ACCESSIBILITY AND COMPUTING

A Regular Publication of the ACM Special Interest Group on Accessible Computing.

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SIGACCESS Newsletter

A regular publication of the ACM Special Interest Group on Accessible Computing

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Who we are

SIGACCESS is a special interest group of ACM. The SIGACCESS Newsletter is published regularly in January, June, and September*. We encourage a wide variety of contributions, such as : letters to the editor, technical papers, short reports, reviews of papers of products, abstracts, book reviews, conference reports and/or announcements, interesting web page URLs, local activity reports, etc. Actually, we solicit almost anything of interest to our readers.

Material may be reproduced from the Newsletter for non-commercial use with credit to the author and SIGACCESS. Deadlines are one month before publication dates. Submissions may be sent as hard copy (paper), but machine-readable files are preferred. Postscript or PDF files may be used if layout is important, but word-processor files, text files, or e-mail are also acceptable. Ask the editor if in doubt.

Finally, you may publish your work here before submitting it elsewhere. We are a very informal forum for sharing ideas with others who have common interests.

Anyone interested in editing a special issue on an appropriate topic should contact the editor, who will be delighted.

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* *Regular publication is the ideal, but at present we are behind schedule. We plan to publish more frequent issues until we have caught up with the schedule.*

Accessibility and Computing

The Newsletter of ACM SIGACCESS

NUMBER 79, June 2004

A note from the Editor

Alan Creak

Dear SIGACCESS member :

That starts us off on a new note. If you didn't know before, you now know that good old SIGCAPH is now good new SIGACCESS, and that this publication is now called *Accessibility and Computing*. Our chairperson Vicki Hanson offers comments on the change (page 3) and expresses her confidence and optimism about the future. May it indeed be so !

Also in this issue, we have a review of CWUAAT (on Universal Access and Assistive Technology), an exploration of the effectiveness of speech recognition for computer input, and an examination of why assistive technology has not in fact yielded all the expected, and sometimes promised, benefits. This last article strongly emphasises the USA's experience with the Americans with Disabilities Act, but those of us from other parts of the world will recognise the problems as universal. There is a great deal of food for thought here, and a strong hint that there is plenty of work still to be done.

Acronymology

Our new title, "Accessibility and Computing", is interesting in at least two ways if we try to abbreviate it.

First, our publication's full initials – AAC – are also the common acronym for both "Augmentative and Alternative Communication", a topic of considerable significance to SIGACCESS, and the journal published by ISAAC, the International Society for Augmentative and Alternative Communication.

I don't suppose there's a serious risk of confusion, but anyone tempted to abbreviate the title might consider using "A & C", just in case.

At a different level of significance entirely, could it be a delicate compliment that the capitalised letters in the title are also the initials of the Editor ? The Editor, deeply unworthy of such a compliment, asserts that the coincidence is just that. But anyone can dream.

Tell us about it ...

Keep those articles rolling in ! Yes, of course you've heard it before, and thanks to those who've responded. But there really are not many of you. "Why not ?", I ask myself.

Perhaps it's your natural modesty – if so, overcome it, for we would like to hear what you have to tell us.

Perhaps it's lack of time – if so, we understand, only too well, but perhaps you've already written some report or

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note or summary which, with just a little attention, could be interesting to a wider audience.

Perhaps you're shy – if so, remember that in SIGACCESS you're among friends.

Perhaps you're deterred by the demands of writing a formal article – if so, don't be; we don't need formality, just interesting material.

One thing which I'm sure cannot be an obstacle is lack of material. If you're reading SIGACCESS more than casually, you're engaged in a field which is packed with material crying out to be communicated, and you have some stories to tell.

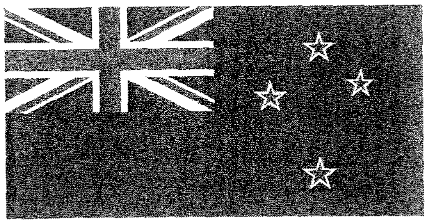
Consider this. If every one of our professional members sent a one-page report of something – current activity, inspiring thought, new observation – it would keep us going with regular issues for several years. Looked at from the other direction, even if that was all we did (and I hope it won't be), you'd have to contribute only one page every few years.

But please do not allow that to deter you from submitting two pages. Or three ....

A debt repaid.

In SIGCAPH Newsletter #58 of June 1997 there appeared an article by me. It was the Editor's custom at that time to print the national flags of all the countries represented among the authors of articles, but the New Zealand flag didn't appear. There was an Australian flag, which to the uninitiated looks rather similar, and I asked whether there had been a mistake. No, replied the Editor, possibly aware of an Australasian prickliness which is sometimes observable between the two estimable countries concerned, the New Zealand flag would appear shortly.

But the next two Newsletters were full of other material, and the New Zealand flag never turned up. So I (as a contributor) reckon that the Newsletter owes me a New Zealand flag, and I (as a conscientious Editor) am unable to avoid the logic of the argument, and conclude that the debt should be discharged. So here it is :



Any other outstanding debts ? Just let the Editor know (and send the evidence).

- and (*gulp*) farewell !

This is my last edition as Editor of the Newsletter.

I hasten to state that this does not betoken any dramatic upheaval at head office, and we part on the best of terms. It had always been my understanding that I was keeping the seat warm for someone else; when offering to take on the job, I wrote, "I shall keep going as long as necessary, external circumstances permitting, but think of me as a temporary editor. There must be someone more appropriate for the job somewhere !"

Now the more appropriate someone has turned up. He's Simeon Keates, who is – presumably coincidentally – the author of one of the articles in this issue. Welcome, Simeon, and thanks for taking over !

It has been an interesting experience for me, and I've learnt a lot. (Incidentally, belated apologies for some curiously low-level closing double quotation marks in issue #75; that's something I won't do again.)

Finally, my thanks go to the officers of the SIG, who have been uniformly supportive; to the ACM staff, who have given help and advice with unfailing courtesy and patience; and to the many contributors who have graciously tolerated my pedantic attempts to tell them how to write. All of you have helped to make my editorship much more enjoyable than I had expected.

Over to you, Simeon.

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A Word About SIGACCESS

Vicki L. Hanson, Chair

The recent name change of our organization to SIGACCESS reflects not so much a dramatic change in direction as it does a better characterization of member interests. We received a great deal of feedback from members about their interests this past year. While interests are many and varied, all members share a desire to use technology to support the needs of persons with disabilities. A new mission statement for the SIG reflects these goals:

> SIGACCESS promotes the professional interests of computing personnel with disabilities and the application of computing and information technology in solving relevant disability problems. The SIG also strives to educate the public to support careers for people with disabilities.

At the ASSETS conference this past October, attendees met to discuss their varied interests and share their expertise. A number of new opportunities for the organization were suggested:

- To maintain community ties and foster the continued exchange of ideas among researchers and practitioners, attendees were in favor of an annual ASSETS conference. We will be working to make that happen, with the next conference to be ASSETS'05. Keep updated about the conference on our website at http://www.acm.org/sigaccess/

- There is an interest in promoting computer science programs that educate students about accessibility issues and provide accessible computing opportunities for students with disabilities who wish to pursue degrees in computer science and related disciplines. More information about this will be forthcoming.

- Members also wish to exchange information about relevant educational opportunities. We will be looking to our SIG website to provide a place for such an exchange of information.

This is an exciting time for our SIG. With recent growth in membership, and the vitality of the ASSETS conference, we have the opportunity to engage in activities that will truly benefit the community. We welcome your comments on how the SIG could better meet your needs. Suggestions can be sent to any of the SIG officers, listed at http://www.acm.org/sigaccess/contact.php

Report on

2nd Cambridge Workshop on Universal Access and Assistive Technology (CWUAAT 2004)

Simeon Keates
IBM TJ Watson Research Center

"Design for a more inclusive world", the 2nd Cambridge Workshop on Universal Access and Assistive Technology (CWUAAT '04), was held in Fitzwilliam College, Cambridge, UK on 22nd to 24th March this year. This workshop was the latest in a series of biennial events that were inspired by the highly successful Cambridge Workshops on Rehabilitation Robotics that began in the late 1980s.

The aim of the earlier workshops, as with CWUAAT, was to bring together researchers and practitioners to listen to high quality presentations, and also to socialise together and have the opportunity for extended informal discussions. Cambridge colleges with their sense of isolation from the world outside, to say nothing of the wonderful food and ambience, represent ideal venues for achieving this, and Fitzwilliam was no exception for CWUAAT.

Where the earlier workshops focused exclusively on Rehabilitation Robotics, the CWUAAT conferences have addressed a broader range of topics, including:

- design issues for a more inclusive world;
- enabling computer access and the development of new technologies;
- assistive technology and rehabilitation robotics;
- understanding users and involving them in the design process.

Reflecting the diverse call, CWUAAT '04 attracted participants from many different fields of research and geographical locations. Overall there were 85 participants representing almost 20 countries spread across five continents. Their backgrounds varied from robotics to ergonomics, computer science to social science.

The continued sponsorship of CWUAAT by Royal Mail allowed participants to receive free copies of two books, *Countering Design Exclusion: An introduction to inclusive design* (Keates, S and Clarkson PJ) and *Design for a more inclusive world* (Keates, S, Clarkson, PJ, Langdon, P and Robinson, P eds.), as well as the CWUAAT proceedings.

CWUAAT consisted primarily of long paper presentations. There were also two discussion sessions, a poster/demonstration session and a couple of keynote presentations.

The keynotes were delivered by Alan Topalian of Alto Design Management, and Julie Howell, Digital Policy Development Officer for the Royal National Institute for the Blind (RNIB). Alan discussed the development of a new British Standard on managing inclusive design (BS7000 Part 6: Guide to Managing Inclusive Design). This is believed to be the first standard of its kind to focus on guiding companies on how to put in place the correct structures and mechanisms to embrace inclusive design throughout the whole product life-cycle, from concept through to decommissioning. BS7000-6 is in its final stages of drafting and should be published later this year.

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Julie Howell delivered a typically exuberant and fascinating presentation on the need to make computers accessible, particularly in the context of recent legislative developments such as the UK's Disability Discrimination Act. Her presentation was illustrated by numerous real-life examples from the work of the RNIB, including their remarkable success working with Tesco.com to develop the Tesco Access web-site.

The two discussion sessions focussed on different types of technology. Colette Nicole, from Loughborough University, continued Julie Howell's keynote theme of computer access, particularly web access for people used to using AAC equipment, such symbol boards. Colette, in conjunction with the ACE Centre Advisory Trust, also brought along a working version of the WWAAC browser for participants during the demonstration session. Colette's presentation led to a spirited discussion, with many diverse opinions from the floor on potential future directions for bringing AAC users and the Web closer together.

In his opening presentation for the other discussion session, Koos van Woerden of the TNO Institute of Applied Physics gave a detailed account of the current state of rehabilitation robotics research around the world, with a particular emphasis on robots that had entered the marketplace. Of approximately 20 robots that are available commercially only two, the Handy 1 and Manus robots, have achieved any kind of significant market success. Both of these robots managed to meet and satisfy very particular market requirements and there was a discussion about why so many of the other robot projects appeared to be having difficulty replicating their achievements.

The poster and demonstration session had over 30 contributions on display. Many of the posters in particular showed innovative works-in-progress and stimulated a great deal of discussion. One of the avowed aims of CWUAAT is to offer a forum for authors of such posters to present their work in a supportive environment and to obtain feedback and comments from their peers.

Other interesting themes that emerged from CWUAAT included finding methods for helping companies implement inclusive design practices, the importance of emotions when developing new technologies, smart house design and people's perceptions of assistive technology.

The Robin Jackson Best Paper Prize was awarded to Ben Robins, Kerstin Dautenhahn, Rene te Boekhorst and Aude Billard for their highly original paper, "Effects of repeated exposure of a humanoid robot on children with autism – can we encourage basic interaction skills?" In their paper, which was a follow-up to a paper presented two years earlier at CWUAAT 2002, the authors discussed the results of an empirical study on which children with autism were given the opportunity to interact with Robota, a humanoid doll. The children could either copy movements made by Robota, or else initiate movements for the doll to copy. The prize judges were impressed not only by the scientific merit of this work, but also by the clear demonstrable benefit and enjoyment experienced by the children who participated in this study.

The future of CWUAAT is looking very promising. The 3rd CWUAAT will be held in Cambridge in Spring 2006 and the name will be changing to represent its truly multinational nature. The 3rd CWUAAT will become the 1st International Conference on Universal Access and Assistive Technology (ICUAAT). If you are interested in helping to organise ICUAAT or would simply like more details, please e-mail me at: lsk@us.ibm.com.

PS – Please note that I successfully managed to refrain from waxing lyrical about the exceptional quality of the food and the port at the gala dinner.

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Are we speaking slower than we type? Exploring the gap between natural speech, typing and speech-based dictation

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As computers are becoming capable of doing numerous things, it is hard to find an office without a computer. Most users depend on the standard keyboard and mouse to communicate with a computer. However, typing is not natural, and requires significant practice or training. Many people never learn to type both fast and accurately. Typing using the standard keyboard is even more difficult for users whose native language does not use the basic Roman character set. In addition, extensive typing puts excessive burden on hands, arms, necks and upper body, which may induce various computer-related problems such as Repetitive Strain Injury (RSI).

Compared with typing, speech is natural, fast, easy to learn, and free of physical confinements. Most people learn to speak when they are toddlers, and eventually people speak at an average rate of approximately 125 to 150 words per minute. When speaking to computers, the physical burden on hands, arms and the upper body are relieved and people no longer need to be seated in front of the computer. With these advantages, speech-based dictation is a promising alternative for general computer users as a way to avoid computer-related motor function diseases. Speech-based dictation can also allow interactions with computer systems while an individual's hands or eyes are involved in other types of tasks such as driving a vehicle. More importantly, speech-based dictation technology can prove critical for individuals with physical impairments that hinder the use of their hands or arms.

Speech-based dictation has experienced dramatic improvements during the second half of the twentieth century. Instead of speaking discrete words, users are able to dictate to computers naturally without extra pauses. Vocabulary sizes now exceed 30,000 words and processing speeds have improved significantly.

A Problem

Even with the dramatic improvements, reports indicate that users can only produce 8 to 15 corrected words per minute (Karat *et al.*, 1999; Sears *et al.*, 2001) with hands free dictation technologies. Clearly, this is significantly slower than the average typing speed for many computer users and is also far below normal speaking rates. One major reason for the low productivity lies in the existence of recognition errors and the difficulty users experience correcting these errors. Speech is ambiguous, noisy, and context dependent. No matter how mature the recognition algorithms become, it is unlikely that recognition errors will ever be completely eliminated. Therefore, speech-based solutions must acknowledge the existence of errors and be prepared to handle them.

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Various researchers reported that users experienced many more errors when using speech to interact with the internet, electronic maps, or text documents as compared to more traditional interaction solutions (e.g., Christian *et al.*, 2001; Oviatt *et al.*, 1997; Karat *et al.*, 1999).

The process of correcting an error consists of three major activities: detection, navigation, and correction. Within the context of dictation, both navigation and correction activities can be completed through speech-based commands, but existing speech-based navigation and correction techniques are extremely ineffective.

Karat *et al.* (1999) reported that users spent around 75% of the time on navigation and error correction while composing text documents using speech. Similarly, Sears *et al.* (2001) found users spent one third of the time on navigation and another third on error correction. In one recent study, novice users spent approximately 40 minutes to compose a text document using speech recognition (Feng *et al.*, in press). Surprisingly, only four of the 40 minutes were actually spent on speaking.

Towards a solution

Existing commercial dictation products adopt two major techniques for navigation. Target-based solutions work by specifying the target word, such as 'select boy'. Direction-based solutions work by specifying the movement direction, such as 'move up', which moves the cursor up by one line. More powerful direction-based commands also specify the movement distance and unit, such as 'move up five lines'.

Empirical studies suggest that when target-based solutions and the powerful direction-based solutions were provided to the user, both approaches resulted in high failure rates (e.g., 10-20%). Further, when these commands failed, it normally caused severe consequences, such as moving the cursor to a wrong location, adding text to the document, or even deleting text from a document. As a result, users had to spend a significant amount of time to recover from failed navigation commands.

The primary reason of these command failures is recognition errors, which accounts for around nine percent of the total number of commands issued. The second most common reason is misconstructed commands, which accounts for approximately five percent of all the commands issued; examples include 'move up five rows' instead of 'move up five lines'. The third major reason is unacceptably long pauses within a command, which causes the command to be interpreted as two separate parts. Long pauses caused around three percent of the commands to fail.

Solutions built on top of confidence scores, normal length of pauses, and the tradeoff between power and reliability of a technique have been developed, implemented, and evaluated (Sears *et al.*, 2003). These solutions used confidence scores to ignore some target-based navigation commands that involve recognition errors, allowed longer pauses when issuing commands, and simplified the direction-based navigation commands such that users had at least one highly reliable alternative at all times. These changes resulted in fewer failed commands, less severe consequences when commands did fail, and more effective decision-making process.

Why it works

We also investigated the time allocated to dictation, navigation, and error correction when using this new solution for composition tasks during a longitudinal study involving nine trials. Our results indicate that navigation and error correction accounted for a large portion of the users' time during

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the early trials. As users gained more experience, they became more efficient at all three major activities. More importantly, percentage of the total task time users spent on dictation increased from 47% in the first trial to 62% in the last trial, indicating that users were able to spend more of their time concentrating on the real task of creating text. The percentage of their time spent on navigation dropped from 22% in the first trial to only 12% in the last trial, which is a dramatic reduction when compared to earlier solutions where users spent 33% of their time on navigation. More detailed analysis confirmed that the major improvements in productivity were due to dictation quality and more effective use of navigation commands.

The two major metrics that can be used to evaluate dictation are speed and quality. Dictation speed can be assessed by focusing on the rate at which users spoke. Using this metric, dictation speed was stable across all trials. At the same time, the amount of time spent composing text and checking for errors was greatly reduced as users gained more experience.

The dictation quality can be assessed by analyzing the number of recognition errors as well as the amount of correctly recognized text that users decide to be modified. Recognition errors can be viewed as system errors, but better dictation quality, such as pronouncing words more clearly and at an appropriate speed may reduce the number of recognition errors. In addition to recognition errors, some correctly recognized words are ultimately changed by the user to better express their ideas. Our research suggests that the recognition error rates remain stable across trials, but the number of correctly recognized words that users eventually choose to change drops significantly. These results suggest that users do get better at composing text with experience.

Interestingly, the amount of time users spent on navigation activities dropped by 68% between the first and last trials. Much of this decrease can be explained by three reasons. First, there were fewer targets that needed to be reached due to the improvement in dictation quality. Second, fewer navigation commands failed as users gained more experience. Third, users adopted more effective command usage strategies with more practice.

Finally, the decrease in correction time was not due to the way the correction commands were used. Correction time improved as a result of improved dictation quality and the more effective use of navigation commands, both of which reduced the number of words that had to be corrected. After interacting with the system for approximately nine hours, users still spent around 30% of the task time on error correction activities, indicating that correcting words remains a major challenge for speech-based dictation solutions.

In summary, experience does help narrow the gap between natural speech and speech-based dictation. On average, users with some experience were able to compose a text document at a rate of around 16 words per minute, which is significantly higher than novices who could complete similar tasks at a rate of only 10 words per minute. However, the gap is still there. While we do not envision speech-based dictation ever becoming as fast as natural speech, we suggest that speech-based solutions have the potential to allow data entry rates that are similar to, or higher than, those achieved by average computer users interacting with a keyboard and mouse. However, such improvements would be dependent upon more effective navigation and correction solutions as well as continued improvement in the underlying recognition engines. Currently, we are working toward this goal by focusing on novel navigation solutions and more reliable error correction techniques.

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Beyond Standards: Reaching Usability Goals Through User Participation

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Abstract

The promise of social inclusion, reinforced by online technologies, has not become the reality for most people with disabilities. In 2002, over ten years after the implementation of the Americans with Disabilities Act, more people with disabilities are unemployed than at any time in the last thirty years. Most online educational environments are still not accessible to students with disabilities or those using assistive technologies. While enrollment of people with disabilities in colleges and universities has increased, few have been able to graduate, find successful employment, and move on to independent lifestyles, free of government assistance.

To support the vision of universal usability, designers and instructors of assistive technology must go beyond the limited constructs of engineering standards and integrate actual users of assistive technology as participants into both the design and delivery processes.

Keywords

Online learning environments, Americans with Disability Act, ADA, accessibility, universal usability, universal design, assistive technology, Disabled Student Services, learnability

Introduction

The enactment of the Americans with Disability Act (ADA) in 1990 was heralded as the ushering in of major social change for the United States, awarding people with disabilities civil rights that they had long been denied (Batavia & Schriner, 2001). These changes were expected to impact every level of government, business, and education. Unfortunately, the ADA was implemented without clear goals, outcomes, or coordination between governmental agencies. Without a method of measuring the progress of social change, it became difficult to determine if life was getting any better for people with disabilities because of the implementation of the ADA.

It has now become clear that the promise of social inclusion has not become the reality (Kruse & Schur, 2003; Lee, 2003). In 2002, over 10 years after the implementation of the ADA, more people with disabilities are unemployed than at any time in the last 30 years. Most online educational environments are still not accessible to students with disabilities or those using assistive technologies (Bray, Flowers, Smith, & Algozzine, 2003; First & Hart, 2002). While enrollment of people with disabilities in colleges and

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universities has increased, few have been able to graduate, find successful employment, and move on to independent lifestyles, free of government assistance.

Impact of Legislation on Accessibility

A review of case studies is particularly important in understanding progress towards access to online education because it is through these court decisions that academic administrators, manufacturers of technology, and engineers formulate product standards and production quality measurements (Hudson, 2003). Consistency in case law is necessary to formalize processes leading toward accessible products and services.

The Rehabilitation Act, under Section 504 and Section 508, is intended to prevent discrimination in employment and education in any facility that receives Federal monies (Slatin & Rush, 2003). In 1998, amendments to Section 508 of the Rehabilitation Act expanded these guarantees to electronic and information technologies. The 1975 Individuals with Disabilities Education Act (IDEA) defined the process, through individual educational assessments (IEP), of the implementation of the Rehabilitation Act in K-12 schools for students that have been diagnosed with disabilities affecting their learning. In 1998, the IDEA was amended to include mandatory technology assessments for all students receiving IEP services. Additionally, the Telecommunications Act of 1996 required manufacturers of telecommunication equipment and providers of telecommunications services to ensure that all their products were accessible by persons with disabilities. While all of these laws have had significant effects on enforcing compliance to accessibility of technology, the ADA has had the largest impact in either advancing or restricting enforcement of accessibility standards (Abram, 2003; First & Hart, 2002; Frieden, 2003).

Definition of Disability under the Law

The definition of what constitutes a disability under the ADA is difficult to ascertain through a review of case law (Levy, 2001; Schwochau & Blanck, 2003). Not all disabling conditions are protected under the ADA or sections of the Rehabilitation Act. The ADA defines a disability as a physical or mental impairment that substantially limits one or more major life activities; there must be a record of those impairments, and/or others must regard a person as having a disability. These broad concepts have left equally broad assumptions and interpretations of what constitutes a protected disability within case law (Levy, 2001; Schwochau & Blanck, 2003). The Supreme Court has determined that the extent that a disability limits a person from one or more major life activities is one way of determining a covered disability. This has only led to further confusion over what constitutes a major activity and how to measure a substantial limitation to that activity. These are important unanswered questions to which academic administrators need answers in developing policies and procedures covering accessibility practices on their campus, yet are still undefined under present case law.

Internet Compliance

The arguments surrounding forcing compliance to accessibility to the Internet are poised within a more general question of whether the Internet should be regulated (First & Hart, 2002; Frieden, 2003). There are two primary approaches opposing regulation of cyberspace. One approach originates from a perspective of opposition to government control, allowing Internet providers to self-govern their products' content and usability standards (First & Hart, 2002). This libertarian approach further believes that it is impossible to regulate the Internet because of its immense, intertwined, and disconnected components. Cyberspace is seen as an intangible, virtual, nonphysical world that borders on the spiritual and is something quite different than what is present in the real world. Any attempt to regulate the Internet is seen as an attempt to limit free speech. A second approach is based on the concepts of allowing market forces to regulate the growth and direction of the Internet, with people with disabilities comprising a significant number of potential users and consumers of computer and Internet products and services.

There are also many reasons people support the regulation of Internet activities, from wanting to protect children from abuse, through prevention of cyber crime, to supporting the development of Internet accessibility and usability standards (First & Hart, 2002). Arguments based on accessibility recognize that without government regulation of the Internet, there will be no guarantee of providing access for all people to the Internet. Compliance to the Rehabilitation Act and the enforcement of the ADA because of student complaints are responsibilities of the U.S. Department of Education through the Office of Civil Rights (OCR) (Frieden, 2003). Case law concerning access to the Internet and online education has concentrated in three areas of legal concern: access to effective communication, the definition of a place of business, and the reasonableness of use of finances (First & Hart, 2002; Frieden, 2003).

Between 1994 and 1999, the OCR investigated eight claims within the California Community College system (First & Hart, 2002; Frieden, 2003). Each complaint was resolved within the institution and each centered around issues of effective communication and equal access to both on-campus computers and Internet systems, specifically access to computer laboratories, usability of instructional and other course-related materials, library information, class schedules, and Internet classes. This approach of determining compliance emphasizes individual learning differences deriving from the effect that the environment has on a person's learning capabilities and their ability to understand information presented in alternate formats. It also places more importance on educational institution policies and procedures of how student services are provided rather than complying to generalized preset solutions that may or may not apply for all students.

The OCR used a three-pronged test to determine the adequacy of the access to educational resources and material: accuracy, timeliness, and appropriateness (Frieden, 2003). The timeliness and accuracy of the communication of information is such that the OCR recognized that for a student to successfully participate in a class, he/she must have the same access to information and discourse with other students and faculty members that other students have. The appropriateness of the communication concerns the modality in which alternate means of communication is delivered and the effectiveness of the communication in enabling the student to understand the information. That the materials and information reside in a physical building or on the Internet did not matter to the OCR when the educational institution is considered a public university or college.

Public Accommodations

Even in terms of transportation services to public facilities, the OCR maintains the same criteria of effective communication (Frieden, 2003). In Martin *et al.* v. MARTA, a group of people with disabilities filed a claim under the ADA and the Rehabilitation Act saying that the public transportation system's Web site was not accessible. Following the precedent of the OCR, the courts found that alternate forms of communication, such as the telephone, were not adequate or equal to the information that was available on the Web site. In this situation, the information was not accurate, timely, or delivered in an appropriate format where people with disabilities could affectively use it in the way that others would expect to use the information. The courts did not say, though, that the same system would be invalid in all situations. Each Web site must be considered uniquely, dependent on the populations served, the content of the information, and the technologies chosen to carry the communication.

Another controversial area in which the courts have produced confusing case practice decisions concerns the definition of public accommodations (Computer and Internet Lawyer, 2003; First & Hart, 2002; Frieden, 2003; Hudson, 2003). Both the Rehabilitation Act in Section 36.303 and the ADA in Title III define public accommodations broadly, but within a strict concept of a physical place. Advocates for people with disabilities would like the courts to broaden the definition further to include all virtual places on the Internet, providing a clear direction for a future accessible Internet (First & Hart, 2002). Opponents of broadening the definition to include all of the Internet argue that the intent of Congress was only for the ADA to apply to physical places and they had no intention of trying to regulate the entirety of the Internet, which was an unknown factor at that time (Computer and Internet Lawyer, 2003). For students with disabilities taking online courses, the possibility that large sections of the Internet are not accessible to them places them at a disadvantage to other students who can obtain information and services anywhere (Frieden, 2003).

Case law is inconclusive on the definition of public accommodations at this time and is causing considerable confusion to those involved in Web site design and development (Hudson, 2003). Assistant Attorney General Deval Patrick stated in a letter to U.S. Senator Tom Harkin that it is clear under Section

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36.303 that public places do include the entire Internet. In another highly publicized case, courts decided that Southwest Airlines' Internet site did not fall under the ADA's definition of public accommodations because the online ticket center did not have a physical place associated with its ticket service (Computer and Internet Lawyer, 2003). The Telecommunications Act of 1996 provided legislation that requires the products of all manufacturers and providers of telecommunication services, including those of the Internet, to be accessible for people with disabilities. But, like the ADA and Rehabilitation Act, the courts have emphasized clauses expressed in terms of "undue burden" and "readily achievable", overriding many consumer attempts at enforcing the accessibility requirements.

Status of accessibility

Attainment of equal civil rights, employment opportunities, and the American dream of economic security have long been associated with educational advancement and the completion of college degrees or technical vocational programs (First & Hart, 2002). Internationally, educators have recognized that one of the goals of education is to educate people to become competent citizens that can contribute to their communities by being productive workers, informed voters, and compassionate neighbors (Association of International Educators [NAFSA], 2003). It is increasingly becoming more important to have access to, and the capability of, using technology and the Internet to be a productive citizen. Voting, banking, and rapid communications through e-mail, faxing, and information retrieval is linked to one's ability to use online technologies (First & Hart, 2002). Federal and state legislation promoting social inclusion of people with disabilities is often focused on access and success in schools and universities (Frieden, 2003; Levy, 2001).

Employment

The economic lives of people with disabilities have not improved during the 1990s after the enactment of the ADA. Employment and income levels are the worst they have been in over 30 years (Batavia & Schriner, 2001; Bound & Waidmann, 2002; Kaye, 2000a,b; Schur, 2003a,b). United States Census reports for the year 2000 showed that, at a minimum, 8 million Americans had been certified as eligible to receive disability income and, at a high end, as many as 50 million people had reported substantial impairments that limited major life activities (Kruse & Hale, 2003). Thirty-three million of these people are of working age. Only about 30% of working-age adults with disabilities are employed full or part time, compared with 80% of adults without disabilities (Batavia & Schriner, 2001). Surveys report that over 75% of unemployed people with disabilities would like to have a job, but have not been able to find one. People with disabilities are three times more likely to live in poverty.

The Internet and Technology

The lack of access to computers and the Internet limits people with disabilities from learning essential skills needed to complete college, vocational, and job-related programs that could lead to more independent lifestyles (Kaye, 2000a,b). The term "digital divide" describes the measure that separates social populations into those that have and do not have access to computers and the Internet (First & Hart, 2002; Kaye, 2000a,b). Americans with a disability are less than half as likely as those without a disability to own a computer and only one quarter as likely to use the Internet.

Access to the use of computers and the Internet correlates with educational success, income levels, access to health services, and other vital community resources (Kaye, 2000a,b). Less than 3% of people without high-school diplomas use the Internet compared to over 64% of people with college degrees. Even within each of these populations, people with disabilities are half as likely to own computers and use the Internet as those people without disabilities in the same grouping. Lower usage of the Internet has been linked to a lack of cultural affinity to the Internet for many populations on the wrong side of the digital divide. However, in contrast to other populations that are not connected, people with disabilities who have access use the Internet twice as often as people without disabilities (Preece, 1999). The courts have been inconsistent in enforcing access to the Internet under the ADA for people with disabilities, who are in consequence being left out of many online educational opportunities.

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The pursuit of better standards

Estimates of Web site inaccessibility to users with disabilities range from 80% up to 95% (Sullivan & Matson, 2000). In an attempt to help manufacturers of Internet products and services to comply with regulations mandating that their products are accessible to people with disabilities, several international organizations, nonprofit agencies, and private companies have attempted to provide design accessibility guidelines or evaluation tools to evaluate accessibility compliance (Chisholm, Vanderheiden, & Jacobs, 2001; Wall & Sarver, 2003). Nearly two hundred guidelines have been produced by varying governmental and professional organizations trying to capture the multitude of criteria involved in universal usability product design (Vanderheiden, 2000). The ability of these standards and tools to actually help Internet designers develop accessible Web sites has been questioned by groups representing people with disabilities (Sierkowski, 2002). Usability evaluations show that many accessibility problems are misidentified or go completely unnoticed.

The Web Content Accessibility Guidelines 1.0 have been adopted by the World Wide Web Consortium (W3C) as the Web Accessibility Initiative and are intended to be used by all Web content developers and developers of authoring tools to promote accessibility (Bray *et al.*, 2003; Chisholm *et al.*, 2001). These guidelines provide comprehensive methodology and production standards to begin Web development. Errors are given priorities from one to three depending on their severity and the population of users that may be affected. Two usability problems have been identified with the W3C guidelines: (1) the complexity of the guidelines makes it difficult for multiple design teams to coordinate effective product development, especially when team members are separated over long distances; and (2) users of assistive technologies have reported usability errors that are due to the vast differences between learning styles of people with disabilities and also to the rapid introduction of new products that the guidelines did not consider (Jackson, 2003). Mere adherence to these guidelines does not guarantee compliance to accessibility laws.

A number of automatic validation tools are also available to help evaluate the accessibility levels of a completed Web site, including Bobby, A-Prompt, W3C HTML Validation Tool, AccVerify, and Lift (Slatin & Rush, 2003, chap. 6; Sloan, Gregor, Rowan, & Booth, 2000). All of these tools are beneficial aids but assume that the developers have the time and motivation to comprehend the complex and often lengthy recommendations that the validation tools produce. Studies indicate that most designers have not been adequately trained in their use or fully understand the need to comply with accessibility requirements. These tools have also been found to bypass emerging technologies and miss important usability problems. Designers often will use these tools as evidence of accessibility compliance under Section 508, although most people with disabilities will still not be able to use the products. Acceptance of these tools does not guarantee compliance to accessibility laws.

Other methods of reaching accessibility goals

The Digital Media Access Group at the University of Dundee, Scotland, carried out research into the potential of developing a single evaluative tool that could help developers create accessible Web sites and Internet products (Sloan *et al.*, 2000). They were hopeful of finding a method that would comprehensively and efficiently uncover all accessibility problems and present the information uncovered in a way that would be usable by Web designers of products and services. The Digital Media Access Group's study did not find a single tool or process that would achieve these goals. There are too many possible combinations of technologies, design attributes, and applications for one method to work in every situation. Additionally, computer users' capabilities are too complex for one method to be able to ascertain usability for all people. The best method of determining the extent of accessibility and usability of any product is to evaluate its use by observing people using the product (Sierkowski, 2002; Slatin & Rush, 2003, chap. 6; Sloan *et al.*, 2000). In this case, those people must include people with disability and users of assistive technology.

In developing a unique set of accessibility heuristics to be used in usability evaluations, Paddison and Englefield (2003) established the necessity of developing unique criteria to establish and measure how people with disabilities use technology. Paddison and Englefield identify technical accessibility and usable accessibility as two attributes of the development of products and environments that prevent people with disabilities from participating in substantial life activities, including the use of services, products, and information. These attributes differentiate between the engineering practices (ensuring that all technical components of a computer environment meet current accessibility legislative requirements) and usability principles that accentuate practices of user-centered design. A key concern of Paddison and Englefield is the need for evaluators to have knowledge in accessibility, the use of assistive technology, and other real-world issues facing usability of technology by people with disabilities. While Paddison and Englefield felt that the best situation would be to involve actual users of assistive technology as evaluators, they acknowledged that it is often difficult to include them within research studies.

In explaining the importance of concurrently measuring performance, usability, and learnability within usability evaluations, Williams (2004) emphasized the need to involve real users and experts. Williams additionally emphasized the affectiveness of a team approach and having participants working together as a collaborative team. Unfortunately, just as Paddison and Englefield (2003) found, Williams acknowledges the difficulty of locating, procuring and supporting the assistance of actual users for performance and usability evaluations (Williams, 2004).

Several studies have shown the ability of people with disabilities to successfully participate within participatory action research models (Dymond, 2001; Edwards & Imrie, 2003). These studies indicate that people with disabilities want to be involved in the design and development of products and services that they will utilize, but are often prevented from participating because of difficulties concerning transportation, communication, or accessibility to research facilities. Participatory action methodologies, including online focus groups, have been effective in involving expert users of assistive technologies as participants.

Industry-Based Solutions

Adobe Systems (2002) launched a company initiative to make all of their products comply with Section 508 of the Rehabilitation Act by forming a cross-functional accessibility task force with representation from all company-wide departments, including engineering, user interface design, marketing, and sales. In addition, recognizing the essential need to involve manufacturers of assistive technology products and users of assistive technology into their accessibility design process, Adobe developed partner relationships with various assistive technology companies and service providers. These companies included Freedom Scientific, GW Micro, and SSB Technologies. Accessible products and services provided by Adobe under their Accessibility program have all been evaluated through usability studies incorporating major brand name accessibility products of screen readers and alternate computer control devices. Current accessibility products include Adobe Acrobat 6.0 and Adobe GoLive 6.0. These products have been accepted well by users of assistive technology and are being incorporated within training programs throughout the United States (Adobe Systems, 2002; High Technology Training Unit, 2003).

Another industry attempt at developing an accessibility development process was initiated by Sun Microsystems (Sun) (Jackson, 2003). In response to requirements stemming from Section 508 of the Rehabilitation Act for all Internet products and services to be accessible for people with disabilities, Sun established an Accessibility Program Office that created a Web site to help groups and individuals design accessible products. Additionally, Sun established a set of accessibility guidelines that attempted to be inclusive of all matters pertaining to creating accessible products and services.

The process of establishing these guidelines included existing company-wide efforts already established within individual departments to come up with a single set of guidelines that could be used throughout the internationally based company (Jackson, 2003). Sun's new emphasis was on the development of a single methodology and the training of all writers and developers on how to use these guidelines within their work. The process also included developing partner relationships with other software manufacturers whose products include assistive technologies and disability advocacy groups, such as Freedom Scientific, AT&T Bell Labs, Trace Research and Development Center, and the National Society for the Blind (Smaragdis, 2000). Sun's philosophy is that a product's conformity with accessibility guidelines does not ensure that it will be accessible for people with disabilities. Assistive technology developers and users must be part of all product design stages to insure usability of the final product. Sun's Java accessibility API has won acclamations from disability advocacy groups as helping others make usable accessibility products.

Community Based Solutions

A number of community-centered technology initiatives have produced productive models of how to successfully overcome the barriers producing the digital divide (Ritchie & Blanch, 2003). Community Technology Centers (CTCs) have formed in all communities that have active Centers of Independent Living. There are over 500 CTC programs nationwide. These centers typically are underfunded and operate solely with volunteer workers. The Alliance for Technology Access (ATA) is a nationally affiliated group, based in San Rafael, CA, that has resulted in many technology resource centers, supporting a community of people associated with the delivery of assistive technology. The ATA activities include the hosting of national assistive technology conferences, extensive research into the usability and delivery of assistive technology, and the development of funding for assistive technology programs.

Many community colleges and universities support Disabled Student Programs that not only provide educational counseling, but also technology evaluations and training (High Technology Training Unit, 2003, p. 1). California's High Technology Center, located at De Anza Community College, is a model-training program that provides technology assistance to 107 California Community Colleges. The High Tech Center Training Unit of the California Community Colleges supports community college faculty and staff wishing to acquire or improve teaching skills, methodologies, and pedagogy in assistive computer technology, alternate media, and Web accessibility. The yearly International Conference on Technology and Persons with Disabilities, hosted by California State University at Northridge (CSUN), brings together many people involved in independent living centers, disability advocacy centers, education, and the manufacture of assistive technology products, where the latest achievements in assistive technology can be shared (Center on Disabilities [CSUN], 2003).

Online Community Solutions

A study by Eklundh *et al.* (2003) investigated the use of home pages on the Internet, within the KnowHow Project, to ascertain the feasibility of forming adult online learning communities based on personal home pages. Personal home pages have been identified as the most visible Web genre and the most identifiable to a person's interests, personality, and emotional perspective. The home page allows an individual to present personal information to other users. They can be set up as either global or local access, depending on the goals and direction of the community and the individuals involved. Eklundh *et al.* explored the extent to which knowledge is shared individually through home pages and the ability of groups to form a cohesive community. Members reported greater feelings of affect towards other community members, increased motivation to participate in community activities and discussions, and improved self-efficacy in being able to navigate and use online technology resources.

Another example of an accessible online educational community of practice where students with disabilities are able to participate equally with non-disabled students is the master's degree program in Rehabilitation Counseling at San Diego State University (Sax, 2002). An essential construct of a graduate program in counseling is the high level of trust, communication, and mutual support that is developed between students and faculty. Rehabilitation Counseling programs typically have higher than average enrollments of students with disabilities. The first graduating class of Spring 2000 had 200 students, representing 18 states, three Pacific jurisdictions, with 15% of the students with diagnosed disabilities needing accommodations. Accommodations for all instructional materials included captioned videotapes with text transcriptions, videotapes copied to audio tapes, materials labeled and produced in Braille, all Web site information easily read from a screen reader, streaming videos captioned, and sign language interpreters hired for special assignments. Student and faculty evaluations of the online learning experience ranged from excellent to very enthusiastic. No differences between the online and face-to-face relationships were measured, especially in the quality of peer relationships and professional relationships formed out of cooperative learning projects.

Conclusion

The ability of people with disabilities to be involved as participants of usability evaluations, as university students or as workers, heavily relies on their ability to affectively use assistive technology (Riemer-Reiss & Wacker, 2000; Scherer, 2004; Wattenberg, 2004a). Studies by Riemer-Reiss and Wacker, 2000, found that as high as seventy-five percent of assistive technologies are abandoned by people with disabilities. Many users become dissatisfied with their devices and services, usually resulting in the discontinuance of the assistive devices. Factors that affect these user choices are relative advantage, compatibility, trialability, and re-invention.

Assistive technologies, while having the potential of helping and enabling people with disabilities, often result in opposite outcomes that limit, isolate, or make people feel more dependent on others' help to survive (Scherer & Parette, 2004). The usefulness of assistive technology, according to Scherer and Parette, is dependent on whether the person using the technology can utilize it to feel more connected to their environment, including self-identity, with other individuals or groups of people, the use of money, and the feeling of control over their destiny. How assistive technology is delivered is as important as whether the technology was originally designed to be accessible or not.

According to Scherer (2004), the primary reasons that people with disabilities do not use assistive technology is a lack of facilities, or insufficient effort to integrate the technology into their learning styles, social environments, family structures, and community activities. As the options of assistive technology and their availability have increased in the last few years, so have the recommendations by rehabilitation specialists increased for their use by people with disabilities. However, the evaluation process of determining what technology is appropriate for each person is a difficult task and has only just begun to be studied (Scherer, 2004, Wattenberg, 2004a). Additionally, there is little known about how assistive technology is used and integrated into a person's lifestyle and learning capabilities. Scherer's findings indicate that it is not usually the inability of the technology to work or to perform the needed adaptive action, but the emotional acceptance and usage of the technology by the person with the disability that prevents assistive technology from being more widely accepted and used.

Research is needed into how people with disabilities use, and learn while using, assistive technology. Walth and Wattenberg (2004) developed tactile instructional aids and curriculum supporting visually impaired students in learning how to use a specialized screen reader for operating a computer using Windows applications. Facilitating previous cross-disciplinary research from the fields of Cognitive and Neuro Psychology, Speech Pathology, and Education, Walth and Wattenberg developed limited sets of accessibility heuristics in order to further their work. Studies have identified the need for all computer users to form mental images of applications with graphical user interfaces and Web-based information to efficiently perform cognitive processes of learning (Aldrich & Sheppard, 2000; Saariluoma & Kalakoski, 1997). People with visual impairments have difficulty forming mental images of graphics screens because of the necessity of translating audio descriptions of the graphical information, and often have little previous experience with the visual relationships used in computer design (Yesilada, Stevens &, Goble, 2003). Walth and Wattenberg utilized actual users of assistive technology as usability evaluators in their studies. The heuristic usability evaluations on the usage of screen readers by students with vision-impairments provided information and identification of usability problems to develop new instructional strategies and curriculum.

Wattenberg (2004a) developed a set of accessibility heuristics based on the learnability criteria of intelligibility, comprehension, and persistency of comprehension of students with learning disabilities using a screen reader application. Understanding and comprehending human speech is dependent on two cognitive processes: the ability of somebody to understand individual words and their ability to comprehend the meaning of spoken phrases (Cahn, 1990; Morton & Tatham, 1996; Lai, Wood & Considine, 2000; Wattenberg, 2004a). Cahn (1990) used the terms "intelligibility" to denote the quality of synthesized speech needed to render words understandably, and "comprehension" to denote the quality of producing comprehendible phrases. The listener's affect is the level in which they are able to learn how to interpret the orally produced sequences to actually comprehend the content and emotional messages. By measuring the

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students' persistency of affect over longer periods of reading times, the usability study identified learnability problems that could result in improved instructional strategies leading to higher reading comprehension and user acceptance of their assistive technology.

Further research is necessary concerning the following research questions to support greater acceptance of assistive technology by people with disabilities and increase the ability of users of assistive technology to be participants in research studies:

- What are the problems associated with people working collaboratively while using assistive technologies, such as people with and without vision?
- How can we measure the affective learnability of someone using an assistive technology?
- How can we affectively match a person with a disability to an assistive technology?

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