The Status of Persons with Disabilities in the Geosciences

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In *Land of Plenty*, the Congressional Commission on the Advancement of Women and Minorities in Science, Engineering, and Technology Development urges "drastic steps" to increase the proportion of women, minorities, and persons with disabilities in science and engineering fields. Unless the science, technology, engineering, and mathematics (STEM) workforce reflects the increasing diversity of the general population, the U.S. demographic shift predicted for the coming decades will lead to a shortage of skilled workers in these fields. The Commission recommends increasing the number of women, minorities, and persons with disabilities who are prepared to enter the STEM workforce, improving the retention and reentry of women, minorities, and persons with disabilities in STEM education and careers, and broadening access to precollege education that prepares students for careers in STEM.

Nearly twenty percent of the U.S. population has a disability (U.S. Bureau of the Census, 2000). For persons aged 16-64, 18.6% have a disability and 12%—nearly 22 million people—report that a disability affects their employment. Among college students, 10.6% report having a disability (NCES, 1999); furthermore, 19% of undergraduates with disabilities are African American, Hispanic American, Asian American, or Native American (AAAS, 2002). Despite this, persons with disabilities account for only 7% of the science and engineering workforce (NSF, 2004).

Statistical data on the participation of persons with disabilities in geoscience education and careers is limited and insufficient for the analysis of trends (Czujko and Henly, 2003), but the available data indicate very low participation rates relative to other sciences and engineering. In 2001, only 2.4% of the doctorate recipients in the geosciences had a disability (NSF, 2004). Of a total undergraduate geoscience enrollment of 32,932 in 1995-96, only 59 students with disabilities, or 0.17 %, were reported (unpublished, American Geological Institute). Since nearly 11% of the total undergraduate enrollment comprises students with disabilities, there appears to be a large pool of students that the geoscience disciplines are not reaching.

What is the status of geoscience education for persons with disabilities?

The National Science Foundation defines the geosciences to include geology, geophysics, meteorology, atmospheric science, oceanography, soil science, planetary science, and environmental science. There are many examples of successful geoscientists with disabilities, from field geologists who use a wheelchair to biochemists and marine biologists who are blind. Yet, persons with disabilities such as visual and mobility impairments may face a number of challenges in these disciplines because of the emphasis on field research and visualizations at the undergraduate level. Of equal importance to the physical challenges are the attitudinal barriers, which are likely to play

a major role when students are choosing a field of study. One of the most effective ways to encourage students with disabilities to pursue science is to change the attitudes and behavior of teachers (McCann, 1998; Weisgerber, 1990). Unfortunately, the traditional focus on field work has led to the perception among some faculty and many students that geoscience careers are only for the strong and "able-bodied."

During the past five years there has been a growing interest in the status of persons with disabilities in the geosciences. Special sessions on students with disabilities were held at the Geological Society of America annual meeting in 1999 and 2003, and the 2004 Call for Abstracts included three separate proposed sessions on teaching geology to students with disabilities. Prior to 2000, very few institutions or programs developed comprehensive strategies for inclusion of persons with disabilities in the geosciences (see Cooke et al., 1997; Schaefer and Ragan, 1999; Skouge et al., 2000 for exceptions). Instead, strategies for accommodating students with disabilities were typically developed for the specific cases when a student with a disability enrolled in a geology course (e.g. Davis, 1990; McManus, 1999; Ross and Willis, 1999). The recent shift suggests an increased understanding among geoscientists of the importance of responding to the needs of all students in a more comprehensive manner.

The experiences of geoscience educators who have worked with students with disabilities in the classroom or field have led to a variety of specific accommodations for overcoming visual and mobility barriers in geosciences courses (Cooke et al., 1997; Grogger, 1999; Ross and Willis, 1999; Asher, 2001; Klemm et al., 2001; Owens and Lambert, 2003; Doyle et al., 2005). Of equal importance, the limitations of the adaptations have spawned the development of new programs that use a comprehensive approach to enhance participation of students with disabilities in the geosciences. These include the University of Arkansas at Little Rock's initiative to infuse universal design principles into the geosciences (Thornton, 2003; Williams et al., 2003), the University of Southern Maine's programs targeting high school earth science students with disabilities and their teachers (Cohen et al., 2003; Locke and Cohen, 2003), and Wright State University's CLASS workshops for science teachers and students (Orozi and Brame, 2003).

Given the nation's goal to include all students with disabilities in science education, and the need for the geosciences to reach a broader talent base, the timing is ideal for the community to mobilize an effort to assess and improve the status of persons with disabilities in the geosciences. Today's geoscientists may work in the field, in a laboratory, or on a computer—barriers to a career should not occur in introductory level classes. Moreover, once a student advances beyond introductory level college courses, the sophisticated instrumentation and automation of many types of analysis improves accessibility of the curriculum, facilitating success by all students. Geoscience educators can best serve students with disabilities if they have access to information about effective teaching strategies, available instructional resources, and the range of career options. Recommendations for effective programs, policies, and practices should be informed by research concerning the learning challenges inherent to the geosciences.

Why is participation in the geosciences among students with disabilities so low?

Previous reports on the participation of minorities in the geosciences have identified a number of factors that may influence the choice of major and negatively affect a student's decision to choose geosciences as a career. These factors include the lack of exposure to geosciences in middle and/or high school, lack of appropriate role models and mentors, and limited awareness of geoscience career options among teachers, guidance counselors, and parents (NSF, 2001; AGU, 2002; Barstow et al., 2002; Wechsler, 2005). These factors may also be contributing to the low participation of persons with disabilities in the geosciences. There are very few professional geoscientists with a disability who are prominently featured in the popular media, in informal science programming (such as science documentaries or museum exhibits), or in career materials developed by geoscience professional organizations. Students with disabilities therefore have little to no exposure to successful geoscientists with disabilities who could serve as role models and help students envision a geoscience career.

Exposure to science, either in the classroom or in after-school programs or other informal venues, may increase the likelihood that students will develop and maintain an interest in pursuing advanced courses or a college major. As long as the earth and environmental sciences are optional courses at the high school level, fewer students will be exposed to the discipline and have the opportunity to consider geosciences as a viable career option. This limited exposure likely is exacerbated for students with disabilities, who may be discouraged from taking field- or laboratory-based courses.

Students with disabilities encounter unique challenges in any scientific discipline, yet the geosciences remains one of the sciences with the lowest participation levels for persons with disabilities. What is the reason for the low numbers? In fact, contrary to the statistics, the geosciences have a number of similarities to other scientific disciplines that suggest participation levels should be comparable. Like other sciences, a geoscience degree requires a strong background in math, physics, and chemistry. These "gateway" first-year college courses can pose a significant challenge for students with disabilities who have not received adequate training in these areas prior to entering college. Similarly, as with biology and chemistry, an undergraduate geoscience education includes substantial laboratory work, including the use of wet labs, microscopes, and chemical instrumentation. Students with disabilities and their faculty must work creatively and cooperatively to address any obstacles to laboratory learning, but those obstacles are by no means insurmountable (e.g. American Chemical Society, 2001).

What are some of the differences between the geosciences and other sciences that may contribute to low participation of students with disabilities? As previously noted, K-12 students have less exposure to the geosciences compared to other sciences, either as a result of graduation requirements or, in some schools and regions, a lack of teachers qualified to teach earth science. The lack of exposure may be magnified for students with disabilities, who may not have equal access to field trips or field courses, or who may be in special education classrooms where teachers themselves have had little experience in teaching earth sciences. Additionally, teachers and students may perceive the heavy

emphasis on field observations and the use of maps, satellite images, and aerial photography as a serious disadvantage for achieving success in the geosciences.

At the college level, a student's choice of major is in part related to the perception of a particular discipline as offering a rewarding career. Many students may be attracted to the geosciences if they understand the roles of professional geoscientists and their contributions to society. In addition to strong mentoring from geoscience faculty, opportunities for internships and research experiences can increase awareness of geosciences among students with disabilities. Career materials should encourage and promote the diversity of geoscience professionals and the breadth of options available to students. To date, the geoscience professional organizations have had limited success in reaching out to students with disabilities and in promoting awareness of the needs and abilities of students with disabilities among geoscience educators, institutions of higher education, and employers. The American Chemical Society can serve as a model in this regard, both with the publication of *Teaching Chemistry to Students with Disabilities* and in the establishment of the ACS Committee on Chemists with Disabilities.

What lessons have been learned from previous projects?

Anecdotal evidence suggests that geoscience faculty teaching students with disabilities for the first time have little or no knowledge of the resources available to support instruction and student learning. For example, a handful of publications have addressed the challenges and solutions in working with students with visual impairments who enroll in introductory geology courses (Travis, 1990; Ross and Willis, 1999; Asher, 2001; Hansen and Havholm, 2004). While some faculty have reported positive experiences in teaching a student who has low vision or is blind (Asher, 2001), preparations may be last minute and may not take full advantage of the lessons learned by other educators in similar situations (Jannett, 2004). In addition, geoscience educators have limited awareness of assistive technology that can enhance instruction, and personnel in disabilities services offices may not have sufficient knowledge of the geosciences to connect students with appropriate tools. Improved access to resources, compilation and dissemination of lessons learned, and tools for instructional planning would enhance the educational experience for both teacher and student.

Based on previous studies, a number of critical concerns can be identified:

1. Geoscience educators would benefit from resources that document "best practices" for teaching, for example,
    -an introduction to geology laboratory book designed for teaching students who are blind or have low vision
    -multimedia demonstrations of assistive technology that enhances common laboratory and field activities (e.g. water chemistry, rock identification)
    -a design guide or template for a universally designed introductory geoscience course

2. Schools, institutions of higher education, and geoscience departments may lack guidelines for ensuring equal access to field experiences. Such guidelines might include methods of evaluating the accessibility of field stations and field course locations, provision of transportation to and from sites, and recommendations for policies that encourage full participation.

3. To improve participation rates in higher education, K-12 students with disabilities should be encouraged and supported to participate in geoscience enrichment programs, such as after-school programs, job shadowing, internships, clubs, and science fairs.

4. Informational materials promoting geoscience careers should reflect the diversity of the U.S. population, including highlighting the achievements of professionals with disabilities and the diverse options available to students who choose to major in geosciences. Geoscience professional societies could maintain a database of geoscientists with disabilities and promote networking among those scientists and K-16 students with disabilities.

5. Businesses, corporations, government agencies, and other organizations that employ geoscientists can raise awareness in the broader community by developing and promoting programs that enhance the success of their geoscientists with disabilities (e.g. mentors for new employees, assistive technology). Professional societies can help by publicizing the stories of successful geoscientists with disabilities and directing employers to appropriate resources.

What research questions have yet to be answered?

Despite having over a decade of documented experience by faculty members working with students with disabilities in the classroom, laboratory, and field, the geoscience education community has not developed a coherent set of best practices for teaching geosciences to students with disabilities. Gaps in knowledge exist concerning the effectiveness of teaching strategies, faculty and student attitudes, and the nature of social/cultural barriers within the geosciences. Answers to the following questions might help educators respond to the needs of students with disabilities in the geosciences:

- What activities, in formal or informal learning environments, promote interest in geosciences among K-12 students with disabilities?
- How can geoscience career awareness best be promoted among students with disabilities, and at what optimum age?
- What actions, events, or conditions at the precollege level discourage enrollment in advanced geoscience courses in high school?
- What are the major barriers/challenges in college-level introductory coursework?
- What is the participation level of students with disabilities in college geoscience survey courses?
- What actions and attitudes among teachers and college faculty promote success in geosciences for students with disabilities?

- How can universal design principles be applied to geoscience course content to improve learning by all students?
- How does the recent emphasis on visualization technology as a learning tool in the geosciences affect participation of students with disabilities (e.g. can visualizations enhance learning for students with certain learning disabilities)?

Conclusions

Despite significant advances in the accessibility of science careers to persons with disabilities, the number of students with disabilities entering the geosciences remains low. Very little data exist to support the development of hypotheses concerning why this is true. If the low numbers are to be countered, as a starting point geoscience educators must be willing to consider the impact that teacher attitudes and pedagogical style can have on the participation of students with disabilities in science, and act in ways that will improve participation for all students.

Efforts to date usually have focused on specific cases where a student enrolls in a class, whereas there have been few attempts to look at the system that recruits, admits, and supports students in pursuing geoscience careers. A web site of a major university advises faculty that geology may not be a viable major for a student with a disability who cannot access typical field sites. This is unacceptable. It is time to view the discipline from a perspective beyond that of a "typical geology major" in today's classroom. Geoscience careers are diverse, and diverse students of any gender, race, ethnicity, socioeconomic background, or disability status can achieve a successful geoscience career.

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