of Canadian postsecondary students with disabilities (Fossey et al., 2005). For example, the samples contained more women than men, the students were older than typical postsecondary students, and those with low vision vastly outnumbered those who were blind. Nevertheless, the most valuable aspect of this investigation is not the representativeness of the samples, but the ability to answer specific questions, compare the views of students with low vision and those who are blind, and give a voice to students with visual impairments.

Which information and communication technologies do students use?

Virtually all the participants who were blind used screen-reading or text-to-speech software, close to 90% used scanners with OCR, and more than two-thirds used refreshable braille displays. The participants with low vision were most likely to use screen magnification—more than two-thirds did so—and close to half used a large-screen monitor. Half the participants used software that reads what is on the screen, and one-third used scanning with OCR. Most participants indicated that they used at least two different adaptive computer technologies for reading, suggesting that it is important to ensure

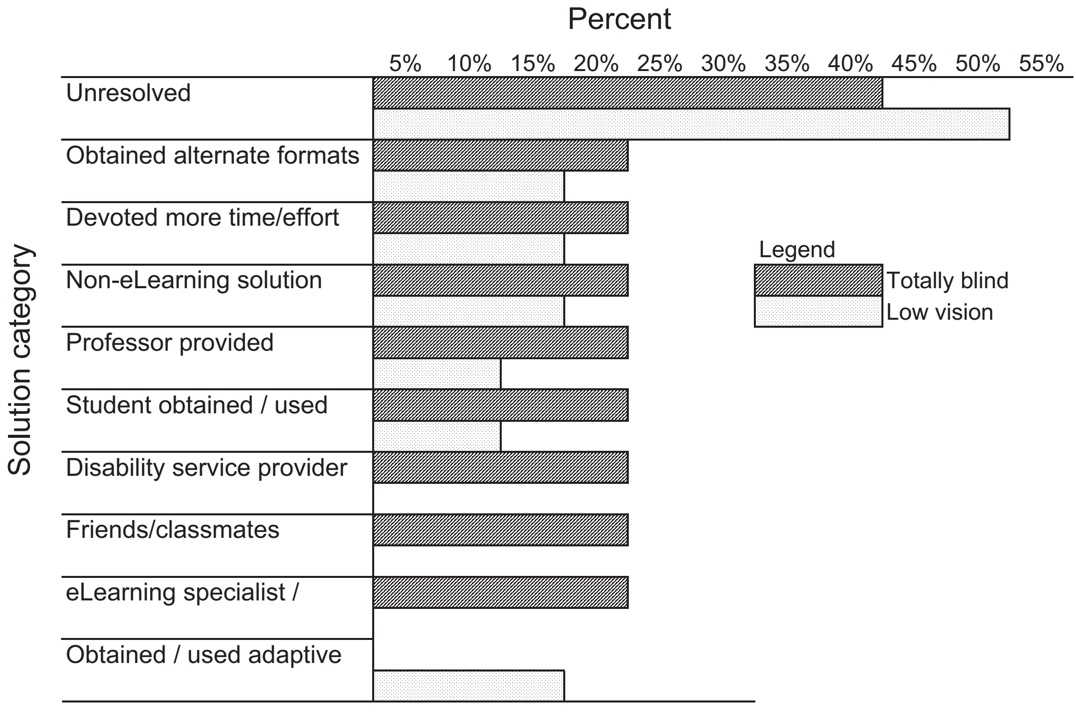

Figure 2. Percentage of students reporting each solution category.

that students have access to all the information and communication technologies that they need.

How well are students' technology needs met?

Overall, the participants' technology-related needs were generally well met and were better met at home than at school. Also, the information and communication technologies students used at school were significantly less up to date than those they had at home; this was especially true for the participants who were blind. These findings suggest that colleges and universities need to install the latest versions of adaptive software. Students need to be able to use up-to-date technologies off campus, as well.

Although the results show that the technology-related needs of the participants with low vision were reasonably well met in most areas that were surveyed, this was not the case for the participants who were blind. Both groups indicated problems related to training in computer technology, technical support, the availability of adaptive computer technology in both specialized and general-use computer labs, the use of e-learning for testing, and the school's technology loan program. The participants who were blind also had significant problems with distance education courses, informal technology-related help at school, accessibility of the library's computer systems, and e-learning used by instructors. Both groups indicated that the following generally met their needs: the ability to use necessary adaptive technologies in class, the design of the school's web pages, technical expertise on campus, the availability of course materials in electronic formats, hours of access to needed technologies, helpfulness of the staff members, availability of Internet access, and funding for needed information and communication technologies for personal use. In addition, both groups felt comfortable using the adaptive technology they needed in the classroom.

Which forms of e-learning are highly accessible?

Given the findings on information and communication technologies, it was not surprising to find that the participants with low vision found most forms of e-learning more accessible than those who were blind. Indeed, none of the 18 types of e-learning that we evaluated was completely accessible to the participants who were blind, although the ratings for several types were acceptable. The following types of e-learning materials had extremely poor accessibility for these students: online content that uses Flash, CD-ROM tutorials used in class or computer labs, videoconferencing, and PowerPoint presentations viewed online using a browser. For the participants with low vision, most e-learning materials were reasonably accessible and two were exceptionally so: course-related files in Word and e-mail.

Problems and solutions with e-learning materials

Problems

The participants who were blind generally experienced more problems with e-learning materials than did the participants with low vision. For example, although these were generally rated as accessible, problems related to certain web sites and course management systems proved to be an issue, especially for the participants who were blind. Although the most popular web sites and course-management systems used in postsecondary educational settings have favorable accessibility ratings, the reported accessibility problems with these e-learning materials are due to the fact that these are the most common means of delivering e-learning in post-secondary education (Malik, Asuncion, & Fichten, 2005). Examples of difficulties with course web sites or course-management systems included a web-based real-time chat facility that did not work with a screen reader; usability issues, such as having to navigate through a number of frames; and images that lacked "alt tags" or descriptions that can be read by screen readers. Fixed font sizes on web sites and the incompatibility between the participants' adaptive software and the course management systems were also mentioned.

Both groups commented on the inaccessibility of some course notes and materials, including those in PDF. The problem with PDF is that its accessibility depends on how it was made. Instructors often scan old, heavily annotated documents to distribute to students and save them as image-based PDF files. If the original paper document had handwritten margin notes, was heavily underlined, or was photocopied several times, attempts at OCR generally do not yield usable files. Similarly, unless specifically designed to be accessible (that is, tagged), documents with multiple columns and those with tables and figures, when rendered as a PDF files, can create difficulties because of the way screen readers interpret PDFs. Those who intend to make PDF files accessible need either to create them to be accessible or to provide an accessible alternative (such as a Word version).

Inflexible time limits to complete activities that are built into online testing components of course management systems was also a problem for both groups, a finding also noted by others (see Kamei-Hannan, 2008). This problem is due, in part, to poor accessibility of the interface and to timed features. The literature shows that individuals with visual impairments who use adaptive technology generally take longer than do sighted individuals to accomplish the same online tasks (Craven & Brophy, 2003) and that students with disabilities are often entitled to additional time to complete tests and quizzes (Harding, Blaine, Whelley, & Chang, 2006). But instructors can usually specify only one duration for all students in most online testing systems, suggesting that vendors of such e-learning products need to incorporate several time settings into their online tests.

The participants did not always have the adaptive technology they needed to access e-learning materials adequately, especially on campus, and had problems with course files in PowerPoint, which can have embedded materials that screen readers cannot read and text boxes that students often do not know how to navigate. Clearly, there is a need for training that is responsive to students' needs for accessible e-learning materials, such as in general-use software, like PowerPoint, and in course-management systems and other technologies used at the students' schools.

The participants also noted technical difficulties using e-learning materials and experienced problems connecting to web sites and course-management systems. They also had problems downloading and opening electronic files and had difficulty with web pages that would not load and video clips that took a long time to open. These concerns are probably shared by students without disabilities. Research that evaluates the similarities and differences of the problems students with and without visual impairments experience with e-learning materials and their solutions to these problems is needed.

Solutions

The results show that most of the problems with e-learning materials reported by the participants remained "unresolved," with approximately half the participants in both groups indicating that at least one of their three most important problems with e-learning was unresolved. Solving an e-learning problem with a non-e-learning solution (such as a student's husband reading materials aloud), devoting more time and effort, and obtaining additional adaptive technologies were also popular "solutions," suggesting that students with visual impairments have a way to go before they can function independently in an educational environment that uses e-learning materials.

Implications

To support the academic success of students with visual impairments, colleges and universities, along with rehabilitation professionals and educators, need to identify and assess what training they currently provide to students in the use of computer technologies and fill any gaps, especially those identified by the students themselves. Students, of course, need to be proactive in managing their own learning experiences. They need to find out what kinds of adaptations are available to help them use e-learning materials effectively, learn to use adaptive technologies that can help them access e-learning materials, request accommodations that they require, and ask for assistance.

As long as software and hardware are designed and built without consideration for their accessibility and as long as accessibility is not a key consideration when postsecondary e-learning products are developed and purchased, there will continue to be problems with access to e-learning materials. Universal instructional design, which proposes using instructional strategies and products that are usable by all students, whenever possible, without the need for adaptations, would go a long way toward eliminating access problems. Although much is said about universal instructional design, research is urgently needed to evaluate its tenets and applications.

Improving the accessibility of e-learning through universal instructional design and providing needed technology and training to students with visual impairments, especially those who are blind, will result in fewer unresolved accessibility problems. It will also equip students with visual impairments with the skills they need to succeed in an increasingly technology-driven multimedia world.

References

Argyropoulos, V. S., Sideridis, G. D., & Katsoulis, P. (2008). The impact of the perspectives of teachers and parents on the literacy media selections for independent study of students who are visually impaired. *Journal of Visual Impairment & Blindness, 102*, 221–231.

Asuncion, J., Draffan, E. A., Guinan, E. P., & Thompson, T. (2009). International comparison on accessible technology in higher education. *ATHEN E-Journal* (Issue 4). Retrieved July 6, 2009, from http://www.athenpro.org/node/120

Burgstahler, S. (2006). *Equal access: Universal design of computer labs*. Seattle: University of Washington, DO-IT. Retrieved June 24, 2009, from http://www.washington.edu/doit/Brochures/PDF/comp.access.pdf

Burgstahler, S., Corrigan, B., & McCarter, J. (2005). Steps toward making distance learning accessible to students and instructors with disabilities. *Information Technology and Disabilities*, *11*(1). Retrieved September 2, 2009, from http://people.rit.edu/easi/itd/itdv11.htm

Craven, J., & Brophy, P. (2003). *Non-visual access to the digital library (NoVA): The use of the digital library interfaces by blind and visually impaired people.* Manchester, England: Centre for Research in Library and Information Management, Manchester Metropolitan University.

Fichten, C. S., Asuncion, J. V., Nguyen, M. N., Budd, J., & Amsel, R. (2009). The POSITIVES Scale: Development and validation of a measure of how well the ICT needs of students with disabilities are met. Manuscript submitted for publication.

Fichten, C. S., Nguyen, M. N., Barile, M., & Asuncion, J. (2007). Scale of Adaptive Information Technology Accessibility for Postsecondary Students with Disabilities (SAITAPSD): A preliminary investigation. *Journal of Postsecondary Education and Disability, 20*, 54–75.

Fossey, M. E., Asuncion, J. V., Fichten, C. S., Robillard, C., Barile, M., Amsel, R., Prezant, F., & Morabito, S. (2005). Development and validation of the Accessibility of Campus Computing for Students with Disabilities Scale (ACCSDS). *Journal of Postsecondary Education and Disability, 18*, 23–33.

Harding, T., Blaine, D., Whelley, T. A., & Chang, C. (2006). A comparison of the provision of educational supports to students with disabilities in AHEAD versus non-AHEAD affiliated institutions.

Journal of Postsecondary Education and Disability, *18*, 125–134.

Kamei-Hannan, C. (2008). Examining the accessibility of a computerized adapted test using assistive technology. *Journal of Visual Impairment & Blindness, 102*, 261–271.

Malik, R., Asuncion, J. V., & Fichten, C. S. (2005, May). Accessibility of e-learning in Canadian postsecondary education. Paper presented at the annual convention of the American Psychological Society, Los Angeles.

McGuire, J. M., Scott, S. S., & Shaw, S. F. (2003). Universal design for instruction: The paradigm, its principles, and products for enhancing instructional access. *Journal of Postsecondary Education and Disability*, *17*, 10–20.

Catherine S. Fichten, Ph.D., *codirector, Adaptech Research Network, professor of psychiatry, McGill University, and professor of psychology, Psychology Department, Dawson College, 3040 Sherbrooke Street West, Montreal, Quebec, H3Z 1A4, Canada; e-mail: <catherine.fichten@mcgill.ca>.* ***Jennison V. Asuncion, M.A.,*** *codirector, Adaptech Research Network, Dawson College, Canada: <ascuncion@alcor.concordia.ca>.* ***Maria Barile, M.S.W.,*** *codirector, Adaptech Research Network, Dawson College, Canada; e-mail: <mbarile@dawsoncollege.qc.ca>.* ***Vittoria Ferraro, M.Ed.,*** *research associate, Adaptech Research Network, and professor of psychology, Psychology Department, Dawson College, Canada; e-mail: <vferraro@dawsoncollege.qc.ca>.* ***Joan Wolforth, D.Ed.,*** *director, Office for Students with Disabilities, McGill University, Brown Student Services Building, 3600 McTavish Street, Montreal, Quebec, H3A 1Y2, Canada; e-mail: <joan.wolforth@mcgill.ca>.*