Article

Broadening Participation by Including More Individuals With Disabilities in STEM: Promising Practices from an Engineering Research Center

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Abstract

This article describes successful practices for including individuals with disabilities (e.g., leaders, students, faculty researchers, advisory board members) in the Center for Sensorimotor Neural Engineering (CSNE), an Engineering Research Center funded by the National Science Foundation. The methods, tools, and materials presented in this article can be used by others seeking to increase the inclusion of individuals with disabilities in postsecondary science, technology, engineering, and mathematics (STEM) programs. Methods are employed to ensure that the CSNE is welcoming and accessible to individuals with a wide range of abilities and to recruit individuals with disabilities into significant roles that support the Center's mission. These efforts have resulted in the engagement of individuals with disabilities in the Center's operations, activities, and research at a higher rate when compared with all Engineering Research Centers.

Keywords

broadening participation, engineering, disability, diversity, universal design

Introduction

Passage of specifying legislation has contributed to considerable interest in the accessibility of higher education programs and offerings. Particularly notable legislation includes Section 504 of the Rehabilitation Act of 1973, the Americans with Disabilities

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Act of 1990 and subsequent amendments, and the 2008 Higher Education Opportunity Act. Section 504 of the Rehabilitation Act of 1973 states that

> No otherwise qualified individual with a disability in the United States . . . shall, solely by reason of her or his disability, be excluded from the participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving federal financial assistance or under any program or activity conducted by any executive agency . . .

Almost all postsecondary institutions receive some federal funding and therefore are covered by this law. The Americans with Disabilities Act imposes similar requirements on private and public schools, regardless of whether or not they receive federal funds.

In the United States, the shortage of well-trained professionals in science and engineering fields is due in part to the underrepresentation of specific groups, such as racial and ethnic minorities, women, and people with disabilities (Division of Science Resources Statistics, 2011; National Science Board, 2015). Specifically, individuals with disabilities experience a lower level of career success when compared with their nondisabled peers and are less likely to complete a college education (Bureau of Labor Statistics, 2015; Newman et al., 2010). Barriers to supporting students with disabilities cited by institutions include limited staff resources to provide faculty and staff training on accessibility issues, costs associated with purchasing appropriate technology, and competing institutional priorities (Raue & Lewis, 2011). Although there are relatively fewer individuals with disabilities succeeding in science and engineering fields (Bureau of Labor Statistics, 2015), their success stories demonstrate what is possible (Bellman & Burgstahler, 2016; Disabilities, Opportunities, Internetworking, and Technology [DO-IT], 2015).

This article describes successful practices for including individuals with disabilities in the Center for Sensorimotor Neural Engineering (CSNE), an Engineering Research Center funded by the National Science Foundation. The efforts described in this article have resulted in the engagement of individuals with disabilities in the Center's operations, activities, and research at a much higher rate when compared with all Engineering Research Centers. The strategies presented in this article can be used by others seeking to increase the inclusion of individuals with disabilities in science, technology, engineering, and mathematics (STEM) programs.

Methods: Activities to Engage Individuals With Disabilities at the CSNE

Based at the University of Washington, the CSNE seeks to develop innovative ways to connect a deep computational understanding of how the brain adapts and processes information with the design of implantable devices that interact seamlessly with the nervous system. Participants who have taken part in the activities described in this article include postsecondary students as well as CSNE staff, faculty, and advisory board members.

Table 1. Center for Sensorimotor Neural Engineering (CSNE) Promising Practices to Engage Individuals With Disabilities.

Recruitment and engagement
   Building strategic partnerships
   Recruiting individuals with disabilities onto advisory boards and leadership teams
   Providing research experiences
   Reaching out to potential veteran participants and contributors
   Providing hands-on labs to students with disabilities
Communication
   Highlighting the achievements of people with disabilities
   Creating images for use on promotional materials
   Sending faculty to disability-related conferences
   Sharing inclusion practices at national conferences
   Exploring ethical issues related to people with disabilities
   Using social media and an online blog
Facility, information technology, and product accessibility
   CSNE headquarters facility design consultation
   Lab consultations
   Conducting website accessibility reviews
   Making documents and products accessible
Cultivating a climate of inclusion
   Applying universal design strategies
   Promoting work-based learning to students with disabilities
   Providing accommodations and supporting faculty
   Embracing disability as an aspect of diversity
   Mentoring individuals with disabilities
   Building disability-related components into grant proposals
   Seeking additional funding for disability-related efforts
Strategies for data collection and evaluation
   Creating center-wide correspondence
   Considering demographic questions in program applications
   Engaging in outreach during annual reporting cycle
   Evaluating the effectiveness of programs for people with disabilities
   Using a common assessment tool

The CSNE developed and met a goal to engage at least 20 individuals with disabilities in significant roles within the first 5 years of operation. To meet this goal, the CSNE engaged people with disabilities as research interns, advisory board members, leaders, support staff, faculty researchers, and officers in a student leadership council. An additional 120 individuals with disabilities engaged in Center offerings through outreach activities and as mentees. Specific activities that contributed to the success of CSNE's engagement of people with disabilities are listed in Table 1. A brief description of each activity follows.

Recruitment and Engagement

Strategic Partnerships. CSNE staff members work with the offices at Center institutions that serve students with disabilities. Typically, these offices help arrange academic accommodations for students with disabilities and help ensure their equal access to the campus. At CSNE institutions, disability services offices are regularly contacted about CSNE offerings such as workshops, seminars, and summer research opportunities.

Recruiting Individuals With Disabilities Onto Advisory Boards. Members of the CSNE community work at recruiting individuals with disabilities onto advisory boards, where they have key roles such as helping define the direction of the research and identifying funding sources and collaborators. These individuals bring a unique perspective to the Center as well as knowledge about accessible facilities, alternative ways of using technology, and how individuals with disabilities use products.

Providing Research Experiences. The CSNE promotes summer research programs to students with disabilities. Staff members visit local high schools to speak with special education instructors and "504 coordinators" about the CSNE's Young Scholars Program (csne-erc.org/content/young-scholars-program). Undergraduate students with disabilities are recruited through postsecondary disability services offices nationwide.

Reaching Out to Potential Veteran Participants and Contributors. Veterans of the United States armed forces represent a unique group of individuals who can contribute greatly to engineering projects. Veteran students' presence on college campuses is on the rise: during the first 10 years of the post-9/11 G.I. bill, more than 924,000 veterans had used the benefits (Lang & Powers, 2011). Many veteran students also have disabilities. In 2013, an estimated 21% of the roughly 10 million noninstitutionalized civilian veterans aged 21 to 64 years reported having a service-connected disability (Erickson, Lee, & von Schrader, 2015). The CSNE coordinates a successful Research Experiences for Veterans program now in its fifth year (www.csne-erc.org/content/veterans).

Providing Hands-on Labs to Students With Disabilities. Through partnerships with local schools, the CSNE has hosted more than 120 youth with disabilities in neuroscience and neural engineering awareness activities, raising interest in additional offerings such as CSNE summer programs.

Communication

Highlighting the Achievements of People With Disabilities. CSNE community members regularly look for opportunities to highlight the achievements of participants with disabilities. For example, in a video produced by the CSNE, a summer program participant talks about her research and her disability (www.youtube.com/watch?v=MvaELcQ8aY0).

Creating Images for Use on Promotional Materials. When hosting individuals with disabilities during outreach activities and summer programs, CSNE staff members photograph a wide variety of students in action, including those with disabilities. Such images are used in promotional materials and web pages, which sends a message that individuals with disabilities are actively involved and are welcome at the Center.

Sending Faculty to Disability-Related Conferences. The CSNE education and diversity team looks for opportunities to send faculty and others to disability-related conferences. For example, one faculty member at a CSNE partner campus was provided funding to attend the California State University Northridge's *Annual International Technology and Persons with Disabilities Conference*.

Sharing Inclusion Practices at National Conferences. In 2014, the CSNE executive director and diversity manager presented a session at a national conference in Seattle, WA, called "Promoting the Successful Participation of People with Disabilities in STEM" (www.uw.edu/doit/promoting-successful-participation-people-disabilities-stem-2014). The session focused on some of the practices shared in this article. Such participation is intended to increase interest and engagement in CSNE programs among individuals with disabilities.

Exploring Ethical Issues Related to People With Disabilities. Staff members have implemented activities to explore the ethical issues of engineering research as they relate to individuals with disabilities. For example, the CSNE hosted the Seattle premiere of a movie called "FIXED: The Science/Fiction of Human Enhancement" (www.fixedthemovie.com), an award-winning documentary that explores the social impact of human augmentation. A post-screening discussion included individuals with disabilities as panel members. The authors acknowledge that not all organizations have a direct connection to issues of importance to the disabled community. However, when new technologies are engineered, it is important to ensure that individuals with disabilities are able to use those technologies effectively and have a voice in their development.

Using Social Media and an Online Blog. The CSNE blog and social media accounts are used to promote disability-related events and increase awareness about the inclusion of people with disabilities. A post in the CSNE *Engage and Enable* blog called "Lawyer, cyclist and person with a spinal cord injury" (csne-erc.org/engage-enable/post/lawyer-cyclist-and-person-spinal-cord-injury) describes a "End User Round Table" discussion that explored the concerns and interests of an individual with a spinal cord injury as they relate to the CSNE's engineering ambitions. Another blog post called "*Kayla Brown, disability activist, looking for allies in the scientific community*" (csne-erc.org/engage-enable/post/kayla-brown-disability-activist-looking-allies-scientific-community) shared information about disability culture, disability identity, and engineering principles.

Facility, Information Technology, and Product Accessibility

CSNE Headquarters Facility Design Consultation. Several students with disabilities participated in the design phase of the CSNE headquarters. They toured the facility under construction and met with members of the design team. Students talked with architects about floor surfaces, location of door opener buttons, maneuvering in tight spaces, and other aspects of disability-friendly design. Many of their suggestions were implemented in the final design of the Center.

Lab Consultations. Members of the CSNE are invited to participate in accessibility reviews of lab spaces. For example, during the summer of 2015, four CSNE students and one researcher conducted an accessibility review of the University of Washington (UW) "CoMotion Makerspace" facility. An article published in UW Today shared findings broadly (www.washington.edu/news/2015/08/05/how-makerspaces-can-be-accessible-to-people-with-disabilities/). In January 2016, a group of ERC student leaders conducted an accessibility review of the University of Washington Bio-Robotics Lab. Tools and methods for conducting accessibility reviews are offered in the Resources section of this article.

Conducting Website Accessibility Reviews. It is important that individuals with disabilities can access the Center's web offerings as easily and effectively as those without disabilities. To that end, the CSNE website is regularly reviewed, using the Web Accessibility Content Guidelines 2.0, published by the World Wide Web Consortium (Web Content Accessibility Guidelines, 2016).

Making Documents and Products Accessible. CSNE staff members regularly explore the accessibility of documents and products so that individuals with disabilities have equal access to the content. When PDF files are created for promoting summer programs, or when curricula materials are published, the files are converted into accessible documents (e.g., images are labeled, keyboard navigation is clarified, header items are labeled).

Cultivating a Climate of Inclusion

Applying Universal Design Strategies. The term *universal design* was put forth by the architect Ronald Mace, who challenged the conventional approach of designing for the average user and described an approach for more accessible and usable products and environments (Story, Mueller, & Mace, 1998). The DO-IT Center has developed numerous resources to promote universal design in science and engineering, including the Center for Universal Design in Education (www.uw.edu/doit/programs/center-universal-design-education/overview), Equal Access: Universal Design of Engineering Departments (www.uw.edu/doit/equal-access-universal-design-engineering-departments), and Equal Access: Universal Design of Engineering Labs (www.washington.edu/doit/equal-access-universal-design-engineering-labs). The CSNE seeks to employ concepts of universal design in courses, labs, activities, and other offerings.

Promoting Work-Based Learning to Students With Disabilities. Work-based learning helps students with disabilities develop critical skills. An article called *Promoting work-based learning to students with disabilities: A case study of University of Washington projects* (Bellman, Burgstahler, & Ladner, 2014) describes activities to recruit industry partners and promote success for students with disabilities in work experiences. The CSNE employs many of the practices described in the article as it connects students to industry partners.

Providing Accommodations and Supporting Faculty. The CSNE's success in engaging individuals with disabilities reinforces the idea that STEM departments should be ready to support students, faculty, and staff with disabilities. They should know about and engage resources on campus such as the office that provides academic accommodations and campus access.

Embracing Disability as an Aspect of Diversity. Disability is all around us—a ubiquitous component of human diversity—yet when it comes to campus and workplace diversity-inclusion efforts, its importance often lags behind race, ethnicity, gender, sexual orientation, and socioeconomic status. Although the disability rights movement has its own history, individuals with disabilities face many challenges that are common to other underrepresented groups such as lack of role models on campus, others' minimal understanding of disability culture and identity, and experiences of stereotype threat and implicit bias. Allies of the disability community in postsecondary environments can inform others about these issues and create opportunities for learning.

Mentoring Individuals With Disabilities. The CSNE provides opportunities for individuals with disabilities to receive mentoring, where participants are encouraged to learn science (attraction), choose to keep learning mathematics and science (retention), graduate (persistence), and continue into STEM careers (attachment). Mentoring is provided through electronic communities, at events, one-to-one meetings, and within lab settings.

Building Disability-Related Initiatives Into Grant Proposals. Writing activities to support individuals with disabilities into grant proposals highlights initiatives that might need to be considered in the project budget, informs collaborators that disability inclusion will be part of day-to-day operations, shows funding agencies that disability inclusion is important to the grant-seeking team, and explicitly demonstrates to individuals with disabilities that project leaders are interested in their participation.

Seeking Additional Funding for Disability-Related Efforts. Opportunities to seek additional funding for disability-related efforts are often available. At the CSNE, supplemental funding from the National Science Foundation (NSF) allowed the creation and growth of the Research Experiences for Veterans program discussed earlier. Supplemental funding also supported *AccessERC*, a project to help other NSF-funded ERCs engage people with disabilities, described below in the Resources section of this article.

Strategies for Data Collection and Evaluation

Creating Center-Wide Correspondence. CSNE staff members promote the inclusion of people with disabilities through Center-wide communication. For example, the diversity team delivers presentations about disability inclusion annually at "all-CSNE retreat" events. Another activity, informally referred to as the "October Letter," invites the CSNE community to recruit individuals with disabilities into center offerings in recognition of Disability Employment Awareness Month in October. The email message in 2016, with the subject line "Embracing Disability at the CSNE," included a proclamation from then U.S. President Barack Obama about the great potential of individuals with disabilities in the work place.

Considering demographic Questions in Program Applications. The following statement appears on CSNE program applications:

> Information you choose to provide about your race/ethnicity, disability status, age, or national origin is optional and will remain confidential. This information is, however, valuable to us and to the NSF in tracking participation of various groups in NSF-funded programs.

All applicants are asked "Will you need any accommodations to participate in laboratory or classroom activities?" The data collected are not shared with the team evaluating applications. Rather, the data are used later to explore how students identify themselves and how best to support them.

Engaging in Outreach During Annual Reporting Cycle. Each winter, a centralized, program-level data collection system called ERCWeb solicits data from all ERCs. During this time, it is important that individuals with disabilities disclose disabilities to the NSF, if they are comfortable doing so, as the ERCWeb system uses the demographics collected to generate data that speak to each ERC's diversity goals. Recognizing this, CSNE staff members contact individuals with known disabilities to ask if they will be contributing data to the system and answer questions about how the ERCWeb system functions.

Evaluating the Effectiveness of Programs for People With Disabilities. CSNE staff members recognize the importance of evaluating the effectiveness of programs and activities. For outreach directed at individuals with disabilities, specific questions can be administered to gauge effectiveness. For example, in a postactivity survey of a CSNE learning lab for 25 students with disabilities, 92% of the students stated that activities like the CSNE learning lab could motivate youth with disabilities to pursue science and engineering fields.

Using A Common Assessment Tool. The CSNE has worked closely with project evaluators to develop a "common assessment tool" to evaluate effectiveness. The tool can be used by CSNE staff at partner institutions for a wide variety of activities. The tool,
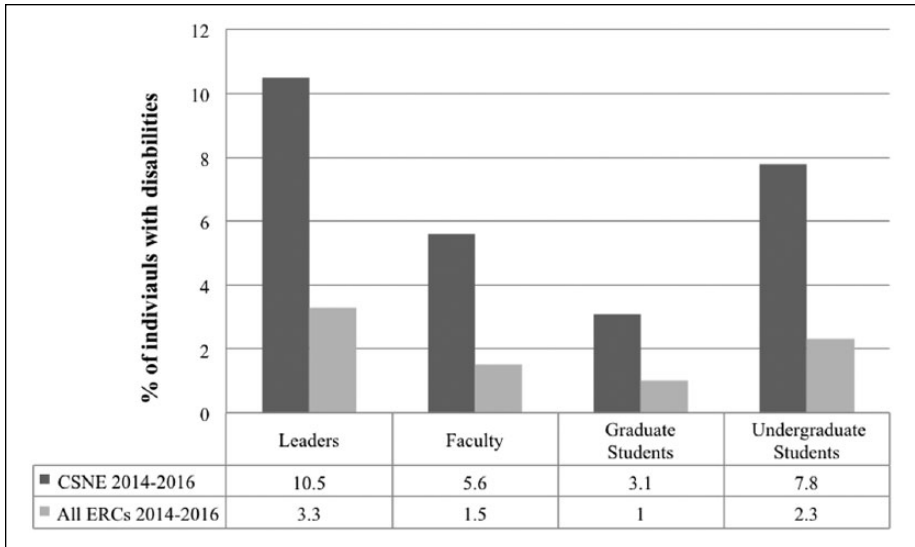
Figure 1. Individuals with disabilities by role. Center for Sensorimotor Neural Engineering (CSNE) compared with all Engineering Research Centers (ERCs) (2014-2016).

which includes questions about disability, allows evaluators to compare the experiences *across institutions* of participants who disclose disabilities to those who do not.

Results

Although it is noteworthy that all students with disabilities who have engaged in CSNE research are continuing their pursuit of STEM fields at postsecondary institutions, and individuals with disabilities associated with the Center have remained active and engaged in Center activities for more than 6 years, staff members at the CSNE look at two baseline data sets with which to compare progress:

1. *National data.* There are national data that describe the percentage of individuals with disabilities represented within institutions of higher education and specifically within engineering fields. It is estimated that students with disabilities represent about 11% of the undergraduate population of postsecondary institutions (U.S. Department of Education, 2015). It is further estimated that about 4% of undergraduate students with disabilities on postsecondary campuses are pursuing engineering (U.S. Department of Education, 2015).
2. *Data from similar NSF-funded projects.* The NSF provides information through its "ERCWeb" centralized data collection system about the percentage of individuals with disabilities represented in NSF-funded Engineering Research Centers, summarized in Figure 1 and Table 2. Data demonstrate that the CSNE

Table 2. Percentage of Individuals With Disabilities Participating on Teams.

	Leadership team	Faculty	Graduate students	Undergraduate students
All ERCs 2016	2.2	0.8	1.0	1.7
All ERCs 2015	4.3	1.8	1.3	2.0
All ERCs 2014	3.3	2.0	0.9	3.3
CSNE 2016	7.7	7.1	2.4	4.0
CSNE 2015	7.1	5.1	2.6	12.8
CSNE 2014	16.7	4.7	4.4	6.6

Note. CSNE = Center for Sensorimotor Neural Engineering; ERC = Engineering Research Center. Data from NSF ERCWeb System, 2014-2016.

is exceeding other ERCs in the engagement of individuals with disabilities in all areas measured by the ERCWeb system.

Discussion: Implications and Portability

The implementation of strategies highlighted in this article can help address the shortage of well-trained professionals in science and engineering fields and help address the lower level of college completion and career success for individuals with disabilities when compared with their nondisabled peers. A variety of tools, freely available to the public, designed to facilitate the full inclusion of individuals with disabilities in STEM, are listed in the appendix.

Appendix

The publications *Equal Access: Universal Design of Engineering Departments* (www.uw.edu/doit/equal-access-universal-design-engineering-departments) and *Equal Access: Universal Design of Engineering Labs* (www.uw.edu/doit/equal-access-universal-design-engineering-labs) are designed for staff and faculty, and delivered as a checklist of critical accessibility considerations. The following resources may also benefit those who wish to employ practices described in this article.

AccessERC Website

DO-IT's NSF-funded *AccessERC* project (www.washington.edu/doit/programs/accesserc) works to increase the participation of people with disabilities in NSF-funded ERCs.

AccessEngineering Website

DO-IT's NSF-funded *AccessEngineering* project (www.washington.edu/doit/programs/accessengineering/overview) increases the participation of people with disabilities in engineering academic programs and careers.

STEM Educators Community of Practice

The STEM Educators Community of Practice (www.uw.edu/doit/resources/communities-practice#stem) is comprised of K-12 and postsecondary educators and administrators interested in promoting the success of students with disabilities in STEM.

The AccessSTEM Knowledge Base

The *AccessSTEM* Knowledge Base (www.uw.edu/doit/programs/accessstem/knowledge-base) contains more than 700 case studies, promising practices, and Q&As regarding accessibility of technology, college, graduate school, and careers for individuals with disabilities.

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Author Biographies

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