NSF Disability Proposal: Writeup

May 5, 2008

Contents

1 Focus on Blind and Visually Impaired Students

With less than 0.2% of school-age children, visual impairment is a rare disability [22]. In addition, within the United States there are fewer than 36 university degree programs for teachers of the blind[1], leading to shortages of teachers for visually impaired students. As such, blind and visually impaired students are underserved within the public school setting with braille illiteracy as high as 80%[2] and only 45% acquiring a high school diploma[3] [22]. This has led to unemployment rates for visually impaired persons to stagnate at 70%-75%[4] [22].

That said, of the 4-year college freshmen that report a disability, 16% report being "partially sighted or blind[5]" [15].

2 Disability and STEM

For persons with disabilities, the employment rate is 83% in science and engineering, compared to 26% in the overall disabled U.S. population [4]. Despite the apparent increase in employment for pursuing STEM fields, the NSF reports that approximately 365,500 people in STEM are disabled (about 7%) compared to 13% disabled people in the general workforce, and 9% that are college-educated [9].

Evidence points to persons with disabilities are discouraged from pursuing STEM fields. For example, Calculus is discouraged for disabled students with K-12 [9][21], which prevents students from pursuing the higher level mathematics needed for STEM. In addition, "[s]pecial education teachers often lack knowledge about science curriculum" [14].

2.1 Visual Impairment and STEM

For blind and visually impaired students the discouragement to pursue STEM is even higher. Traditional science education focused on abstract concepts and visualization [17][18][14] which is assumed to be inaccessible.

For mathematics, the Nemeth Braille Code is taught. The issue arises in that Nemeth Code training is insufficient for higher-level mathematics, assuming a teacher of visually impaired students has trained in Nemeth[16].

In addition to braille, blind students can access reading materials through audio. Yet, audio libraries, such as the Recordings for the Blind and Dyslexic, usually have more liberal arts books. Computer science and mathematics books are more difficult to acquire [15].

2.1.1 Visual Impairment and Computer Science

For a blind or visually impaired person to use computers, accessible technology (like screen readers and magnifying software) must be available. The issue that arises is that accessibility

[1] quoting Keigwin study (2004)
[2] quoting Faherty (2006) and *Braille Monitor* (2000)
[3] quoting Keigwin study (2004)
[4] quoting Faherty (2006) and *Braille Monitor* (2000)
[5] quoting "College Freshmen with Disabilities" (2001)

is usually an afterthought in the development of mainstream products [10][12] in part because of the small amount of people with visually impairments [20]. Even for so-called accessible programs and hardware are difficult to use as training materials and manuals are rarely in an accessible format [12].

With the advent of the GUI, programming and general computer use has become more difficult for a visually impaired person [23]. For example, creating forms using a text editor and importing it into a program is an impossible task when one is unable to check the form for layout [11].

With 10 million blind or visually impaired persons in North America and at least 1.5 million using computers[6], the need to have more accessible computers is apparent [15]. "As computers become an integral part of all students' educational experiences and as designers of software and web sites continue to use pictures and animation, the question of equal access to information for people who are blind or visually impaired becomes significant" [15].

3 Postsecondary Education for Blind and Visually Impaired Students

3.1 Other University Programs

3.1.1 Purdue University

TAEVIS[7], a subdepartment of the Office of the Dean of Students, specializes in transcribing school materials into an accessible format for students with print disabilities. Rather than rely solely on disability experts, TAEVIS employs graduate students to assist in the transcription of documents (i.e. chemistry student aids with chemistry texts).

After a visually impaired student enrolls for the semester, TAEVIS contacts the student's professors. Professors are to provide all written materials students would normally receive (syllabus, handouts, textbook, exams, figure drawings, lab manuals, etc.) as soon as possible. These are brailled or recorded and given to the visually impaired student at the same time as his/her sighted peers.

In addition, TAEVIS provides note takers and audio tapes, proctored exams, create tactile graphics, and (for chemistry and biology students) 3D models are provided for certain class concepts.

3.1.2 University of Virginia

Through an interdepartment collaboration between the Learning needs and Evaluation Center, the Athletics Department, Information Technology and Communication, and the Library, the University of Virginia has developed a more efficiently accessible university.

They placed screen reading software[8] licences onto a network for students to use as needed [3].

[6] quoting AFB

[7] http://www.taevisonline.purdue.edu

[8] Kurzweil 3000 (for Learning Disabilities and/or Low Vision)
Kurzweil 1000 (for blind or severe visual impairment)

In addition, using the Information Technology and Communication Department's knowledge allowed for faster and higher quality scans for the Learning needs and Evaluation Center's electronic texts [3].

3.1.3 University of Washington

The University of Washington has DO-IT[9] to encourage and aid disabled students in "in challenging academic programs and careers" (particularly STEM).

The University of Washington has transition programs[10], an e-mentoring community, and promotes accessible technology use [6].

3.1.4 School of Electrical & Computing Engineering (Australia)

The School of Electrical & Computing Engineering uses the same labs, teaching staff, materials for blind and sighted students. The difference being that blind students attend a separate lab to avoid excessive noise [20].

3.1.5 Curtin University of Technology (Perth, Australia)

To allow visually impaired students to access the Cisco Certified Network Associate level 2 GUI, the Curtin University of Technology uses iNetSim *(see "programs" in later section)* [2].

3.2 Educational Considerations

3.2.1 Acceptance of Visual Impairment

For students that experience loss after childhood, their emotional and psychological needs must be addressed first. There are societal prejudices about people that are blind (ineptness, dependency, loss of significance in life, etc.) which are more likely to be believed with age [15]. Within even postsecondary education, the professional world and blindness advocacy groups, blindness is considered a financial burden and proof of one's inability to interact with society [21][23][15].

Before education for living with a visual impairment can begin, one must accept that visual impairment is a difference rather than a fault [22][15].

3.2.2 Braille

While it is typical to use screen enlarging technology for students with residual vision (the ability to read print when one is legally blind) [8], braille instruction should be encouraged particularly if the student experiences eye strain and continuing vision deterioration. Braille is time consuming to learn but provides literacy in the longterm.

[9] http://www.washington.edu/doit/

[10] HS to college, community to 4-yr college, noncomputing to computing, undergrad to grad, college to career, & grad to professoriate

3.2.3 Testing

It can be guaranteed that alternative testing times and/or places will be used for proctored exams for visually impaired and blind students. The discussion then becomes who proctors the exam.

Disability services would have a high knowledge of the disability and know how to address testing. Yet, for more technical fields, one can expect that disability services would be unfamiliar with the meaning and pronunciation of terms [26].

Having the tutor gives the exam allows the continuation of reading agreements so that there is less chance of misunderstanding of the question or answer. Yet, if the tutor acts as the proctor, there is a possibility of excessive helping (whether intentional or not) due to the relationship between the tutor and student [24]

3.2.4 Tutoring, Labs, and Group Work

Blind students were found to have most difficulty with academic situations (i.e. study groups & lab partners)[11] [15]. This is because during normal class activities, a blind student may not be getting the attention he/she needs for understanding [26], or it may simply be impractical [15]. In these cases, alternative events, times, and/or places should be implemented.

3.2.5 Mentoring

Mentoring and the creation of community for blind students is encouraged. Mentors should be successful role models that encourage the student to accept their blindness while explaining societal biases against the blind. In addition, a belief/message that blind students are not that different from their sighted peers should be sought [22]

3.2.6 Note-taking

Whether using one or more tape recorders, a brailler or braille slate, or a laptop, blind and visually impaired students should be encouraged to take their own notes [22]. The difficulty with notes on a computer is that screen reading software may mispronounce technical terms [26]. If necessary, the instructor or a tutor can check the notes for accuracy [19].

If note-taking skills are insufficient, a notetaker can be employed [15]. These notes could be done solo or an addition to the student's own notes.

Vocabulary must also be considered. For print, important terms are in bold, making them easier to find. This becomes a useless distinction in braille or audio formats. Digital formats with hyperlinks allow for easier searching [18].

3.2.7 Mathematics

Like any students, visually impaired students have different approaches to mathematics. For higher level mathematics, there are Some prefer to braille the equations, and do the work by hand. The disadvantage being that braille is written linearly, and increases the difficulty [5].

[11] Quoting Patterson, et al. (1986) and Stoval & Sedlacek (1983)

Others may prefer to do the equations and calculations in their heads, but this will typically require someone else to write down each step to prevent confusion [5].

When tutoring, the tutor and student should have an agreement on how to say an equation to avoid confusion. Further, information should be presented linearly and the identification of patterns in formulas [24].

3.2.8 Visualization

Most illustrations in texts are a side view with the angles, lengths, and/or shading indicating depth. Typically, these are simplified and transformed into tactile images for the blind. But, these tactile graphics may cause more confusion as a blind student compares it to their mental images.

Firstly, blind students do not have no preference for the bottom of the page being the bottom of an image [18]. Therefore, the bottom and top must be identified. Secondly, visualization is from a top-down view, rather than a side-view. Using only one's fingertips, one is unable to identify the image as a whole. This makes spatial illustrations based on angles or lengths irrelevant [18][20].

3.3 Tools

3.3.1 Pegboards

A low-tech solution to binary conversion and mathematics, the use of a pegboard allows a tactile method to identify ones and zeros (one being a peg and zero being no peg) [20].

3.3.2 Amplitude and Frequency Adaption

Using speakers (rather than oscilloscopes) to define amplitude/frequency [20].

3.3.3 WinTriangle

Developed by Science Access Project[12] (Dept. of Physics, Oregon State University), WinTriangle is an opensource word processer developed for the blind [9].

3.3.4 PHANToM

PHANToM is a pen-like device that allows the user to haptically explore a virtual, 3D space [14]

3.3.5 iNetSim

Based on Mac OS X Tiger's VoiceOver, iNetSim makes Cisco labwork/simulations accessible to visually impaired students [2].

[12] http://dots.physics.orst.edu/

3.3.6 Molly Project

The Molly Project[13] is a scripting language to make forms easily in Visual BASIC [11].

References

[1] Martin Agran, Sunggye Hong, and Karen Blankenship. Promoting the self-determination of students with visual impairments: Reducing the gap between knowledge and practice. *Journal of Visual Impairment & Blindness*, pages 453–464, August 2007.

[2] Helen Armstrong and Iain Murray. Remote and local delivery of cisco education for the vision-impaired. In *Proceedings of the 12th annual SIGCSE conference on Innovation and technology in computer science education*, pages 78–81. ACM, 2007. http://0-doi.acm.org.catalog.library.colostate.edu:80/10.1145/1268784.1268809.

[3] Debbie Berkly, Lori Kressin, and Cyril Oberlander. Deploying assistive technology across campus: A collaborative approach. In *Proceedings of the 35th annual ACM SIGUCCS on User Services*, pages 11–15, 2007. http://doi.acm.org/10.1145/1294046.1294050.

[4] Laura Bonetta. Focus on careers: Diversity-opening doors for scientists with disabilities. *Science*, 318(5853):1161–1164, November 2007. http://www.sciencemag.org/cgi/content/short/318/5853/1161.

[5] Mark Brazier, Michelle Parry, and Ephraim Fischbach. Blind students: Facing challenges in a college physics course (leveling the playing field for the visually impaired). *Journal of College Science Teaching*, 30(2):114–116, October 2000.

[6] Sheryl E. Burgstahler and Richard E. Ladner. Increasing the participation of peole with disabilities in computing fields. *Computer*, 40(5):94–97, May 2007. http://ieeexplore.ieee.org/xpl/tocresult.jsp?isnumber=4198228&isYear=2007.

[7] The George Washington University HEATH Resource Center. Students who are blind or visually impaired in postsecondary education. http://www.heath.gwu.edu/node/211.

[8] Anne L. Corn and Robert S. Wall. Access to multimedia presentations for students with visual impairments. *Journal of Visual Impairment & Blindness*, 96(4):197–211, April 2002. http://search.ebscohost.com/login.aspx?direct=true&AuthType=cookie,ip,url,cpid&custid=s4640792&db=aph&AN=6533629&site=ehost-live.

[9] Jessica Ebert. Scientists with disabilities: Access all areas. *Nature*, 435(7042):552–554, June 2005. http://search.ebscohost.com/login.aspx?direct=true&AuthType=cookie,ip,url,cpid&custid=s4640792&db=aph&AN=17230945&site=ehost-live.

[13] http://oldpanther.adelphi.edu/ siegfrir/molly

[10] Pier Luigi Emiliani. Assistive technology (at) versus mainstream technology (mst): The research perspective. *Technology and Disability*, 18:19–29, 2006.

[11] Kenneth G. Franqueiro and Robert M. Siegfried. Designing a scripting language to help the blind program visually. In *Proceedings of the 8th international ACM SIGACCESS conference on Computers and accessibility*, pages 241–242, 2006. http://doi.acm.org/10.1145/1168987.1169035.

[12] Elaine Gerber. The benefits of and barriers to computer use for individuals who are visually impaired. *Journal of Visual Impairment & Blindness*, 97(9):536–550, September 2003.

[13] J. Hope, B. R. von Konsky, I. Murray, L. C. Chew, and B. Farrugia. A cisco education tool accessible to the vision impaired. In *Proceedings of the 8th international ACM SIGACCESS conference on Computers and accessibility*, pages 235–236, 2006. http://doi.acm.org/10.1145/1168987.1169032.

[14] M. Gail Jones, James Minogue, Tom Oppewal, Michelle P. Cook, and Bethany Broadwell. Visualizing without vision at the microscale: Students with visual impairments explore cells with touch. *Journal of Science Education and Technology*, 15(5-6):345–351, December 2006.

[15] Nancy F. Kaplan. *Computer technology, education and disability: Experiences of postsecondary students who are blind or visually impaired.* PhD thesis, New York University (New York), 2006. ProQuest Digital Dissertations database. (Publication No. AAT 3199974). http://0-proquest.umi.com.catalog.library.colostate.edu:80/pqdweb?did=1059998441&sid=2&Fmt=2&clientId=951&RQT=309&VName=PQD.

[16] Gaylen Kapperman and Jodi Sticken. A case for increased training in nemeth code of braille mathematics for teachers of students who are visually impaired. *Journal of Visual Impairment & Blindness*, 97(2):110–112, February 2003. http://search.ebscohost.com/login.aspx?direct=true&AuthType=cookie,ip,url,cpid&custd=s4640792&db=aph&AN=9108852&site=ehost-live.

[17] James H. Mathewson. The visual core of science: definition and applications to education. *International Journal of Science Education*, 27(5):529–548, April 2005. http://search.ebscohost.com/login.aspx?direct=true&AuthType=cookie,ip,url,cpidcustid=s4640792&db=aph&AN=16969134&site=ehost-live.

[18] Provi M. Mayo. *Assessment of the impact chemistry text and figures have on visually impaired students' learning.* PhD thesis, Purdue University (Indiana), 2004. ProQuest Digital Dissertations database. (Publication No. AAT 3166672). http://0-proquest.umi.com.catalog.library.colostate.edu:80/pqdweb?did=888822651&sid=2&Fmt=2&clientId=951&RQT=309&VName=PQD.

[19] Anita M. Meehan and Derrie Hoffert. Strategies and resources for teaching statistics to visually impaired students. *Teaching of Psychology*, 20(4):242–244, December 1993.

http://search.ebscohost.com/login.aspx?direct=true&AuthType=cookie,ip,url,cpid&custid=s4640792&db=aph&AN=9411030145&site=ehost-live.

[20] Iain Murray and Helen Armstrong. A computing education vision for the sight impaired. In *Proceedings of the sixth conference on Australasian computing education*, volume 57, pages 201–206. Australian Computer Society, Inc, 2004. http://0-delivery.acm.org.catalog.library.colostate.edu/10.1145/980000/979995/p201-murray.pdf?key1=979995&key2=4730782021&coll=ACM&dl=ACM&CFID=16161194&CFTOKEN=30205052.

[21] NSF. Panel session: Information on disabilities from the perspectives of graduate students, October 2007. http://www.nsf.gov/od/oia/activities/ceose/mini-symp-pres/Speeches_by_Grad_Stu_Oct_15_2007.pdf.

[22] Denise M. Robinson. *Learning strategies that enable blind students to access education: A Delphi study.* PhD thesis, Capella University (Minnesota), 2006. ProQuest Digital Dissertations database. (Publication No. AAT 3229498). http://0-proquest.umi.com.catalog.library.colostate.edu:80/pqdweb?did=1221706081&sid=1&Fmt=2&clientId=951&RQT=309&VName=PQD.

[23] Robert M. Siegfried. Visual programming and the blind: The challenge and the opportunity. *ACM SIGCSE Bulletin: SESSION: Accessibility*, 38(1):275–278, March 2006. http://0-doi.acm.org.catalog.library.colostate.edu:80/10.1145/1124706.1121427.

[24] Richard Spindler. Teaching mathematics to a student who is blind. *Teaching Mathematics and its applications*, 25(3):120–126, 2006. Interlibrary Loan.

[25] Wendy Strobel, Jennifer Fossa, Sajay Arthanat, and Jennifer Brace. Technology for access to text and graphics for people with visual impairments and blindness in vocational settings. *Journal of Vocational Rehabilitation*, 24(2):87–95, 2006. http://search.ebscohost.com/login.aspx?direct=true&AuthType=cookie,ip,url,cpid&custid=s4640792&db=aph&AN=20237126&site=ehost-live.

[26] Mark D. Womble and Gary R. Walker. Teaching biology to the visually impaired. *Journal of College Science Teaching*, 30(6):394–396, March/April 2001.