Increasing the Representation of People with Disabilities in Science, Engineering, and Mathematics

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Abstract

There are three main factors which cause individuals with disabilities to be under-represented in science, engineering, and mathematics fields: preparation of students with disabilities; access to facilities, programs, and equipment; and acceptance by educators, employers and co-workers. Technology can have a positive affect on all of these factors and help to open doors to new areas of study and employment. This paper explores the role of information technology, describes a campus program designed to positively influence each of the factors, and makes a series of recommendations for action.

Introduction

Access to higher education can enhance the employability and vocational success of individuals with disabilities (DeLoach, 1992; Sampson, 1984). Although the number of individuals with disabilities attending post-secondary institutions is increasing, few pursue academic careers in science and engineering and, for those who do, the attrition rate is high. Individuals with disabilities are also under-represented in science and engineering professions, and scientists and engineers with disabilities experience higher unemployment rates than do other scientists and engineers (Malcom & Matyas, 1991). Nevertheless, the employment rate for scientists and engineers with physical disabilities is much higher than the estimate for the overall U.S. population with physical disabilities. These facts suggest that students with disabilities can find success in science, engineering, and mathematics fields.

Recent advancements in adaptive technology provide efficient, relatively inexpensive access to computers and networks for people with a variety of disabilities (Brown, 1992; Burgstahler, 1992a). As a result, careers that exploit technology are particularly accessible to individuals with disabilities. The increased use of technology in science, engineering and mathematics

combined with the increased availability of access technologies strongly suggest that the time is right to promote the inclusion of people with disabilities in science, engineering and mathematics fields.

Discussion of the Problem

Individuals with disabilities are under-represented in science, engineering, and mathematics educational programs and professions. Causes of this problem can be found in three areas: preparation of students with disabilities; access to facilities, programs, and equipment; and acceptance by educators, employers, and co-workers.

Preparation

For an individual with a disability to experience life to the fullest, independent-living and self-advocacy skills must be developed (Transition summary, 1988). As the end of high school approaches, so does the termination of a structured environment and pre-college support systems (Burns, Armistead, & Keys, 1990). Adolescents with disabilities who wish to attend college are often faced with responsibilities that they are unprepared to meet because they are conditioned to depend on others (Transition summary, 1988). Once enrolled, students with disabilities often hesitate to request the specific accommodations they need (Amsel & Fichten, 1990). The levels and types of resources available to students with disabilities in pre-college programs, on post-secondary campuses, and in employment situations are different and programs to help bridge the gaps between these critical stages are rare.

Students with disabilities are rarely encouraged to prepare for science, engineering and mathematics fields. Since they do not consider a career in science, engineering, or mathematics an achievable goal, they do not take the courses necessary to prepare for post-secondary studies in these areas. High school and college students with disabilities, counselors, social service agency staff, and special education teachers often lack an understanding of the content and requirements of science, engineering, and mathematics programs in higher education and of the technology and other resources that make it possible for students with disabilities to pursue these fields.

Students with disabilities lack access to role models with similar disabilities who are successful in careers that they might otherwise have thought impossible for themselves (Aksamit, Leuenberger, & Morris, 1987; Fonosch & Schwab, 1981). Potential role models are often separated by great distances, leaving individuals with disabilities isolated from those facing similar obstacles in school and work (Brown & Foster, 1990; Moore & Nye, 1986).

To prepare for science, engineering, and mathematics studies, students need to be able to use the powerful tools of the trade at an early age. Although network technology can reduce social isolation and allow independent access to information resources (D'Sousa, 1991), these

tools are not often readily available to pre-college students with disabilities.

Access

Computers, adaptive technology, and network resources can bridge the communication and accessibility gaps for people with disabilities. Electronic communications provide new options for independent access to people and resources. Computer and network access can increase levels of independence and have a positive impact on the academic progress and career success of individuals with disabilities (Coombs, 1991; Burgstahler, 1992a; Burgstahler, 1992b; Horn, Severs, & Shell, 1988). Unfortunately, many individuals with disabilities and people in their primary support systems are unaware of the tremendous contributions technological innovations can make to the lives of individuals with disabilities. Students with disabilities are not guaranteed access to computing and networking technology in pre-college and college programs (Burgstahler, 1992a; Horn & Shell, 1990). Likewise, lab facilities are often inaccessible to students with disabilities.

Those who wish to pursue science and mathematics fields need access to publications in these fields. Scientific and mathematics publications are not readily available in alternative formats for the print-impaired. Making them available in electronic format can assist those who have adaptive technology to produce materials in alternative format, such as large print, however some barriers still exist in making mathematics and scientific symbols accessible to those who are blind. A number of approaches being explored for making materials accessible to individuals with disabilities are reported in other articles in this issue. Universal access to publications will require the creation of new products as well as promotion of the use of existing methods.

Acceptance

A National Science Foundation task force (Changing America, 1989) stated that negative attitudes are the single most significant barrier faced by individuals with disabilities pursuing careers in science and engineering. Faculty and employers lack information about the rights and needs of students with disabilities and their potential contributions to society; they often have negative attitudes about including students with disabilities in academic programs and employment. Professors are particularly reluctant to include students with learning disabilities (Leyser, 1990) and have little knowledge of the characteristics and needs of students with this type of disability (Akamit et al.; Dodd, Fischer, Hermanson, & Nelson, 1990). Faculty in science, engineering, and mathematics are less accepting than those in social sciences and education (Fonosch & Schwab, 1981). However, faculty attitudes have been found to be more positive when faculty members have previous contact and more information about students with disabilities (Aksamit et al., 1987; Fonosch & Schwab, 1981; Sedlacek & Stovall, 1983).

The Role of Information Technology

Information technology plays a key role in the three areas addressed in this paper. In order for students with disabilities to prepare for careers in science, engineering, and mathematics fields they must begin to use computing and networking tools at a young age. These tools can help them access resources, communicate with others, and perform academic tasks independently. The importance of the availability of adaptive technologies for individuals with disabilities cannot be over-estimated. Such tools are required if individuals with disabilities are to compete with their non-disabled peers. For all students and employees, the ability to perform tasks efficiently and professionally can earn the respect of educators, employers, and peers alike. The ability to control powerful technological tools can thus contribute to the acceptance of a person with a disability as an equal partner in learning and working situations.

One University's Efforts

At the University of Washington (UW), a project is working to increase the participation of individuals with disabilities in science, engineering, and mathematics programs and careers. DO-IT (Disabilities, Opportunities, Internetworking, and Technology) began in 1992 and is primarily funded by the National Science Foundation. Below, some of the DO-IT activities that address the areas of preparation, access, and acceptance are discussed.

Preparation

The DO-IT Scholars program offers students with disabilities, beginning in their Sophomore or Junior year of high school, opportunities to study science, engineering, and mathematics; experience campus living; develop self-advocacy skills; interact with mentors; and use technology to pursue academic interests.

Internetworking. DO-IT Scholars learn to use computers and the Internet to explore academic and career interests. Computer and adaptive technologies are selected for each participant; local Internet connections are established; and in-home training is provided. One Scholar who is blind reports, "Getting access to the Internet was the best thing that ever happened to me. In a way, my computer and access to the net have become my eyes to the world." A DO-IT industry partner reports, "Network communication is a liberating experience for many of these kids, since their disabilities aren't visible in their email. They have been quick to exploit the technology, both to communicate among themselves and also to explore worlds that were previously inaccessible to them." A parent points out that too often, without a special program like DO-IT, students with disabilities have "inferior and inadequate equipment and if they can get the right technology there is nothing that can stop them in what they want to do with their lives."

Mentoring. Through electronic communications and personal meetings, DO-IT Scholars are

brought together with post-secondary student and career Mentors to facilitate academic, career, and personal achievements. DO-IT Mentors study and/or work in a variety of fields including computer programming, post-secondary education, statistics, physics, engineering, computer science, computer consulting, and biology. One Scholar describes mentors as people who "provide us with useful contacts in academics, career, and personal areas ... They help participants find their talents, interests, and confirm their goals." Experienced Scholars practice communication and leadership skills as peer Mentors for new Scholars. Scholars and Mentors are encouraged to reach out and help others. For example, they communicate with patients at a children's hospital through an electronic mail account established at the hospital through DO-IT. A parent reports that her son, a Scholar with attention deficit disorder, "has already passed on some of what he got to another ADD child, by taking a boy to register for high school and showing him around so he will know where things are the first day of class."

Summer Study. During live-in programs held during two consecutive summers at the University of Washington, each Scholar studies science, engineering, and mathematics by participating in lectures and labs and using computer applications and the Internet network. Subjects include oceanography; heart surgery; chemistry; virtual reality; geophysics; material sciences, civil, mechanical and electrical engineering; mathematics; biology; physics, and astronomy. Accommodations are made in each activity to ensure that all participants remain as active as possible. In the words of Scholars after attending a summer program, "I'm excited about many different careers I could go into," and, "I learned what college life is all about." A mother of one of the Scholars pointed out how the summer study program boosted her son's "belief in himself and his abilities...This experience has changed the course of his life." Scholars learn self-advocacy skills as part of the summer curriculum. One parent reported her son's plans to "talk to the math department head about challenging the math class he has been put into ... He says it's too easy and he wants a more difficult class where he can learn something new. He is not asking for me to help. He has the courage to go and work on this on his own. Him being his own advocate has been coming, but this jump in ability is a direct result of the DO-IT experience." After observing two summer programs, a corporate partner noted, "We repeatedly hear the comment that these kids have never experienced a situation like this before - where the focus is on their abilities (rather than their disabilities) and yet everyone else has their own challenges to overcome. The combination seems to produce an almost immediate sense of community and an extremely supportive intellectual environment."

Special Projects and Events. Throughout their involvement in DO-IT, Scholars have opportunities to pursue projects of special interest, using Mentors and staff as resources. Options include collecting scientific resources, administrating systems, editing the newsletter, teaching in the summer program, and helping with other DO-IT events. DO-IT Scholars as well as other pre-college and college students with disabilities and their families, teachers, counselors, and service providers are invited to participate in special events, including the

UW Computer Fair booth, presentation and reception; the UW Engineering Open House; and the UW Health Sciences Open House. Events generate a lot of interest and often attract children with disabilities and their parents who, after meeting DO-IT Scholars and Mentors, are encouraged to use technology and to pursue science, engineering, and mathematics interests.

It is too early to measure the ultimate impact of the DO-IT project, but evidence has begun to appear in the many successes of the DO-IT Scholars so far. Four DO-IT Scholars graduated from high school in 1994 and are pursuing college programs in genetics, computer programming, electrical engineering, and general studies in preparation for more advanced studies in science. One Scholar won a NASA Space Grant four-year scholarship to the University of Washington; she became aware of the scholarship program during a DO-IT summer study session. A DO-IT Scholar won an honor for his essay about the Internet in a national contest sponsored by the National Science Foundation, National Center for Education Statistics, and NASA; he was invited to speak at the Washington State Governor's Technology Conference. Two participants worked with a Mentor to organize a field trip for Scholars and other students with disabilities to Battelle Pacific Northwest Laboratories in Richland, Washington; one earned a paid summer internship at the Labs. DO-IT Scholars have appeared on local television and radio shows and in conference presentations. One Scholar is working part-time at Microsoft and in the Adaptive Technology Lab at the University of Washington. A DO-IT Scholar is now the editor of DO-IT News, the project newsletter. DO-IT Scholars and Mentors have formed the nucleus of an electronic community of people who share both a love of science, engineering, and mathematics, and the challenges of a disability. DO-IT sponsors one-day college transition workshops and adaptive technology seminars open to on- and off-campus individuals with disabilities, families, service providers and educators. These programs extend the impact of the DO-IT project to a large audience, helping more students with disabilities transition and adjust to college life and make effective use of information technologies. Plans are underway to teach day camps on the use of computers and the Internet to young children; most of the instruction will be done by experienced Scholars.

Involvement of corporate sponsors in DO-IT Scholar activities is expected to pay off in terms of more accessible workplaces for individuals with disabilities. A Microsoft representative states, "I sincerely hope and expect to someday count DO-IT graduates among my colleagues at Microsoft." For Battelle Pacific Northwest Laboratories, involvement in the DO-IT project has "provided a way for our staff scientists and educators to learn first hand what we can do to ensure that our working environment welcomes students of diversity, including those with disabilities. The overarching goal of our participation is to enrich science and technology by opening the door to a diverse, highly talented work force. We consider ourselves a partner with the University of Washington in the DO-IT program. Through DO-IT, we have been able to link students to our scientists via Internet, provide opportunities for scientists to interact in

person with disabled students including hosting DO-IT Students for a tour of our laboratories, and provide a summer internship for a selected DO-IT student."

Access and Acceptance

DO-IT works to create a barrier-free campus for students with disabilities, particularly in the academic areas of science, engineering, and mathematics. The latest adaptive technologies are available in convenient locations. Students with disabilities were surveyed to access the barriers they have faced and plans are underway to survey computer and science labs to pinpoint accessibility problems, recommend solutions, and implement recommendations.

The most effective way DO-IT improves access and attitudes towards students with disabilities is to invite University faculty to teach in the summer study program for DO-IT Scholars. Staff provide assistance in making presentations and labs accessible to all Scholars. Without exception, instructors come away with a positive impression of the capabilities of students with disabilities and a better understanding of access requirements.

Disability awareness presentations are delivered regularly to faculty. These programs reach a wide audience and increase awareness of the potential of students with disabilities, improve attitudes towards students with disabilities, and provide creative and practical approaches for ensuring access to educational opportunities. A short videotape, funded by U.S. West Communications, introduces viewers to faculty and post-secondary students with disabilities demonstrating successful techniques that allow full participation in academic programs and careers. NEC Foundation of America has assisted with nation-wide distribution of the videotape and accompanying presentation materials. Plans are underway to adapt the model used for faculty to similar presentations for pre-college educators and employers.

Electronic tools on the Internet allow DO-IT participants, mentors and staff to reach a large and growing audience of thousands world-wide. Electronic discussion lists and a gopher server deliver program and disability-related information and facilitate communication on issues related to participation of individuals with disabilities in science, engineering, and mathematics. Printed materials also promote the inclusion of individuals with disabilities in science, engineering, and mathematics fields and promote the use of access technologies to level the playing field for individuals with disabilities in the information age.

In summary, DO-IT helps students with disabilities transition to post-secondary studies and careers in science, engineering, and mathematics and creates a positive and accessible learning environment for students with disabilities programs. The long-term outcome of projects like DO-IT will be to increase the number of individuals with disabilities in science, engineering, and mathematics professions.

Recommendations and Conclusion

A review of the literature and of the experiences at the University of Washington lead to several recommendations to promote the inclusion of people with disabilities in science, engineering, and mathematics academic programs and careers.

Preparation

To help students with disabilities become prepared to pursue these fields efforts should be undertaken to:

- Help people with disabilities develop independent-living and self-advocacy skills and facilitate transitions to college and employment.
- Encourage students with disabilities to take mathematics and science classes in high school and college so that they can pursue careers in science, engineering, and mathematics.
- Establish positive, motivational, and lasting interactions between disabled high school and college students and practicing engineers and scientists who have disabilities.
- Make sure students with disabilities begin to use computers, electronic communications, and network resources to increase their independence in pursuing academic studies at an early age.

Access

To improve access to science, engineering and mathematics fields we must:

- Make facilities, computers, science equipment, and programs accessible to people with a variety of disabilities.
- Assure that scientific and mathematics publications are readily available in appropriate alternative formats.

Acceptance

In order to create a positive environment for learning and working, efforts should be undertaken to:

- Increase the awareness of pre-college and college educators regarding the potential contributions and accommodation needs of people with disabilities.
- Help employers and co-workers appreciate the potential contributions of people with disabilities and create a flexible work environment where productivity can be maximized.

In all of these efforts successful individuals with disabilities should be given opportunities to share the specialized expertise they have developed through their own personal experiences. Individuals with disabilities can be empowered with opportunities to apply their skills in efforts to promote the participation of other individuals with disabilities in science, engineering, and mathematics academic programs and careers.

We must continue to increase the understanding of factors affecting the under-representation of individuals with disabilities, implement creative programs to address problems, and share successful practices. Many small steps taken locally can, together, create a substantial impact and move us closer to a shared vision where people with disabilities have equal access to opportunities in science, engineering, and mathematics.

More information about DO-IT [1]

Read the *AccessSTEM* Student-Centered Community Building Model [2] to learn more about this work.

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- [1] https://www.washington.edu/doit/about/contact-us
- [2] https://www.washington.edu/doit/accessstem-student-centered-community-building-model
- [3] http://staff.washington.edu/sherylb/
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- [5] http://creativecommons.org/licenses/by-nc-sa/3.0/
- [6] http://www.washington.edu/online/privacy/
- [7] http://www.washington.edu/online/terms