Workshop for Emerging Deaf and Hard of Hearing Scientists

GALLAUDET UNIVERSITY

May 17–18, 2012
Washington, D.C.

The workshop was supported by the National Science Foundation under CNS-0837508 and MCB-1232380.

Workshop for
Emerging Deaf and Hard of Hearing Scientists

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Chapter 1: Introduction

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Aims of the workshop

Deaf and hard of hearing individuals are a greatly underutilized national resource that could make tremendous future contributions to science if given the chance. Historical research has revealed that deaf and hard of hearing individuals have made significant contributions to the field. For example, deaf astronomer Anne Jump Cannon (1863–1941) catalogued many stars and was awarded the Henry Draper Medal from the National Academy of Sciences in 1931. The co-developer of the Internet, Vinton Cerf (1943–), also deaf, received the Turing Award and was inducted into the National Academy of Engineers. Deaf and hard of hearing persons have discovered chemical elements, biological principles, stars and comets, and patented hundreds of inventions (Lang 1994; Lang and Meath-Lang 1995). Yet, the proportion of deaf and hard of hearing people in science, technology, engineering, and mathematics (STEM) is very small (0.13–0.19%) compared to that of the general population (11–15.3%; NCSES 1996, 2004, 2009, 2011b). Supporting the education of the next generation of young deaf and hard of hearing scientists, then, is crucial and will certainly enhance both the field and society in general.

To explore how we can increase the successful participation of deaf and hard-of hearing professionals in STEM, Gallaudet University hosted a two-day mentoring and networking event, Workshop for Emerging Deaf and Hard of Hearing Scientists (http://www.regonline.com/builder/site/Default.aspx?EventID=1044760), May 17–18, 2012, to discuss common barriers, challenges, and solutions to pursuing degrees or careers in various STEM disciplines. The 97 workshop participants included high school, college, and graduate students as well as K–12 educators, sign language interpreters, university professors, and government employees.

The workshop focused on the importance of vertical mentoring, also known as cascade mentoring, which has been successful for women in STEM (Packard 2003; Packard and Nguyen 2003; Larios 2005; Fang and Van Vliet 2006; Yen et al. 2007). In addition to vertical mentoring, network mentoring—that is, mentoring among different people at different levels—can be successful as opposed to traditional one-on-one mentoring (Yen et al. 2007). A study of mentoring minorities revealed that a successful mentor can differ from the mentee in terms of gender, field of study, ethnic background, socioeconomic status, or disability status, but mentees prefer a mentor who closely resembles them demographically (Frierson et al. 1994). This workshop laid the foundation for network mentoring among participants, recognizing that having more than one mentor in the field can benefit deaf or hard of hearing STEM students. The workshop allowed participants to establish mentor relationships with others in STEM who are deaf or hard of hearing and also those who have had similar experiences or challenges due to shared educational backgrounds or communication preferences.

Underrepresentation of deaf and hard of hearing professionals in STEM

STEM degrees among deaf and hard of hearing students. According to the report *Doctorate Recipients from U.S. Universities* (NCSES 2011a), 237 deaf and hard of hearing people earned doctorates in diverse fields including non-STEM disciplines in 2010. Of those doctorates, 21% were in life sciences, which includes agricultural and natural sciences, biological and biomedical sciences, and health sciences; 13% were in physical sciences, which includes chemistry, mathematics, and computer science; and 6% were in engineering. These numbers are substantially lower than those of the general population, where 36% earned doctorates in the life sciences, 26% in physical sciences, and 16% in engineering (NCSES 2011a).

During the years 2006–2010, 301 deaf and hard of hearing people earned doctoral degrees in specific STEM fields (Table 1). Some sub-disciplines were not reported because fewer than 4 people earned degrees in those fields, such as astronomy, and geological and earth sciences. The highest percentage of people earning degrees was in the biological and biomedical sciences (24%) with the lowest percentage found in ocean and marine sciences (1.7%).

Table 1. Number of deaf and hard of hearing doctorates earned in different STEM fields from 2006-2010

Major field of study	Number reporting deaf/hard of hearing
Agricultural sciences/natural resources	14
Biological/biomedical sciences	71
Chemistry	13
Computer and information sciences	17
Engineering	43
Health sciences	51
Mathematics	13
Ocean/marine sciences	5
Physics	9
Psychology	65
Total	301

Note. Counts include individuals reporting one or more other functional limitations in addition to deaf/hard of hearing. Data from Survey of Earned Doctorates, special tabulation (July 2012).

The rate of STEM majors among deaf and hard of hearing undergraduates, however, is comparable to that of the general population (Table 2). At four-year colleges, 17.0% of deaf and hard of hearing students major in math, computer science, engineering, and technology as opposed to 18.2% of the general population. The percentage of deaf and hard of hearing students majoring in STEM fields at 2-year colleges exceeds that of the general population with 13.2% compared to 9.7%. However, many of these students do not obtain doctorates (0.13–0.19% v. 11.0–15.3%; NCSES 1996, 2004, 2009, 2011b), reflecting substantial loss of deaf and hard of hearing students between the undergraduate and postgraduate school years.

Table 2. Percentage of hearing and deaf and hard of hearing students in STEM and non-STEM majors by level of education (Walter 2010)

	4 year		2 year		<2 year	
	Hearing N=9,427,100	Deaf/HH N=56,500	Hearing N=7,633,800	Deaf/HH N=70,100	Hearing N=479,900	Deaf/HH N=2,800
Math/computer/science/ engineering/technologies	18.2%	17.0%	9.7%	13.2%	6.0%	6.2%
Social/behavioral sciences	9.2%	8.4%	2.0%	1.0%	1.0%	0.0%
Non-STEM field	65.3%	64.6%	66.3%	72.2%	86.5%	86.5%
Undeclared or not in a degree program	7.3%	10.0%	22.0%	13.5%	7.5%	7.3%

Source: U.S. Department of Education, National Center for Education Statistics, 2007–08 National Postsecondary Student Aid Study (NPSAS:08)

Figure 1 details the distribution of deaf and hard of hearing undergraduate students in various STEM fields, which varies from 30% and 28% in engineering and biological and biomedical sciences, respectively, to 2% in science technology (Walter 2010).

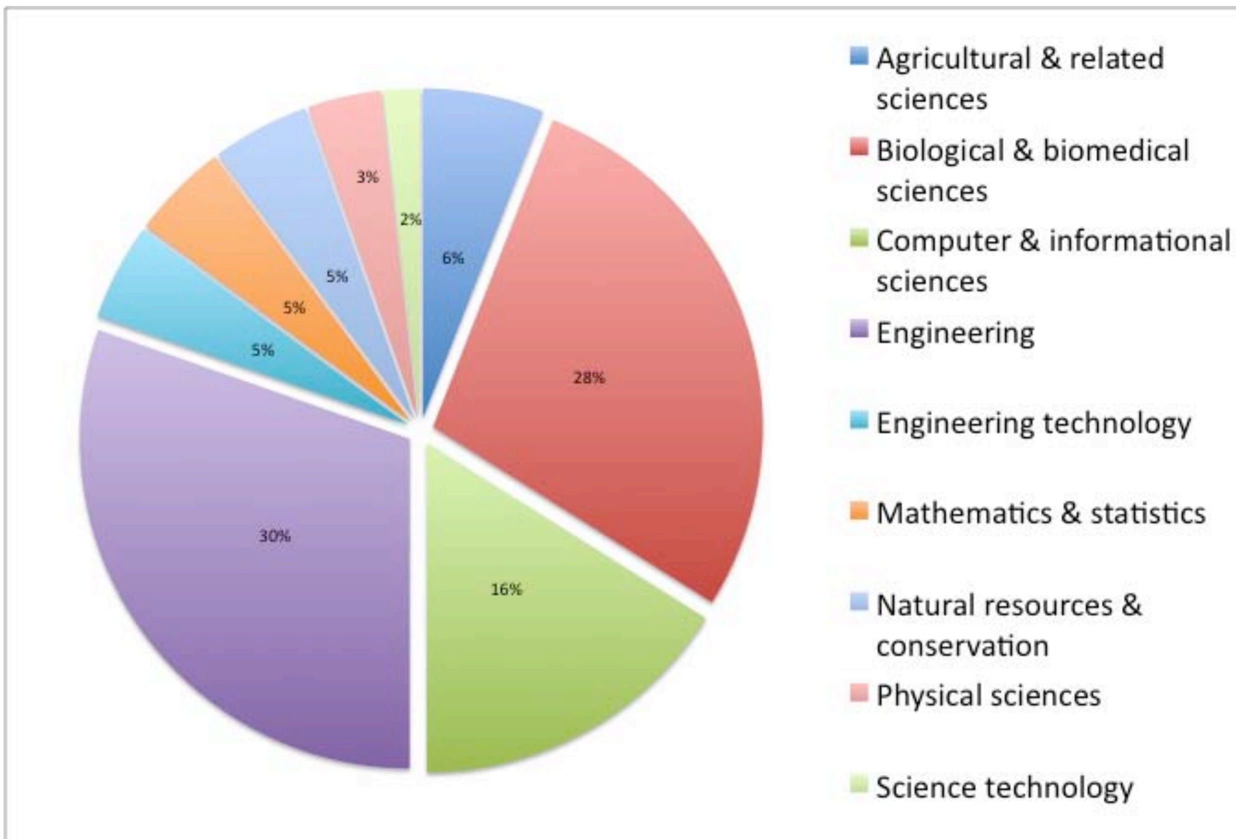

Figure 1. Distribution of STEM disciplines among deaf and hard of hearing undergraduate students (Walter 2010)

Demographics of workshop participants. The workshop had 97 participants of which 55% were deaf, 17% were hard of hearing, and 28% were hearing (Figure 2). Of the deaf and hard of hearing attendees, most preferred to communicate through ASL (77%), while others preferred captioning (13%), Signed English (6%), and cued speech (4%; Figure 3). Participants included high school, undergraduate, and graduate students and established professionals (Figure 4). The STEM fields of the deaf and hard of hearing participants were quite diverse (Figure 5) and included people in psychology, psycholinguistics, veterinary medicine, biomedical sciences, physical sciences, nanoscale science and engineering, and statistics. Several high school and beginning college students were uncertain about their area of interest in STEM. The distribution of STEM fields of attendees at the workshop was similar to that found for deaf and hard of hearing doctorates summarized in Table 1.

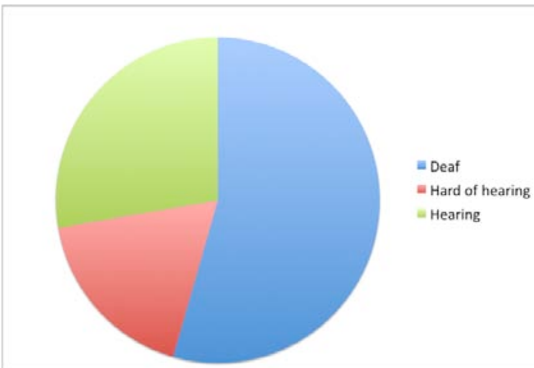

Figure 2. Hearing status of workshop participants

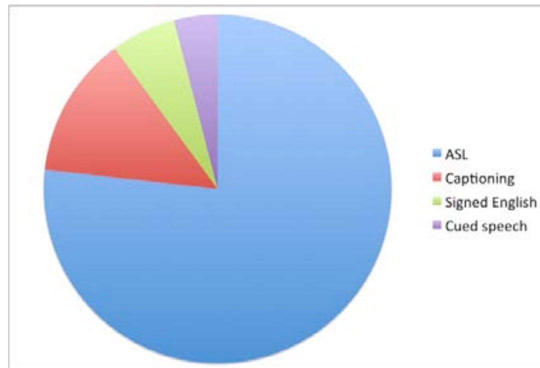

Figure 3. Communication preferences of deaf and hard of hearing workshop participants

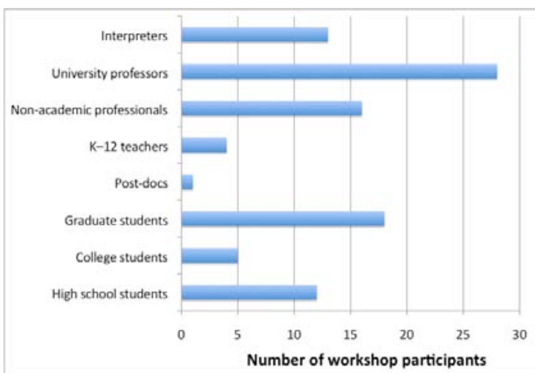

Figure 4. Educational level or type of employment of workshop participants

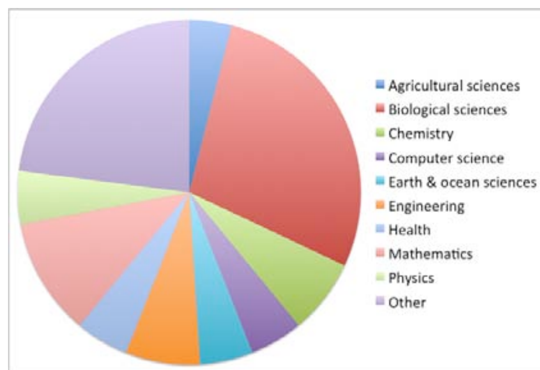

Figure 5. STEM disciplines of deaf and hard of hearing workshop participants

A need for a mentoring and networking framework for deaf and hard of hearing people in STEM

Prior to the workshop, we established that a mentoring and networking framework for deaf and hard of hearing people in STEM was direly needed to support people transitioning from high school to college and from undergraduate to graduate school. We need to first recruit and retain students in STEM fields for their undergraduate studies, and then find ways to address the serious loss of students from the undergraduate to postgraduate part of the educational pipeline (a decline from 17.0% to 0.19%; Walter 2010; NCSES 2011b).

Student mentoring and networking. Many programs have focused on one stage of students (e.g., high school or college) rather than building a foundation for these students to successfully build a career path. For example, TechGirlz at the National Technical Institute for the Deaf (NTID) and Science Star programs at Gallaudet University focused on middle school and high school students, respectively. While these efforts help pique interest in STEM fields, a more systematic approach to maintaining and nurturing interest is necessary to grow the next generation of deaf and hard of hearing STEM professionals.

In order to be successful, a mentoring program for deaf and hard of hearing students must incorporate mentoring throughout all stages of education. As such, universities are beginning to advocate mentoring among undergraduate and graduate students and postdoctoral researchers, leading to a unified learning community in research groups (Gonzalez 2001). For postgraduate students, the National Institute on Deafness and Other Communication Disorders at the National Institute of Health (NIH) offers a program that incorporates mentoring through all levels; however, it is limited to those who are in NIH's research areas (http://www.nidcd.nih.gov/research/training/pages/action_plan.aspx).

Some recent mentoring efforts have shown promise. One example is the Deaf STEM Community Alliance (http://www.rit.edu/ntid/dhhvac/), which hosts an online virtual academic community for STEM faculty, students, and staff of NTID, Camden County College, and Cornell University. The primary elements of the virtual academic community include Web-conferencing tools to provide students with remote tutoring, mentoring, interpreting, and captioning services; the establishment of a synchronous/asynchronous communication network to create the academic community; and access to electronic resources, such as sign language dictionaries, professional organizations, captioned media, reports, and papers.

Besides mentoring, deaf and hard of hearing students perceive networking as a critical resource to maintain their participation in STEM. In June 2008, Rochester Institute of Technology (RIT) hosted the Summit to Create a Cyber-Community to Advance Deaf and Hard of Hearing Individuals in STEM, which focused on establishing infrastructure that would provide access for deaf and hard of hearing students in STEM. The undergraduate and graduate students in attendance expressed a strong interest in meeting more students throughout the country who are majoring in STEM fields in order to exchange experiences and ideas.

Professional mentoring and networking. Earlier attempts to establish mentoring or networking programs for deaf and hard of hearing STEM professionals have had either limited success or have become inactive. Mentoring efforts occasionally are part of a larger program, such as FORWARD to Professorship, which serves many minority groups. However, these efforts do not always address the challenges unique to deaf and hard of hearing people in the workplace. A deaf-focused networking effort started by Deaf Women in Science and Engineering (DWSE) provided presentations at various conferences (e.g., Deaf Women United) but ceased activity. Consequently, the program has been dormant for more than five years.

Deaf and hard of hearing scientists in the workforce agree that networking is vital for their retention and career development in STEM fields. Networking facilitates discussion of topics such as (1) obtaining access at conferences and workshops and in the workplace; (2) sharing and building important resources, such as cataloguing technical signs (Lang et al. 2007) and increasing the pool of interpreters or real-time captioners knowledgeable of STEM content (Seal et al. 2002; MacDonald 2009); and (3) establishing a support system. Currently, an organization of deaf academicians and researchers from various fields exists (www.deafacademics.org), but interactions are limited to email Listserv or Facebook, and most discussions focus on issues in the social sciences. Few STEM scientists who work for the government or in private laboratories actively participate in this group. There also have been scarce opportunities for deaf and hard of hearing scientists to meet in person to discuss challenges they face in STEM (Table 3). Consequently, the establishment of a formal network of deaf and hard of hearing scientists that includes people in academia, government, and private research laboratories is very much needed.

Table 3. Recent networking and educational opportunities at conferences or workshops that focused on underrepresented groups in STEM (not necessarily just on deaf and hard of hearing people)

Conference/Workshop & Purpose	Location	Dates
STEM Mentoring for Youth with Disabilities: Research, Practice, and Resources — Discuss and review literature about STEM mentoring for youth with disabilities, girls, and racial/ethnic minorities.	Webinar	May 17, 2012
Emerging Researchers National (ERN) Conference in STEM — Help undergraduate and graduate students to enhance their science communication skills to better understand how to prepare for science careers in a global workforce.	Atlanta, GA	February 23–25, 2012
American Association for the Advancement of Science: Foundation for Science and Disability — Promote the integration of scientists with disabilities into all activities of the scientific community and of society as a whole and promote the removal of barriers that hinder success of students with disabilities in pursuit of scientific careers.	Vancouver, British Columbia	February 17, 2012 (next meeting will be in February 2013)
Association of Medical Professionals with Hearing Losses (AMPHL) — Provide information, promote advocacy and mentorship, and create a network for individuals with hearing loss interested in working in health care fields.	Portland, OR	August 6–7, 2011
FORWARD to Professorship — Provide information, skills development mentoring, and networking for a successful bid for a tenure-track professorship in STEM. Deaf and under-represented minorities are strongly encouraged to participate.	Washington, DC	May 23–25, 2011
Academic Workshop for Underrepresented Ethnic Minorities and People with Disabilities — Provide unique, tailored experiences about the academic career ladder for underrepresented ethnic minorities and people with disabilities at the assistant- and associate-faculty level and senior doctoral students.	Los Angeles, CA	February 24–27, 2011
Deaf Academics — Promote interaction and fellowship among deaf academicians around the world.	Florianópolis, Brazil	November 21–24, 2010
Minority Faculty Development Workshop — Equip tenure-track junior and mid-level science and engineering faculty with tools and strategies to better navigate their careers.	Cambridge, MA	March 21–24, 2010
A Working Conference Focused on Supporting Students with Disabilities in STEM: A Promising Practice for Changing Attitudes — Provide stakeholders with a forum to combine knowledge, experiences, and perspectives to change attitudes and beliefs about students with disabilities in STEM.	Midwest	April 1–2, 2009
Summit to Create a Cyber-Community to Advance Deaf and Hard of Hearing Individuals in STEM — Promote and develop a cyber-infrastructure for accessibility for deaf and hard of hearing students in STEM.	Rochester, NY	June 25–27, 2008
CEOSE mini-symposium (National Science Foundation) — Discuss how to encourage full participation of people with disabilities in STEM.	Washington, DC	October 15, 2007

Broadening participation in STEM with a focus on deaf and hard of hearing people

For a long time, the National Science Foundation (NSF) has demonstrated a strong interest in broadening the participation of underrepresented groups in STEM, which it reiterated in a recent Dear Colleague Letter (NSF 2012) about the goal to prepare, engage, and motivate a diverse STEM workforce. In the past, NSF has funded many grants that focus on deaf and hard of hearing people, including Classroom of the Sea and Clearinghouse on Mathematics, Engineering, Technology, and Science (COMETS). The foundation has also supported grants that encourage participation in STEM by deaf students, along with other disability groups, such as the American Association for the Advancement of Science (AAAS) Entry Point! program.

Some well-meaning programs by different organizations, such as Advancing Science in Limnology and Oceanography's (ASLO) Multiculturalism in the Aquatic Sciences (MAS) and Ecological Society of America's (ESA) Diversity in Ecology, do not target people with disabilities, especially deaf and hard of hearing people. However, ASLO is supportive of its deaf and hard of hearing members and provides access at its conferences. Like ASLO, other professional societies, such as Society of Environmental Toxicology and Chemistry (SETAC), Association of Computing Machinery (ACM), and Association for Chemoreception Sciences (AChemS), have a good track record of providing access to deaf and hard of hearing participants. A comprehensive list of organization and conference guidelines (or links) should be developed to share resources, especially when a professional organization or conference organizers encounter having deaf or hard of hearing participants for the first time.

Certain professional societies have proactively included scientists, engineers, and mathematicians with disabilities. ACM has a special interest group on computing education that has had deaf attendees for the past four years. The American Chemical Society (ACS) has a long history of promoting educational and professional opportunities for chemists with disabilities through its Chemists With Disabilities (CWD) committee, on which many deaf and hard of hearing chemists have served. ACS has also developed excellent educational materials for teaching students with disabilities.

Since 1975, AAAS has coordinated many projects that were funded by NSF, including the *AAAS Project on Science, Technology and Disability*, which recently published its 30 year report (AAAS 2007). The project began when a deaf biochemist, John J. Gavin, wrote a letter to William D. Carey, president of AAAS, suggesting the association address disability issues, leading to the watershed symposium in 1975 that framed the future of AAAS activities. Under the leadership of Virginia Stern, AAAS started many other instrumental programs, such as the aforementioned Entry Point! internship program (http://ehrweb.aaas.org/entrypoint/), and significant publications such as *Resource Directory of Handicapped Scientists* (later called *Resource Directory of Scientists and Engineers with Disabilities*). An affiliate of AAAS, Foundation for Science and Disability (http://stemd.org/), was established in 1978 and publishes a newsletter. Many deaf and hard of hearing people have benefitted from these AAAS programs.

Professional societies that focus on STEM education have also been supportive of deaf and hard of hearing participants at their conferences. The National Science Teachers

Association (NSTA) has provided interpreters at national and regional conferences since the mid-1970s, and a subgroup, the Science Association for Persons With Disabilities, was formed and for many years included newsletters as a form of networking. The Association for Science Teacher Education (ASTE) and the National Association for Research in Science Teaching (NARST) have included deaf-related articles in their journals. Science education organizations also have a long history of supporting deaf students (Lang 1983).

Challenges faced by deaf and hard of hearing scientists, engineers, and mathematicians – focus of the white paper

The link between language, cognition, and learning for deaf and hard of hearing people studying STEM has been reviewed intensively by Marschark and Hauser (2008). Their work offers insight on why more deaf and hard of hearing people do not enter STEM fields. These researchers targeted the early educational experiences of deaf children and the lack of exposure to science in comparison to hearing peers (Kelly 2008; Marschark and Wauters 2008). Among the cognitive issues they discuss are how younger deaf students are less likely to connect inferences and automatically relate concepts over multiple dimensions, which is an instrumental skill in STEM (Marschark and Wauters 2008).

The focus of the current white paper is on deaf students who are in their later years of high school education and are ready to pursue STEM degrees, and deaf college and postgraduate students who are ready to continue their education or gain employment in STEM. Some challenges mentioned by Marschark and Hauser (2008) are pertinent to this population:

1. The division of visual attention during the reception of STEM materials through spoken language, sign language or real-time text, the instructor, and other visual materials such as PowerPoint presentations. This will be discussed further in Chapter 5: Technical Resources Available for STEM Students.
2. The ability to integrate STEM information from classes, textbooks, and other study materials as compared to hearing peers (Richardson et al. 2010)
3. The lack of a common sign language lexicon for scientific terms and training for interpreters in techniques for interpreting STEM lectures and laboratories (Redden et al. 1978; Lang et al. 1983; Lang 2002; Lang et al. 2007). This will be discussed further in Chapter 5: Technical Resources Available for STEM Students and Chapter 6: Interpreting in STEM.

During the current project's workshop, these and other issues surfaced in the deaf students' anecdotal accounts. For example, with regard to the issue of multiple visual demands, one graduate student summarized the challenges and how to overcome them:

> *I face challenges as a deaf person in both my classes and at my workplace, but find ways to work through them. For example it can be challenging during labs when I have to look at a sample through a microscope while the instructor is talking. In situations like this I ask the instructor to first explain and then wait to give students time to find and observe what is being looked at before moving on. In the work place, I have several strategies that help me ensure I have correct information. The procedures to follow for using specific lab equipment and data-collecting techniques are written down in a binder. In*

addition to this, I usually repeat back instructions that are new to me or if I am not sure I completely understand what is going on, I give my colleagues a chance to correct me before any mistakes are made.

In order to examine the many language, cognition, access, and other challenges of deaf and hard of hearing people in STEM, we will present on the following pages the experiences of deaf students (Chapter 2) and deaf professionals (Chapter 4) in order to identify effective mentor strategies and reduce attrition from undergraduate and graduate programs. We will also discuss the principles and practices for involving deaf and hard of hearing students in undergraduate research programs (Chapter 3) with better tools and services (Chapters 5 and 6).

This material is based on work supported by the National Science Foundation under CNS-0837508 and MCB-1232380.

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Chapter 2: Experiences of Students in STEM

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Introduction

Prior to the passage of equal access laws in the 1970s, deaf and hard of hearing students had no legal right to equal educational access. Legislative action that led to the Education of All Handicapped Children Act (EHCA) in 1975 revealed that over one million handicapped children had no education access at all. The EHCA, which later became the Individuals with Disabilities Education Act (IDEA), guaranteed a free, appropriate public education in the least restrictive environment to students with disabilities. Additional legislation, Section 504 of the Rehabilitation Act in 1973 and the Americans with Disabilities Act of 1991, prohibits discrimination in educational and public activities.

Unfortunately, the associated funding for EHCA categorized all types of special needs students as one class of person, despite the fact that each group required very different educational needs. It required "mainstreaming" by placing all children with disabilities in the least restrictive environment but did not adequately address communication and social barriers, which are significant challenges for deaf and hard of hearing students. For example, communicating through third party interpreters or captioners has led to little direct communication between deaf and hard of hearing students and their hearing peers or teachers (Lang 2002). Because of communication difficulties, even through third parties, deaf and hard of hearing students consistently relate best to other deaf students (Stinson and Walter 1997).

At the postsecondary level, additional federal, state, and joint federal-state laws and appropriations, such as vocational rehabilitation, have expanded funding to deaf and hard of hearing students to participate in higher education. These laws have also funded federal and state administrative agencies such as the Office of Special Education and Rehabilitative Services (OSERS) and Office of Special Education Programs (OSEP), which were created in part to support the funding and development of more inclusive teaching and learning approaches. Overall, legislative laws and administrative rules in the past 30–40 years have significantly expanded accessibility and availability to education for deaf and hard of hearing students at all levels.

Accommodations at the postsecondary level. Many postsecondary institutions provide at least one accommodation for deaf and hard of hearing students, but these accommodations usually are neither as comprehensive nor as individualized as those received in K–12 settings. Moreover, deaf and hard of hearing students as a group have diverse communication preferences. Consequently, their accommodations and accessible technology preferences are also diverse, and the limited options provided by colleges rarely meet their needs.

Deaf and hard of hearing students tend to be evenly distributed throughout the country, with a few exceptions. This statistic suggests that most colleges enroll only one or two deaf or hard of hearing students, making it difficult for the designated disability services in these colleges to provide adequate accommodations for each student. The accommodation services usually comprise tutoring and notetaker services. However, these services fail to capture real-time lecture and social information in the classroom. A small percentage of institutions do provide sign language interpreters or captioners (Raue and Lewis 2011), which can help bridge the information gap. Furthermore, a small percentage of institutions also provide special career placement services for deaf and hard of hearing students (Raue and Lewis 2011).

Although federal laws mandate accommodations for equal access, the accommodations rarely give deaf and hard of hearing students full access to academic and social information (e.g., students meeting outside of the classroom to study or work on projects). As students progress through their high school and university education, the problems of basic access to visual and auditory instruction intensify as the complexity and volume of information increases. STEM educational activities often combine traditional classroom activities with labs, fieldwork, and collaborative activities that tend to require audio-visual split attention, which taxes most students' auditory and visual limits. Whether it involves viewing bacteria under a microscope or detecting tonal differences in sound waves, STEM educational activities usually require simultaneous visual and auditory learning.

Deaf and hard of hearing students in STEM. High school and college students follow a structured path through their STEM education that focuses substantially on coursework, which students (primarily undergraduate) can supplement with research. In contrast, postgraduate education lacks the same structure as that offered by undergraduate programs. While occasional milestones occur throughout a graduate degree program, graduate students are engaged in a research program for the majority of their graduate career with fewer well-defined goals as compared to undergraduate work. As such, graduate students require a different set of resources to conduct their research and complete their degree program.

Graduate school is a key transition that enables deaf and hard of hearing students to become professionals in their field. However, the graduate students interviewed during this workshop reported that their experience varied greatly regarding the amount of support they received from their principal investigator, their department, and their institution in general.

A few studies have investigated possible reasons for the low persistence rate of deaf and hard of hearing students in STEM, including the quality of mediated instruction; the necessity of attention multitasking and overcoming divided visual attention; heterogeneity in knowledge, comprehension and learning strategies; and the ability to connect concepts or synthesize over multiple dimensions (Marschark and Hauser 2008; Marschark et al. 2008). However, few have looked at students' experiences and what made them successful despite the challenges they encountered in their academic careers (Richardson et al. 2010). Consequently, the Emerging Scientists workshop focused on these issues, asking student attendees and panelists to share their experiences and insights. Despite differences in academic preparation, all students at the workshop had similar successes and challenges.

While the backgrounds of the workshop attendees vary greatly by field, education, preferred communication method, and cultural identity, their comments indicate some common themes. This chapter is organized into three sections that highlight these common themes and describe the experiences and issues that deaf and hard of hearing students in STEM face during their academic preparation: (1) issues in accommodations, (2) self-advocacy, and (3) establishment of a support system.

Issues in accommodations

The group of students who attended the workshop reported different experiences that varied depending on their individual backgrounds. Some students who attended different mainstream programs with sign language interpreters had difficulty getting the resources they needed. For instance, a standardized system of signs for scientific terminology beyond basic words was difficult to locate until the recent emergence of science sign lexicons and forums, so some students reported struggling to follow lectures when interpreters had insufficient scientific training and were unaware of appropriate technical signs. In these situations, STEM courses are minimally accessible, as students do not necessarily receive the same amount nor quality of information as their hearing peers. As a result, the difficulty in obtaining qualified interpreters knowledgeable of technical STEM signs may lead to retention problems for students who are otherwise interested in STEM. Another issue is consistency with interpreters, as one workshop attendee explained:

> *For an hour before the meeting, I would prep the interpreters and discuss with them the vocabulary terms, what my research is, to keep up with the meeting. It was exhausting, plus [I got] two different interpreters every week. We would meet every week, and I would meet with the interpreters week to week. It was exhausting work; something I would have to do that other hearing students would not have to do.*

Several students, including a graduate student panelist, reported difficulty in securing an accessible environment for their graduate education and research commitments. These challenges were directly tied to funding for sign language interpreters and/or real-time captioning. In fact, 67% of workshop student participants reported having problems with receiving quality accommodations, as reported by one participant:

> *At that time when I did transfer over to another university, it was more difficult; I was more my own. [My program] didn't have specific resources for people who are deaf and hard of hearing. They had to contract with interpreters external to the university, and I would have to admit it was not my best experience. I had to fight for a period of time to be able to get interpreting services and to have them on a continuing basis.*

Many universities' disability resource centers provide accommodations only for academic commitments, such as classes and lectures. When students work in a research lab, some universities consider them "employees," so accessibility for research lab-related activities falls outside the scope of the university's student accommodations. The burden of providing accommodations thus rests on the employing department itself and occasionally on the research group within the department.

Graduate students in this situation report feeling pressure from the department and the principal investigator to ask for the minimum amount of accommodations needed, because departmental funds are often limited. In some cases, requests for accommodations are refused due to a lack of funds, thus forcing the deaf or hard of hearing student to attend departmental seminars, research lab meetings, or even study groups for their own oral exam without any accommodations. Some respondents also disclosed their frustrations with the need to exert energy and sacrifice valuable time to advocate or to compensate for low quality services.

Self-advocacy

A few students and professionals shared how they had to learn how to advocate for themselves, learning the proper channels to use to ensure they received the appropriate accommodations they needed. One participant described the importance of having an ally to make the necessary changes:

> *As a graduate student I didn't have the power to be able to make those changes—I didn't feel empowered to do that. I had to advocate to get interpreters, [but] as a student it [was] difficult to [get approval]. But advisors—they would have more authority, they would have more ability to get that. So when [the school] wouldn't provide interpreters, I would have to … go back and forth with them. [It was] the advisors who used their power to help me.*

Without an ally, students must learn how to successfully advocate for their needs. Students recognized the significant investment of time and effort to learn how to effectively lobby for the accommodation and to educate and work with the people who can make it happen. Below are excerpts from three participants highlighting the significance of self-advocacy.

> *I feel like I've had enough support because, I mean, most of all, during the last … two years, I advocated almost every single day. It was a lot of work for me, but, you know, if you wanted to get -- if you wanted to hear everything or every opportunity, you're just going to have to advocate for yourself, because if you don't, you're going to lose the opportunity.*

> *During my freshman year it was difficult for me, because I didn't really advocate for myself because I wasn't mature yet. Throughout this year, I advocated more for myself and so it was easier for me to communicate with [my classmates].*

> *My Ph.D. advisor was not as supportive. I needed to advocate for interpreters, for example, and sometimes I didn't have an interpreter. So there were some complications. But at the post-doc experience, it was just night and day. [They had a] very, very supportive system—the mentors—and I absolutely felt like one of the team.*

A key strategy toward increasing the number of deaf and hard of hearing professionals in STEM fields would be to provide high school and college students with resources to empower themselves in their education and subsequent professional training.

The ability to self-advocate is an essential skill that successful deaf and hard of hearing professionals could share with students.

Support system

Students in mainstream programs often attempt to pursue degrees without a critical mass of other deaf and hard of hearing students. Consequently, they are isolated from the network of resources that naturally occur at deaf-centered institutions (i.e., Gallaudet University, National Technical Institute of the Deaf at Rochester Institute of Technology [NTID/RIT], and California State University, Northridge). Because of this isolation, these students typically are unaware of the resources and programs available to them, such research experiences for undergraduates (REUs) or networks of deaf professionals, such as Deaf Academics.

Furthermore, many students do not network with other deaf and hard of hearing classmates at the same university, because disability resource centers are bound by confidentiality and cannot share names of other students. Yet, it is clear that a support system is essential to academic success. One participant explained the dynamics of study groups:

> *People would get together in study groups, and there was no interpreting support. People would get together in a coffee shop and they'd be talking, and of course, I couldn't follow. So I was studying on my own. I didn't have the advantage of having that network of study peers. That was one disappointment—I didn't have that experience of working with my peers through the study group endeavor. And then there were other deaf students who came in. That was fortunate. But we're at different stages—I'm about to graduate, two of them have just come into the masters level, so I didn't have that advantage either of having a fellow deaf student.*

Of the workshop student participants, 87% experienced communication issues. Consequently, most deaf and hard of hearing students expressed interest in having a network of other students and professionals to share and discuss frustrations related to research and communication barriers with colleagues in the research lab.

However, so few deaf and hard of hearing people are in graduate STEM programs, it is often difficult for graduate students to find experienced role models to help them address their needs in their program and to make future plans, such as for fellowships or employment programs for individuals with disabilities. One participant described the experiences of graduate school without a support system, saying *"Graduate school is a lot harder than your undergraduate experience, so if you're lucky enough to have a supportive system, that can really help."* Having a peer to bounce around ideas with or to get advice from can help reduce frustrations faced by isolated deaf and hard of hearing students. Below is one example of advice that students could learn from peers.

> *Look for programs and people that have had -- deaf people have a willingness to work with deaf people. There could be a program you really want to do, but if they have any hesitation about having a deaf person in the program, move on! Do not waste your time trying to break down the barriers. It's a big wide world out there. Look for somebody who is already open to working with deaf people and you'll have a better experience.*

Peer-to-peer learning. In addition to facing academic challenges and social isolation, deaf and hard of hearing students miss out on peer-to-peer learning. At both RIT's 2008 Summit to Create a Cyber-Community to Advance Deaf and Hard of Hearing Individuals in STEM and this Emerging Deaf and Hard of Hearing Scientists workshop, students stated that support from deaf and hard of hearing peers who have gone through the same process was very helpful. They learn facts and strategies that have been proven to work at that specific university, such as which teachers have the most accessible teaching style for deaf and hard of hearing students, or which interpreters are most familiar with mathematical or scientific formulas.

Discussion

A common thread in the comments from workshop attendees was a need for a strong and visible mentoring network for deaf or hard of hearing STEM professionals. Although Deaf Academics is a visible network, the majority of its participants come from the social science and humanities fields. The few STEM members of this network group rarely have discussions. The ability to exchange resources and information among deaf or hard of hearing STEM professionals and students is vital to increasing the retention of prospective deaf or hard of hearing students in STEM fields and to providing support for students who are advanced in their STEM education. Moreover, the existence of a visible network would empower deaf or hard of hearing students who are not well-connected with other deaf or hard of hearing people (such as those who grew up in mainstreamed environments) to find resources that support their education goals.

At various institutions, a constant theme appears regarding quality of accommodations and how deaf or hard of hearing students and professionals are constantly battling to obtain equal access to information as their hearing counterparts. There are no quick solutions, but the ongoing battles cannot be ignored. Solutions must consider why high quality services are not being provided so deaf or hard of hearing students can focus on their studies, research projects, and making contributions instead of spending their valuable time and energies fighting for access. Increasing the pool of interpreters or captioners who can convey information about advanced topics in STEM fields (discussed in Chapter 6: Interpreting in STEM) and having a corpus of signs for STEM terminology (which is now is in progress; see Chapter 5: Technical Resources Available
for STEM Students) are needed. Universities must also consider extracurricular activities, which play an important part in a student's education, such as field work, lab meetings, study sessions and weekly seminars.

Conclusion

Enhancing the mentoring and networking opportunities for deaf or hard of hearing undergraduate and graduate students in STEM, and STEM professionals in the workforce, may very well have a positive impact on the number of such individuals entering and persevering in these fields. Professional organizations, funding agencies, universities, and colleges must work collaboratively with deaf or hard of hearing individuals to develop and implement effective programs and resources.

This material is based on work supported by the National Science Foundation under CNS-0837508 and MCB-1232380.

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Chapter 3: Inclusion of Deaf and Hard of Hearing Students in Summer Research Programs

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Introduction

Federally funded summer research programs for undergraduates provide excellent opportunities for students to explore scientific career options. Although some research and internship programs are open to students at other educational levels, a wide variety of stipend-paying positions in STEM fields are available specifically to college-enrolled students. Thus, this section focuses on research experiences for undergraduates (REUs) and increasing deaf and hard of hearing students' participation in them. Many of the issues raised here also apply to the inclusion of deaf and hard of hearing students and scientists in other STEM environments.

REUs are typically open to multiple students across the country and are likely to be held at top-tier institutions and research centers. At this educational stage, students should have a sufficient foundation in scientific principles to assess appropriately their interests and aptitudes for research. As several studies indicate, REU programs provide experiences that widen future possibilities and expand diverse skill sets to enhance success at subsequent career stages in STEM disciplines (Seymour et al. 2004; Henry and Washington 2005; Lopatto 2007; Sadler et al. 2009; Pender et al. 2010). Based on these studies and similar assessments of REU programs, participants benefit in various ways, such as:

- Access to specialized research topics
- Access to cutting edge techniques and direct interactions with successful scientists
- Focused activities and learning experiences
- Networking opportunities among scientists and students with similar interests
- Opportunity to meet mentors who can provide short-term and long-term advice
- Participation in fun and authentic experimental investigations

Deaf and hard of hearing students can successfully participate in scientific research projects in hearing environments, as exemplified by a program at James Madison University (Seal et al. 2002). Unique benefits and special challenges are likely to result from such efforts to be inclusive, as has been observed with other programs that aim to diversify the scientific community (Hurtado et al. 2009). Benefits related to interactions among people who are deaf, hard of hearing, and hearing may include:

- Greater appreciation for the contributions and potential contributions of deaf and hard of hearing scientists
- Increased awareness of variations in teaching and learning modalities
- Increased awareness of Deaf culture
- Greater appreciation for diversity
- Opportunities for friendship and mentorship among different cultures and communities
- Improved teaching, learning, and communication skills for all members of the laboratory

Challenging issues and methods to improve outcomes

Issues specific to the inclusion of deaf and hard of hearing students arise at different stages of the program. This chapter explores the following issues that students may encounter as they apply and participate in REUs: (1) successful application and selection into a program, (2) program activities and conducting research, (3) continuing mentoring and training after the program, and (4) assessing programs for continued improvement and federal funding.

Successful application and selection into a program

Finding a good match between an undergraduate applicant and a suitable research program is arguably the most important step in a successful undergraduate research experience. In many cases, however, this step is the most difficult to complete effectively. A vast number of REU programs exist throughout the country, including many that are NSF-funded (http://www.nsf.gov/crssprgm/reu/reu_search.cfm). While deaf and hard of hearing students may be well-suited to a broad range of opportunities, the subset of REU programs that are specifically prepared to host students with special needs may be small. Furthermore, such programs are difficult to identify, as it is not readily apparent how welcoming any particular program is to members of the deaf and hard of hearing community. Potential participants may want to know if a program has other deaf or hard of hearing personnel, be they professionals, students, or members of the community at large. Identifying resources that help deaf or hard of hearing participants establish social and professional connections can make a tremendous difference in the overall experience, especially for those participants who are not familiar with the local and community resources close to the REU site. Finally, deaf and hard of hearing students, like other applicants, need timely access to program information. Because application deadlines may be set many months before a summer research program begins, students without guidance may easily miss these deadlines.

Many research programs are highly competitive, with some selecting only one out of every 10 to 50 applicants. To increase the likelihood of receiving an offer, deaf and hard of hearing students need to understand the best strategies for crafting a successful application. For applicants and program selection committees, good matches may be affected by the self-identification of those who are deaf or hard of hearing. However, prior to selection potential participants may be reluctant to address such issues. Moreover, programs that are seeking to attract deaf and hard of hearing applicants may not know how to target their advertising and opportunities to the correct audiences. Adding to the confusion, websites and Internet links are often out of date, making it difficult for applicants to get accurate information. Changes in program focus and funding sometimes occur rapidly, making it harder to establish and maintain the continuity needed to build strong relationships between members of the deaf and hearing communities.

The pipeline of well-prepared undergraduate students eager to apply for summer research opportunities in STEM fields should grow as efforts to support and prepare scientists at younger educational stages increase. However, the current number of deaf and hard of hearing students seeking such research opportunities remains relatively small. There are several possible reasons for this:

(1) Some potential participants could be lacking skills or information that would help them choose programs that match their long-term interests and their current background.

(2) Many potential applicants do not realize the value of such experiences and are reluctant to apply without the urging of their family members, classmates, and mentors. This problem is not unique to the deaf and hard of hearing population but is common in underrepresented groups (Hurtado et al. 2009).

(3) Potential deaf and hard of hearing applicants attending mainstream colleges have not yet participated in REUs. Unpublished data (from the REU programs described at the end of this chapter) show that nearly all the deaf and hard of hearing participants to date attend three major home institutions that serve this population (i.e., National Technical Institute for the Deaf at the Rochester Institute of Technology [NTID/RIT], Gallaudet University, and California State University, Northridge). For various reasons it is difficult to determine the exact number of deaf and hard of hearing students attending mainstream colleges (Watson et al. 2007; Rosen 2009). Nevertheless, thousands of deaf and hard of hearing students in mainstream postsecondary institutions could benefit from supportive educational programs (Smith 2004; Harris 2012).

With so few applicants, it may be difficult to place multiple deaf and hard of hearing participants in the same REU, leading to individual participants potentially feeling isolated. Furthermore, having too few deaf and hard of hearing participants can reduce the cost effectiveness for the administration of programs, because economies of scale for providing interpreters and other costly resources are absent.

Recommendations. Information to help match deaf and hard of hearing students with research programs that fit their interests and can accommodate their needs benefits both participants and programs. Methods to improve current situations include the following:

- Establish various types of clearinghouses for matching participants and programs. A collaboratively developed website, such as one using "wiki" software, could facilitate the sharing of information and ideas. Such Internet resources could improve access to each REU program's information, pictures, links, videos, and contributions from multiple stakeholders.
- Increase communication between administrators of research programs in hearing environments and the deaf community. Research program coordinators and counselors from schools that serve deaf and hard of hearing students should know as much as possible about REU programs to help determine good matches for their students. Similarly, the more that REU program directors understand the applicants they hope to attract, the better they can design effective programs. For example, individuals from NTID and Gallaudet University could work directly with administrators of federally funded research programs to develop exchange programs for visits and discussions of common goals. Teachers and counselors who know individual students can also help to match students and programs.
- Improve vertical mentoring relationships between deaf and hard of hearing participants who have completed REU programs and younger students who might be interested in one. Efforts to develop this type of vertical mentoring, through such opportunities as the Workshop for Emerging Deaf and Hard of Hearing Scientists, have begun and should expand (see Chapter 7: Where Do We Go From Here?).
- Introduce the possibility of scientific careers for deaf and hard of hearing students by aiming for younger audiences within both the deaf and hearing communities. The earlier that skill sets and information are introduced, the more likely it is that college-level programs will be

successful for all involved. Some current programs include NTID's STEM summer camps for middle and high school students (http://www.ntid.rit.edu/outreach); the University of Washington's Summer Academy for Deaf and Hard of Hearing in Computing (http://www.washington.edu/accesscomputing/dhh/academy/); and Science Camp for Deaf and Hard of Hearing Youth in Minnesota (http://dreamsandinspirations.com/camps/science/).

- Improve communication within the hearing community among those who wish to include members of the deaf community in their research programs. For example, programs that train deaf and hard of hearing students after their freshman and sophomore years of college can work with REU programs that train students after the junior year of college. While NSF-funded programs do not support senior students who have graduated, other programs do exist for these students. Establishing pipelines for continued training and mentoring could help support ongoing career development. Greater cross-discussion between REU programs can help develop common solutions.
- Encourage REU programs to accept deaf or hard of hearing students for two consecutive summers. Students who have gone through the program previously could then help new students. Furthermore, a second year in the same program could help a participant complete a project or contribute to a publication.

Program activities and conducting research

Before participants arrive, programs must prepare for the accommodations and needs of their deaf and hard of hearing participants. For example, dorm rooms and laboratories often require safety modifications, such as visual rather than auditory alarms. However, covering the cost for these modifications is often a point of contention, as a host university might argue it is the responsibility of the organization funding the REU while others might argue the responsibility falls on the host university. In some cases, research participants may register for coursework that obligates the university to provide interpreters and related resources. However, this tactic incurs additional registration and materials fees, so it may not always be possible to take this approach. Furthermore, the ability of participants to receive academic credit for such courses, and research programs in general, depends on credit transfer agreements between the host institution and the student's home institution.

Regarding communication accommodations, needs may vary among participants, as preferences can range from captioning and notetakers to sign language or cued speech interpreters. It is important to meet each student's need. Finding and funding qualified captioners or interpreters can be difficult, especially if the research program requires specialized knowledge of complex and uncommon (or completely novel) scientific terminology. RIT's 2008 Summit to Create a Cyber-Community to Advance Deaf and Hard of Hearing Individuals in STEM addressed these challenges (http://www.rit.edu/ntid/cat/system/files/SummitReport_final2009.pdf). Developing resources (see Chapter 5: Technical Resources Available for STEM Students) and increasing interpreter training (see Chapter 6: Interpreting in STEM) can help alleviate some of these issues.

Communication accommodations on field trips or in special locations may require additional planning and training, which may incur additional costs and cause unanticipated complications. For example, one REU program involved work in an ultra-clean room that required the participant and interpreter to wear full-body clean suits with gloves. In such a situation, the program needs to provide upfront information to the interpreter on clean room requirements—including vetting individuals to verify they can work under such conditions—while remaining mindful of allowing the student and interpreter to communicate clearly. From year to year, research plans and program participants change, requiring REU programs to find different solutions to communication issues.

When deaf and hard of hearing students join programs in hearing environments, the hearing participants, researchers, and program administrators may be unfamiliar with relevant issues. Some may initially be concerned that hosting a deaf or hard of hearing scientist will be too time consuming and require too much effort to make a summer research project worthwhile. Therefore, programs should provide education and information to increase the level of comfort, the appropriate consideration, and the safety and enjoyment of everyone. Full success and inclusiveness requires commitment from the entire team. It is important to foster the desire to work together and to eliminate barriers and prejudices.

If a large research program hosts only one or two deaf or hard of hearing students, they may feel isolated. The deaf and hard of hearing participants may need to exert extra energy and effort to participate in group activities and research endeavors, which may be hard for those who are shy or introverted. Difficulties with communication could reduce the cohesiveness of the group and could cause social and/or learning problems that affect the deaf or hard of hearing student's experience and performance.

Recommendations. Although the problems and solutions inherent to the inclusion of deaf and hard of hearing participants in summer research programs may be specific to individual programs, some general strategies include the following:

- Safety considerations, access modifications to dorms and labs, and communication accommodations are necessary. A combination of approaches may increase the ease of accomplishing the desired goals. In institutions with ongoing programs, it may be helpful to establish liaisons between program administrators, university offices (disability services, summer housing programs, facilities departments), and federal funding agencies that provide financial support for the research programs. There may be supplemental money available from funding agencies when institutional support is insufficient. Economies of scale can be helpful when multiple deaf and hard of hearing students participate in a single year of the program and in multiple years of ongoing programs.
- Ongoing communication, websites, and online wiki sites may increase communication between and among programs at different (primarily) hearing institutions to explore creative solutions to difficulties and to discuss ideas about funding, academic credit, participant status, and other issues.
- The early selection of participants may be helpful so that each individual's needs and requests are known as early as possible. Open communication about how best to accommodate individuals can facilitate careful preparation while minimizing last-minute contingencies and unanticipated costs.
- Efforts to address scientific signing through technology and broader communication among STEM interpreters should help summer research programs (see Chapter 5: Technical Resources Available for STEM Students). Efforts to expand the pool of qualified STEM interpreters should help increase the participation of deaf and hard of hearing people in scientific fields (see

Chapter 6: Interpreting in STEM). Problems that are exacerbated by the current small percentage of deaf scientists should gradually decrease as more deaf scientists engage in STEM-related careers and endeavors.

- Community education can help broaden awareness and make all people involved in a research program more comfortable, considerate, and friendly. Having well-trained professionals conduct workshops and seminars at the start of a program can be helpful. For example, NTID offers a workshop for employers that can be modified and presented on site at summer research programs (http://www.ntid.rit.edu/nce/employers/workshops), such as the following offering:

  > *Working Together: Deaf and Hearing People* is an interactive, experiential workshop that fosters the sensitivity and skills for deaf, hard of hearing and hearing colleagues to work together successfully, leading to increased productivity for all.… [This workshop covers] these topics: Understanding Hearing Loss and Deaf Employees; Communication on the Job; Strategies to Help You Integrate Deaf and Hard of Hearing Employees Into the Workplace; Accommodations for Deaf and Hard of Hearing Employees.

- To prevent participants from feeling isolated and to support the social as well as the scientific aspects of these programs, it is important to select appropriate host labs for deaf and hard of hearing participants. A good match between individual mentors and mentees within each program can significantly influence the effectiveness of the program. Program administrators who pay careful attention to the matching/placement process can increase the effectiveness of the experience.
- It may be possible to integrate aspects of the scientific program with nonscientific, social, and educational components by collaborating with the local and regional deaf and hard of hearing community and with hearing students who are learning ASL or who are training to be interpreters.

Continuing mentoring and training after the program

For long-term efforts to be successful, participants who complete research programs should receive ongoing training, mentoring, and career advice. However, only a handful of deaf and hard of hearing scientists who can mentor younger scientists is currently available. Moreover, few training programs target deaf and hard of hearing individuals in STEM fields at stages beyond the undergraduate level. Thus, the deaf and hard of hearing STEM field lacks continuity in the support that undergraduate participants receive after completing their training during summer REU programs.

Recommendations. Strengthening initial efforts might involve some of the following strategies:

(1) Building on vertical mentoring networks (see Chapter 7: Where Do We Go From Here?) can lead to greater success in matching people with similar career interests.

(2) Sending participants to their home institutions with presentations (such as posters and papers) that they can share with their teachers and peers may encourage ongoing enthusiasm, broaden interest in STEM fields, and stimulate new discussions. They can also participate in regional poster sessions such as University of Maryland at Baltimore

County's (UMBC) undergraduate research symposium (http://www.umbcsymposium.org/) or student poster sessions at discipline-specific conferences.

(3) Using networking and Web-based approaches to connect participants from different programs with one another and with other advisors may help build support systems and foster friendships among like-minded people.

(4) Working with program administrators to share information about past participants (with participants' permission) can help establish broader networks of colleagues. Such information could be used for different purposes, such as developing forums that promote ongoing interactions between scientists in different communities.

(5) Deaf and hard of hearing students who have completed a summer program could be invited back in subsequent years to participate in career development sessions that take place during summer research programs. These types of connections could help establish and strengthen vertical mentoring relationships.

Assessing programs for continued improvements and federal funding

Initial efforts to develop research programs for deaf and hard of hearing participants in hearing environments have been motivated by good intentions. However, long-term assessments and formal evaluation have yet to confirm the best practices and the most effective means of implementing these programs. In addition, more information is needed on how these types of programs have affected deaf and hard of hearing participants, how to evaluate these programs in relation to other ongoing federal funding opportunities and grants, and how federally funded programs can be expanded to encourage the participation of deaf and hard of hearing participants.

For example, the NSF funds many REUs (http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5517&from=fund). These opportunities can result from Site programs that fund a group of students and also from supplements to grants that are directed by individual principal investigators. The assessments of NSF-funded programs include attention to Broader Impact Criteria that address multiple aspects of diversity. However, special assessment criteria might be best to evaluate factors that are unique to including deaf and hard of hearing students. All program participants are usually surveyed for their answers to a broad range of questions. However, surveys that pertain specifically to issues affecting deaf and hard of hearing individuals in STEM-based endeavors are not typically conducted. Thus, survey results may not convey well what best works for training deaf students or if there are any aspects of the program that differentially affect hearing students compared to deaf students. Ultimately, those individuals who make funding decisions may not have enough information about how best to apply federal grant dollars to the training of deaf and hard of hearing students in STEM disciplines.

Recommendations. Efforts to follow past participants should continue and improve. These efforts might include retrospective polling of past participants for their input on which program aspects worked well and which needed improvement.

- Consultation with assessment programs to discuss evaluation approaches that target both individual and multiple programs might be helpful. Potential assessments could be the Survey of Undergraduate Research Experiences (SURE) led by Dr. David Lopatto at Grinnell College (http://www.grinnell.edu/academic/csla/assessment).

- The discussion forums and mentoring networks that are now being established could elicit increased input from the deaf and hard of hearing community concerning their needs and desires for summer REU programs.
- Greater efforts could be made to create interactions and liaisons with appropriate people at federal funding agencies, including those involved with NSF-sponsored REU Site programs.

Some REUs that encourage the participation of deaf and hard of hearing students with hearing and deaf and hard of hearing mentors in STEM include:

- Internships at Tufts University run by Dr. Peggy Cebe (http://www.tufts.edu/~pcebe/internships.html; Cebe et al. 2006; Cebe 2009; Cebe et al. 2011)
- Summer Undergraduate Chemistry Research at James Madison University run by Drs. Gina MacDonald and Dan Downey (http://csma31.csm.jmu.edu/chemistry/faculty/macdonald/macresearch/; Seal et al. 2002; MacDonald 2009)
- REU Site for Increasing Diversity in Engineering at the Pratt School of Engineering run by Dr. Martha Absher of Duke University (http://www.pratt.duke.edu/reu/absher)
- REU Site Program for Microbiology (funded by NSF grant DBI 1062589) at the University of Georgia run by Drs. Timothy Hoover, Eric Stabb, and Ellen Neidle (http://mib.uga.edu/reu/REUindex.htm)
- EntryPoint!: the American Association for the Advancement of Science (AAAS) summer internship program run by Laurene Summers at various governmental and private laboratories (http://ehrweb.aaas.org/entrypoint/)
- Summer Program for the Deaf and Hard of Hearing at Kresge Hearing Research Institute at the University of Michigan run by Dr. David Kohrman (http://www.khri.med.umich.edu/training/senseprogram/summer.php)
- Summer Internships for Deaf and Hard of Hearing Students in Molecular Genetics and Environmental Science at Gallaudet University run by Drs. Derek Braun and Caroline Solomon (http://www.gallaudet.edu/Biology/Molecular_Genetics_Laboratory/Summer_Internship_Opportunities.html)

- Summer Internships in Deaf Health Research at the National Center for Deaf Health Research at the University of Rochester led by Dr. Nancy Chin (http://www.urmc.rochester.edu/ncdhr/?redir=www.urmc.edu)

This material is based on work supported by the National Science Foundation under CNS-0837508 and MCB-1232380.

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Chapter 4: Experiences of Deaf and Hard of Hearing Professionals

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Introduction

Experiences of deaf and hard of hearing professionals within STEM fields vary by work setting (e.g., industry or academia) and preferred mode of communication. This chapter includes input from several of the workshop participants as well as communications with various professionals. For this chapter, we include experiences of scientists, engineers, and mathematicians with advanced degrees (M.S., M.S.E., Ph.D.) in STEM disciplines. Because M.S. and M.S.E. are terminal degrees in many fields (e.g., engineering and geosciences), we have included their experiences here. For the most part these degree holders work at corporations (both small and large), government laboratories or agencies, and academic institutions. While some challenges are unique to the type of employer, success with all employers requires meeting the challenge of fostering effective interactions between deaf and hard of hearing employees and their hearing colleagues, managers, clients, and/or students.

Deaf and hard of hearing people have different experiences as professional scientists and engineers depending on their preferred mode of communication (i.e., spoken vs. signed language) and preferred mode of accommodation in the workplace (e.g., technology, interpreters). Regardless of the communication and accommodation approach, many challenges are common to all deaf and hard of hearing people. As such, we structured this chapter with these commonalities in mind and specifically address issues that are distinct to one communication mode or another. This chapter comprises of three sections that outline typical experiences and challenges of deaf and hard of hearing STEM professionals over the course of their career: (1) getting started in the workplace, (2) succeeding in the workplace, and (3) advancing their career.

Getting started in the workplace

The most critical step in a deaf or hard of hearing individual's career development is landing a job that is intellectually stimulating and professionally rewarding while providing a supportive environment. Personal narratives presented at the workshop reveal that this stage is frequently when deaf and hard of hearing scientists, engineers, and mathematicians leave their trained fields.

Acquiring employment. Deaf and hard of hearing STEM professionals often receive conflicting advice on whether they should reveal their disability on a resume or CV, as a candid statement that the applicant is deaf or hard of hearing can have benefits and drawbacks. The appropriate approach may depend on the specific employer.

Some employers have publicized mandates to improve the representation of people with disabilities in their workforce. The most notable example is the nation's largest employer, the federal government, which specifies nine "targeted disabilities" (of which hearing loss is one) as those most likely to result in job discrimination. To facilitate the job application process for professionals with targeted disabilities, the government hosts USAJobs, an online and accessible employment clearinghouse that lists federal job opportunities. Furthermore, in 2010, President Barack Obama signed executive order 13548, *Increasing Federal Employment of Individuals with Disabilities*, which encourages federal agencies to recruit, hire, and retain staff that includes individuals with targeted disabilities (White House 2010).

In the private sector, the National Academies has made it a priority to improve the disproportionately low representation of members from minority groups in STEM fields (National Research Council 2011). While not required to meet a specific quota, many large corporations are eager to hire employees with disabilities in an effort to diversify their workforce. For these companies, disclosure in the application letter may improve hiring chances.

Meanwhile, one drawback to revealing a disability on the CV is the perception among some potential employers that deaf and hard of hearing employees may require expensive accommodation or that they will not work effectively on teams with hearing co-workers (AMPHL 2011). Consequently, some deaf and hard of hearing job candidates might choose not to reveal their disability when applying for a job. Instead, they strive to pass as hearing individuals through an interview in order to postpone accommodation discussions for subsequent interviews if or when the job is offered. One workshop participant reported, *"When I was a freshman undergraduate I would not disclose that I was deaf on applications at that time. I don't know. I wasn't sure that they could tell."* In general, the most effective approach for a job seeker may be to indicate their hearing status on the CV, such as listing "ASL fluency" under language skills, and expand on the details at the interview. Another participant shared this perspective during a break-out session at the workshop:

> *I'm not sure that I would use the word "deaf" [on an application] but I would say I'm a member of the ASL community. It indicates that I have a language difference rather than a disability, because I can then indicate that I am going to be using ASL. If I were Chinese, I would indicate that I would be speaking Chinese. So that gives people an understanding of the fact that we are just simply using a different language.*

Regardless of whether deaf and hard of hearing job applicants reveal their hearing status on a CV/resume, job candidates who require interpreters or technology (e.g., Communication Access Real-time Translation, CART) will need to make arrangements for these services if they are invited to interview. Because the Americans with Disabilities Act (ADA) requires employers to provide reasonable accommodations for interviews (2009), employers may associate the costs and extra administrative hassle for these services with deaf or hard of hearing candidates. Employers might consider that deaf or hard of hearing candidates need to be "good enough" to deserve their salary as well as the cost of the interpreter/CART needed for day-to-day work. Such thinking can compromise candidates' success early in the interview process as opposed to focusing on their skills. As one workshop participant said, *"[The focus should be on] presenting as the best candidate for the job and advancement into top management positions without burden or worries of accommodations."*

It should be noted that the costs of accommodating deaf or hard of hearing employees may be a greater burden for fixed budget academic institutions than for corporations with large profit margins.

Most workshop participants strongly believed deaf and hard of hearing STEM professionals may have better success seeking employment from companies and institutions that already have deaf and hard of hearing staff. These employers have a proven track record of supporting accommodations for deaf and hard of hearing employees and promoting their professional development. Some examples are academic institutions that serve deaf and hard of hearing student populations (e.g., National Technical Institute for the Deaf [NTID] and Gallaudet University) and government agencies (e.g., NASA, DOE, EPA, and NIH). It is not surprising that these institutions were well represented among participants at the May workshop. For example, one workshop participant remarked on how deaf employees at NASA worked effectively 10 years ago to improve interpreting services:

> *Even new deaf members [who join] our team are impressed with the interpreting services provided to them. Again it's because those of us who worked there at the time were developing [a] new contract [and] worked very hard to make sure that the interpreting services we received from that point forward were high quality.*

Because the deaf community is very strong and visible in areas with large residential schools and colleges for the deaf (e.g., Washington, D.C., Rochester, NY, Texas and California), some participants perceived that jobs with more support may be easier to find in these areas. These regions also may have more government agencies that actively recruit deaf and hard of hearing individuals. One participant reported, *"I believe it may be more difficult to get into companies and corporations outside of the D.C. area."* However, many of the employed workshop participants came from outside the D.C. area, thereby demonstrating opportunities for great STEM careers exist throughout the country. We hope job seekers do no limit themselves geographically.

Negotiating accommodation. Upon hire, deaf and hard of hearing STEM professionals may address accommodation needs during the negotiation process. The negotiation process depends on the size of the workplace. Large corporations and government agencies typically have greater support than smaller companies or agencies. These supports include not only funding for accommodations, but also comprise professional development for employees on diversity issues and training on appropriate practices for the betterment of the workplace. In contrast, smaller agencies generally rely on private donations, fundraising efforts, and educational outreach, so they may have less flexibility with their funding options for accommodations. Also, ADA law provides exceptions for private companies with less than 15 employees to compensate for the financial hardship (ADA 2009).

Within academia, universities focus more on accessibility for students than for faculty (Campbell et al. 2008). While Section 504 of the Rehabilitation Act of 1973 safeguards accommodations for students, it does not apply to faculty and staff. ADA law covers faculty and staff (ADA 2009), but the funding burden of their accommodation usually falls on departments rather than the central university budget. Because they often have fixed budgets, small departments might perceive accommodations, such as a full-time staff interpreter, for one faculty member as an undue financial burden and give favor to a non-deaf candidate (Woodcock et al. 2007). At the workshop, one participant, who is the only deaf person at her university, championed the value of having a full-time staff interpreter to facilitate communication for her hearing students in the classroom, in the laboratory, as well as at advising and other meetings. Having a designated interpreter well-trained in the research vocabulary and knowledgeable in the research culture allows the participant to focus on her job, and her productive record demonstrates her effectiveness. The participant also noted that it is best that the staff interpreter's contract be separate from the contract and negotiations of the deaf researcher. In this way, deaf researchers can negotiate their lab space, salary, and other related issues in a manner similar to hearing researchers without compromising these important factors for the staff interpreter. It should be noted that U.S. researchers who are funded by NSF are eligible for supplementary funding if special assistance or equipment are needed to enable people with disabilities (investigators and other staff, including student research assistants) to complete the work of the funded NSF project through Facilitation Awards for Scientists and Engineers with Disabilities (FASED 2002).

Succeeding in the workplace

Accommodations. A critical issue in the success of deaf and hard of hearing scientists, engineers, and mathematicians is effective accommodation to facilitate conversation with hearing colleagues. This accommodation may include sign language interpreters, CART services, transcription services, FM (personal frequency modulation) systems, notetakers, and instant messaging. While the workshop focused on the challenges of having adequately trained and skilled interpreters, we also present some challenges of these other accommodations.

The career success of a signing deaf professional can depend on the quality of the interpreters who work with them (Woodcock et al. 2007; Hauser and Hauser 2008). Not every certified interpreter is skilled or qualified to interpret advanced science topics. One challenge for interpreters of science is the lack of established ASL lexicon for science terminology (see Chapter 5: Technical Resources Available for STEM Students) and available training/workshops. Shared one participant:

> *Of course it's not my fault that the mentor and I didn't start off on the right foot because of the lousy interpreting services that were provided, but I was unhappy with the services given to me and I let the EEO office know that and told them they needed to provide qualified interpreters from that point forward. It was a long story and quite a bit of a battle I had to fight about receiving quality services. My job requires high-level terminology and therefore, the interpreters need to be prepared.*

When or if deaf and hard of hearing STEM professionals who use sign language interpreters in the workplace pick up on these cognitively inaccurate signs, they may need to adjust their thought processes to make sense of the message. To compound matters, while in the process of correcting a message, additional information may be conveyed and missed (Campbell et al. 2008). The best interpreters have a familiarity with the topic, facility for picking up new ideas, and an ability to communicate technical terms with conceptual accuracy. Consequently, deaf scientists often rely on designated staff interpreters or request the same sub-set of interpreters to build a relationship with and enhance the background of these capable interpreters. One workshop presenter explained:

> *I told them that … a staff interpreter would be more cost effective than contracting out interpreting services. I also wanted to make sure that we*

didn't lose any of our flexibility with hiring interpreters that we felt would be a good fit. I found an interpreter who wanted the staff position. And I can't overemphasize how much it was worth it. I think that not only was it more cost effective to hire the staff interpreter, you also didn't have to worry about the logistics of arranging a new interpreter every so often. We had a consistent interpreter who knew my work.

Several online databases with ASL signs for technical and scientific terms/concepts are available, and they serve as important resources for interpreters to train for science interpreting as well as for hearing scientists who want to sign with their deaf colleagues. (See Chapter 5: Technical Resources Available for STEM Students for more information about these resources.)

Another aspect of working with interpreters is they may only be provided for formal meetings, yet scientific communication frequently happens in the lab and in hallways. Consequently, deaf employees may be left out or have limited participation in these informal settings.

Hard of hearing and non-signing deaf scientists, engineers and mathematicians often use various types of technology to access conversations with hearing colleagues. A common misconception is that hearing aids correct hearing loss like eyeglasses correct vision (Woodcock et al. 2007). Even with hearing aids some deaf and hard of hearing individuals require transcription services, FM systems, or captioning for group meetings and presentations. Like all technology, these systems are effective when they work but are subject to occasional complications such as dead batteries, technical glitches, and slow Internet connections. Real-time captioning suffers some of the same issues as sign interpreting as it requires a transcriptionist who is familiar with the technical concepts and terms.

The accommodation challenges discussed here have focused on large group settings, such as brainstorming meetings, because these are the situations that are most difficult for deaf and hard of hearing STEM professionals. For one-on-one and small group discussions, deaf and hard of hearing people successfully use a wide range of approaches. Instant messaging and email have greatly facilitated communication between deaf and hearing professionals. If the group is well-functioning and understanding, they will use whatever approach works (e.g., repeating, writing, or typing) so that all members of the group can participate.

Networking. While having excellent independent and teamwork skills is important to job success, networking is by far one of the most effective means for professional growth. By interacting with others, STEM professionals—both deaf and hearing—learn new approaches and alternate viewpoints on issues, which is critical to their work. When much of this networking occurs as informal discussions in hallways, in lab, and around coffee pots, deaf and hard of hearing employees can be excluded. When deaf employees are left out of these spontaneous discussions, they can be mistakenly perceived by hearing co-workers as "aloof." These attitudes can exacerbate the exclusion of the deaf employee to the point where they feel socially isolated.

The same networking challenges arise at professional conferences. While accommodations can be arranged for formal presentations, the networking critical to career success happens after hours when accommodations are not available. To succeed with after-hours networking, deaf and hard of hearing professionals may need to write on paper or use an iPad, tablet, or computer, but without a doubt, the best tool for successful networking is their own positive attitude and ability to create innovative solutions. One collaborator shared her experience:

> *In my 22 years of working, I've learned to identify the person who speaks the most or the loudest and buddy up with that person. Or, I'd make sure I'm sitting or standing next to that person. This person can be a strong "sponsor" or communicator or advocate for me, depending on the chemistry and situation. An excellent example was when I was working on a collaborative research project for 3 months; I didn't have a sign language interpreter. Instead, I found a small group of scientists who I was able to communicate and form bonds with during the first week of arrival. We helped each other out with the research project and language communication since some of them needed to practice their spoken English. One colleague wanted to practice his ASL, while I practiced my spoken and written French. This collaborative situation benefited us quite well.*

Another professional shared some advice:

> *If I must lipread in a small group conversation, I position myself near the person most people want to impress, because that is the direction they will face. They will always forget to look at me in their enthusiasm to talk about the subject matter of the discussion, and it's often not worth sacrificing good rapport just to get content.*

If not resolved, social isolation can lead to job dissatisfaction that prompts deaf and hard of hearing STEM professionals to leave the field. To avoid this vicious cycle, deaf and hard of hearing scientists, engineers, and mathematicians must make extra efforts to network with colleagues, ask questions, be friendly, and nurture their networks. Some of this can be done by email and online social media (e.g., Twitter, LinkedIn, Facebook, ResearchGate, Academia.edu) but face-to-face networking is always more effective when possible.

Educating co-workers and employers on deaf and hard of hearing issues. Deaf and hard of hearing STEM professionals working in hearing environments often serve as ambassadors for deafness by informing their co-workers and managers about Deaf culture as well as accommodation issues (Woodcock et al. 2007). This puts an extra burden on the deaf or hard of hearing person. One workshop participant reported:

> *There was a program specialist—the disability program coordinator—[who] I was able to work with. I talked to them about not requesting interpreters [at the] last minute. I talked to them about the experience of being deaf and what my needs were as a person with a disability, them making the decisions for me seemed very -- it put me at a disadvantage. It was very unacceptable. So again, I just continued down my path explaining my issues to them, explaining my concerns, trying to get the appropriate services that I needed.*

Educating managers about deaf and hard of hearing issues can be tricky and depends on the interpersonal dynamics between the manager and subordinate. One workshop participant shared:

> *Now, my supervisor at the time presented some challenges. As a supervisor this person was outstanding. But I realized I had to teach him how to communicate with me. He had an ego that was quite sizable and thought that he didn't have anything to learn. So this was a challenge for me in trying to show him that he did have to learn how to communicate.*

Furthermore, deaf and hard of hearing STEM professionals may be asked to serve on more committees than their hearing peers to provide a disabilities viewpoint for the committee. While some professionals may welcome the opportunity to educate the broader community on deaf and disability issues, the result is time drawn from doing their job. This challenge may be similar to those experienced by women and minority scientists, engineers, and mathematicians.

Working in the field or overseas. In addition to establishing an effective work environment in the office, some deaf and hard of hearing scientists, engineers and mathematicians' jobs take them out of the office and into the field. Working outside comes with its own delights and challenges but for deaf and hard of hearing professionals, arranging accommodations can be significantly more difficult. Suitably skilled interpreters may not be available in remote or international regions, although the latter is improving with the formation of international interpreting agencies, such as European Forum of Sign Language Interpreters (http://efsli.org) and Overseas Interpreting Co. (http://overseasinterpreting.com). Weather conditions (e.g., wind, rain) may render hearing aids and FM systems useless and, unless both wide bandwidth wireless Internet and electricity are available, transcription and CART systems will not work in the field. Under such conditions, deaf and hard of hearing scientists depend on their resourcefulness (e.g., using paper and pen or iPads)—along with patience and good humor—to get the job done. As with in-office work, success depends a great deal on the attitudes and creative problem solving skills of the individual.

Career advancement

Mentoring. Mentors fill important roles for all of us. Packard (2003) delineates seven different roles for mentors: (1) chairperson, (2) peer coach, (3) teammate, (4) insider's guide, (5) developer, (6) sponsor, and (7) sage advice guide. A good mentor need not fulfill all of these roles, but good mentors for deaf and hard of hearing scientists, engineers and mathematicians should understand the challenges for deaf and hard of hearing people. As one workshop participant noted, *"There is no [such] thing as a perfect mentor, but you can collaborate to make it work."*

The best practice may be to use a mentoring team (Packard 2003). Further, it would be ideal to have at least one mentor on the team be deaf and hard of hearing themselves. A closer mentoring relationship can be forged through sharing common experiences and also by being able to converse in the same language without interpreters.

To find effective mentors, deaf and hard of hearing students need to network with deaf and hard of hearing STEM professionals. Yet, finding other deaf and hard of hearing people at professional meetings is difficult. Professional societies are not allowed to share names of other individuals who have requested accommodations, so the only way to meet others in the field is if they happen to see a sign language or spoken language interpreter in the front of the room, someone signing or wearing a hearing aid or other indicator of having a hearing loss, or the use of technology (e.g., CART) during a presentation. That said, such encounters do not always give rise to long-lasting mentoring relationships, especially if one of the parties is not interested in being associated with the deaf, deafened or hard of hearing communities (Woodcock et al. 2007). The workshop —the first of its kind—brought together deaf and hard of hearing scientists, engineers, and mathematicians, and these types of opportunities should be expanded and repeated to build and strengthen mentoring networks. Since the workshop, a Facebook page has been established, and an email list has been used to facilitate distribution of helpful information among and networking between deaf and hard of hearing scientists, engineers, and mathematicians. (See Chapter 7: Where Do We Go From Here? for more information.)

Professional conferences. A critical part of professional development for STEM disciplines is participating in conferences and workshops. As mentioned earlier, these are critical settings for networking. In addition, these conferences and workshop provide a venue for STEM professionals to showcase their research or contribute to their discipline through participation in discussions and planning meetings. Careers are advanced by building a good reputation, and one approach to develop a standing as a good scientist, engineer or mathematician is to provide thoughtful questions and provocative ideas at professional conferences and workshops.

These settings are challenging for deaf and hard of hearing people because most professional discipline meetings are designed for hearing people and are usually intensely oral with ongoing presentations that can last for several consecutive days (Woodcock et al. 2007; Campbell et al. 2008). Similar to non-native English speakers at such events, deaf and hard of hearing attendees cannot interact with other attendees in their preferred communication mode and may be exhausted and feel isolated at times. Even hard of hearing people who use spoken English as their preferred language struggle with the background noise that accompanies large gatherings. Conferences can often be endurance events for all participants, and doubly so for those who must contend with a higher workload, such as interpreter preparation, poor lighting, background noise, and information overload.

The meeting rooms at professional meetings are often dark to show slides but this hinders speech reading and seeing the interpreter. Furthermore, when slides are faint or poor quality, session organizers tend to turn off most lights. Deaf and hard of hearing attendees then have the choice to either interrupt the presentation to request the lights be turned back on or miss the presentation and wait until the end to educate the light operator and session chairs about their accommodation. In a small and informal venue, interrupting can be the best option and serves to remind everyone of the varying accommodations needed by different attendees; however, at large formal presentations (>200 people) interrupting is perceived as rude.

Deaf and hard of hearing conference attendees need to consider the lag time required for conveying a spoken presentation into visual form (whether by interpreter or CART). Interpreting a linear language such as English into a multi-layer language such as ASL is complex and requires additional time. Compounding the problem, when a presenter points to a PowerPoint slide or is ready to proceed to the next one, the interpreter is often behind. Inevitably, deaf and hard of hearing individuals will have missed some of the content, especially when trying to watch the interpreter and read PowerPoint slides simultaneously. For those who rely on speech reading, presenters often speak at a faster rate than normal, especially when given a short time limit, which increases the difficulty of speech reading.

On the other side of the podium, deaf and hard of hearing presenters must also take lag time in consideration. If working with an interpreter, the deaf presenter will likely need to reduce the contents of the presentation in order to complete the session within the limited time. The reduction of contents may be perceived as insufficient or inadequate compared to presentations conveyed in spoken languages. Some deaf scientists have found creative solutions by building voice into their presentation either using computer programs or using skilled and familiar interpreters from their own workplace. This type of presentation preparation is more time-consuming but tends to relay a more accurate message about the deaf researcher's work.

At large national and/or international meetings, there may be several relevant sessions at the same time and hearing attendees move freely from room to room. With interpreters, one can change rooms easily but setting up the interpreters in a good position within each new room can be a challenge. Changing rooms is far more complex with CART or FM systems, which require connections to the Internet, electricity, or audio systems.

In general, STEM professionals report that the organizers of large conferences are responsive to the accommodation needs of deaf and hard of hearing attendees. Most large conferences organizers recognize the importance (and legal requirement) to provide interpreters, CART, or FM systems to attendees who request these services. Although conference registration forms have a box about accommodation requests, it should not be assumed that providing this information guarantees accommodation, especially if the requester is unknown to the conference organizing staff. Accommodation requests should be made directly to the conference organizers at least one month prior to the meeting. Participants reported that their need for the accommodation was sometimes questioned and tested the first few times they attended a particular conference. Figuring out the most effective accommodation for the conference may take a while to perfect. For example, convention centers provide FM systems for conference use, but these systems are usually very weak and only help for mild hearing loss. Furthermore, some FM systems are offered with headsets that are not compatible with hearing aids. Arranging for telecoil loops and similar technology involves not only working with the conference organizers but also with convention center AV staff. Some deaf and hard of hearing STEM professionals find it more effective to bring their own personal FM systems to plug into the conference AV system in order to guarantee adequate amplification. Similar issues arise with arranging interpreters where deaf professionals may prefer a specific interpreting style (e.g., American Sign Language, Pidgeon Signed English, Cued Speech), requiring the conference organizer to be educated before making the appropriate interpreter request.

The organizers of small conferences sometimes balk at the cost associated with providing interpreters. One STEM professional, who often travels with interpreters paid by his/her university shared:

> *[For] other specialized societies, standards committees and industry functions, I generally have [my university] pay. My reasoning is that even though I am contributing to the entity or event, I am equally benefiting in relation to my research program, which is part of my job; hence, my employer is responsible for the accommodation. These organizations are often quite small and lean, to the extent that it often does qualify as a hardship.*

This approach can be especially helpful for international conferences, where interpreting in the professional's natural language may not be available. Another benefit is that the interpreters from the professional's university may already be familiar with the terminology and context of the research.

Conference calls. With airfare increasing and concerns to reduce carbon footprints, we are seeing increased emphasis on conference calls and remote-conferencing between STEM professionals. For small group discussions text-chats work very well, providing both accessible communication and a record of the discussion that is useful for future reference. Another benefit of text conferencing is the text signal is not as vulnerable to Internet traffic as audio and video, which can freeze when traffic is heavy. For larger or more formal groups, deaf and hard of hearing professionals have used team interpreters, VRS (video relay service) with and without VCO (voice carry over), and remote captioning. When using these services the group leader should insist that each speaker identify themselves before speaking, because this information is lost through the interpreting thereby making it difficult to follow the discussion.

If a group is deciding between text and video chat, the fees associated with team interpreting and captioning services can persuade participants to opt for text-based conference calls. One benefit of using a computer with Skype or similar software is users can have video and text windows open simultaneously. If the participants decide to use a video with audio mode for the conference call, having text on the same screen as audio provides easy switching of communication modes from oral to text when a deaf or hard of hearing person needs clarification. Furthermore, hearing aid users can directly link to the computer audio output via Bluetooth, which can provide clearer amplification. Another strategy for conference calls that focus on shared documents is to collocate with a hearing colleague who can relay the non-visual information. Some remote conference programs, such as Google+ Hangout and Adobe Connect, provide auto captioning. With both programs there are additional costs and set up time required to implement the captioning option. At this time the authors have not heard reports of how these systems perform.

Moving into management. One of the greatest aspects about being a manager and/or a principal investigator (PI) is being able to control the communication style of the work group. For deaf and hard of hearing managers, this means they can establish communication pathways that work best for them. One workshop participant reported:

> *I'm at the stage of my career where I have the skills and experience to lead and spearhead team meetings. In this situation, I keep the size small, with approximately six managers. They each look at me and make sure that I understand what they're saying. Other times, we meet individually or communicate via email. For meetings that are being led by the CEO of the company or other senior executive management team leaders, I request sign language interpreters.*

For informal communication, deaf and hard of hearing managers may rely on email, instant messaging, texts, and other text-based communication modes. When such managers are available online for instant chats, issues can be resolved promptly resulting in a flexible and effective work environment. For formal face-to-face meetings the manager might set up both one-on-one and small group meetings around a table with ample light, a white board and suitable accommodation (e.g., interpreters), creating a work environment that is accessible to all participants. One professional emphasized the shared responsibility of communication with supervisees:

> *When I meet with my supervisees, I lipread and speak to them. I make it clear that we are both responsible for communication and I will answer the questions I think they have asked, and don't judge me if what I say isn't relevant. It means they have to ask the question differently, either rephrase or do it by email.*

Hearing supervisees of deaf managers report they readily adjusted to the deaf or hard of hearing manager's communication style. One invited workshop presenter interviewed hearing students in her class who relied on an interpreter to follow her lecture. She discovered, *"The communication differences didn't matter, and I was very happy for these positive reviews for my colleagues."*

Conclusion

To succeed at a career in STEM fields, deaf and hard of hearing professionals need to spend more time planning activities and arranging accommodations than their hearing peers (Woodcock et al. 2007), essentially adding to their workload. The largest obstacles to success may be attitudes and perceptions of hearing people toward their deaf colleagues, staff, and managers. Many workshop presentations mentioned that deaf and hard of hearing scientists must be flexible, persistent, and creative with problem solving. Most importantly, they must maintain their good humor and confidence. At the core of many issues is working patiently and openly with others to find effective solutions that serve everyone.

Acknowledgements: Thanks to Linda Campbell, Angela Lee Foreman, Harry Lang, Scotty Salamoff, Caroline Solomon, and Kathryn Woodcock for input on their experiences.

This material is based on work supported by the National Science Foundation under CNS-0837508 and MCB-1232380.

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Chapter 5: Technical Resources Available for STEM Students

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Introduction

Deaf and hard of hearing students in STEM fields often encounter barriers including lack of adequate captioning and sign language interpretation. They also encounter visual barriers in the learning environment, such as when instructors use visual aids that are optimized for listening and not viewing, thus forcing students to juggle simultaneous visual inputs from the instructor, the visual aid, and the interpreter or captioning. Although these issues are not specific to STEM fields and are present throughout deaf education generally (Lang 2002; Marschark et al. 2006; Pelz et al. 2008), the technical nature and vocabulary of STEM disciplines exacerbates these issues. The 2008 Summit to Create a Cyber-Community to Advance Deaf and Hard of Hearing Individuals in STEM, held at the National Technical Institute for the Deaf (NTID), attempted to address and identify solutions to many of these challenges (http://www-staging.rit.edu/ntid/cat/sites/default/files/SummitReport_final2009.pdf).

In the remainder of this chapter we address resources in (1) sign language, (2) real-time captioning, and (3) making STEM education more visually accessible to deaf and hard of hearing students.

Sign language

As the number of deaf and hard of hearing students in STEM fields grows, American Sign Language (ASL) will need to include more STEM terminology. This will enable improved access to scientific communication among deaf and hard of hearing students and scientists.

Most often, rarely used terms in ASL are fingerspelled. However, as these terms are increasingly used, the community often develops signs for them. Likewise, in STEM fields, seldom-used scientific terms are frequently fingerspelled while common terms more often have standardized signs. However, even some rarely used terms have signs. In some cases, a scientist, instructor, or interpreter may introduce the sign. Research indicates that terms represented by single signs are recalled better than fingerspelled terms or those represented by compound signs (Lang and Pagliaro 2007). Thus, using single signs rather than fingerspelling (or compound signs) in STEM, regardless of how often a term is used, may benefit students. It must be recognized, however, that some technical terms are difficult, if not impossible, to represent with a single sign. When this occurs, instructors may use additional graphics and/or examples to clarify the communication of the scientific content.

Frequently, STEM terms have been invented by scientists who discovered or invented the phenomena. For example the term “electron” was first coined by Irish physicist George J. Stoney in 1891 as a combination of “electric” and “ion,” terms which were already in use. In other instances the STEM term is borrowed directly from common use but given a new, scientific meaning. The term “group,” for example, has a specific meaning in mathematics (a set of objects with a single operation which is associative, has an identity object, and has inverses for all objects). The French mathematician Évariste Galois invented the mathematical concept of a group around 1830 and simply used the French word “groupe.” In other cases scientists coin scientific terms using Greek or Latin etymology. The amino acid “tyrosine,” named by German chemist Baron von Justus Liebig in 1846, references “tyros,” which means cheese in Greek, because it was easily obtained from old cheese. One important fact about scientific terms is that the trend toward convergence is strong; that is, several terms for a single concept might come into existence around the same time, but usually one or just a few survive over time. Having one or just a few terms for one concept helps scientists communicate with each other in an accurate, scientific manner.

Like STEM terms used in spoken language, signs for STEM terms are also invented by people who need them: deaf STEM students and professionals, and their sign language interpreters and hearing instructors. For the most part STEM terms in spoken language already exist and possess a given meaning, and these terms are often given a sign to represent them. In some cases, the sign for a term is a commonly used acronym for that term. For example, fingerspelling “DB” is a commonly used sign for database. In other cases, a sign might somehow conceptually represent the term. For example, a common sign for DNA uses two hands to show the shape of a double helix (see http://aslstem.cs.washington.edu/topics/view/1531). Iconically based signs have the advantage that they may be easier to remember and invoke the concept the term represents. Nevertheless, deaf and hard of hearing individuals may still use different signs to represent the same term, such as fingerspelled DNA, DOUBLE HELIX, and SPIRAL for DNA. Importantly, those who invent STEM signs should be both content experts with degrees in the field and experienced signers (Lang et al. 2007).

One major issue for signs in STEM fields is how they are disseminated. The signs for the same term may differ significantly from one environment (university, K–12 school, scientific laboratory) to another. The resulting diversity of signs for the same scientific concept may cause confusion and misunderstandings between deaf and hard of hearing people in the larger STEM community. Thus, standardization of STEM signs is important for the evolution of STEM signs. Dissemination through different websites (listed below) increases the chances for standardizing the use of conceptually accurate signs.

Gallaudet University, NTID at Rochester Institute of Technology, and California State University, Northridge have large enrollments of deaf and hard of hearing students. STEM signs developed at these institutions are likely to see significant usage by their students and professors, and these signs will likely be used over time. However, the majority of deaf and hard of hearing students in STEM fields are dispersed among mainstream schools and universities around the country. In 2008–2009, over 70% of all postsecondary institutions—and nearly 100% of all large postsecondary institutions—had at least one deaf or hard of hearing student (Raue and Lewis 2011). In many cases there may be only one deaf or hard of hearing student in a particular STEM major at a given institution. Reaching these students and their interpreters is critical in order for them to benefit from shared expertise and knowledge about conceptually accurate signs. Currently, the main approaches for dissemination of STEM signs are online resources, such as dictionaries and discussion forums, and dictionaries on DVDs.

The two major online resources for disseminating STEM signs are dictionaries and forums. A sign language dictionary is an edited compilation of signs. Through consultation with expert users, dictionary editors choose which signs will appear. Forums, on the other hand, are moderated communities, where users of the language contribute signs directly and moderators review discussions for spam and other misuse.

Currently, five major ASL dictionaries and one forum are available online:

- **Science Signs Lexicon** (http://www.rit.edu/ntid/sciencesigns/). Founded in 2001, the Science Signs Lexicon is a dictionary for STEM terms that was created at the NTID with funding from several NSF grants. Its history goes back to the NTID Technical Signs Project, which began in 1975, producing several STEM signs books and a series of videotapes. The research and evaluation-based lexicon currently has over 1,300 signs in various scientific disciplines, organized alphabetically and by discipline. For some terms several alternative signs are given. Many of the signs have illustrations, definitions, and notes about their use in different contexts. The lexicon also includes "General Tips for Signing in the Classroom," 16 videos demonstrating such issues as "What to do when a sign cannot be found," "Morphological Variants," "Two Dimensional and Three Dimensional Handshapes," and "The Issue of Using Initialized Technical Signs." Users of the lexicon can rate and comment on the signs via the website, and new signs can be submitted through a video recording option.
- **Math Signs Lexicon** (http://www.rit.edu/ntid/mathlexicon/). Maintained by Dr. Christopher Kurz at NTID, Math Signs Lexicon features a database of ASL signs for mathematics vocabulary and phrases, covering topics from general mathematics to calculus and statistics and probability. The goal of the lexicon is to provide conceptually accurate signs for vocabulary and phrases. The database includes sign videos, visual materials and texts for mathematics vocabulary. ASL videos of sentences containing the math vocabulary and phrases are included as well as ASL videos explaining different signs for the vocabulary. The targeted audiences are students, teachers of the deaf, mathematics teachers, and interpreters.
- **DEAFSTEM** (http://www.shodor.org/deafstemterms/). DEAFSTEM is a dictionary created by Shodor, a company that focuses on computational science education. The dictionary has over 600 signs with an emphasis on signs for mathematics and computing. For many terms a sign is given along with an explanation in sign language about why the sign's iconicity matches its meaning. The website also has a mechanism to comment on the signs.
- **Signing Math and Science Dictionaries** (http://signsci.test.terc.edu/). The Signing Math and Science Dictionaries for Grades K–12 were researched and developed by TERC—a not-for-profit educational research and development organization—and VCOM3D (with funding from NSF and the U.S. Department of Education). The dictionaries include many of the standards-based terms that students encounter when studying topics in physical science, life science, earth science, and mathematics. Each dictionary incorporates illustrations and English text as well as Signing Avatars© to convey the meaning of each term and its definition in ASL and Signed English. The dictionaries include over 5,500 terms and 5,000 signs, organized alphabetically, and also Spanish versions of the terms

and definitions for one of the dictionaries for grades 9–12. Signing apps for use with an iPad or iPod Touch are available from iTunes for the dictionaries for grades K–8 (http://www.signingapp.com/index_desktop.html).

- **Texas Math Sign Language Dictionary** (http://www.tsdvideo.org/). The Math Sign Language Dictionary was created at the Texas School for the Deaf. It has over 500 signs in mathematics. For many terms, the sign given is simply a fingerspelling of the term.
- **ASL-STEM Forum** (http://aslstem.cs.washington.edu). The ASL-STEM Forum was created at the University of Washington in 2009 with assistance from both Gallaudet University and NTID. The forum is actively growing and features nearly 8,000 STEM terms and 3,000 STEM signs. The terms are organized by discipline and subdiscipline. Terms are added by students and professionals, although signs can be suggested and uploaded by anyone. Signs are stored on YouTube for accessibility to a larger community. A rating system for signs allows for convergence to one or two signs per concept, and comments on signs can be posted to facilitate discussion about the appropriateness of a sign.

Collaboration exists among some of these projects. For example, TERC's physical science and life science dictionaries are being developed through a five-year grant whose co-PIs include the developer of the Science Signs Lexicon. The staff collecting, evaluating, and recording the signs include advisors from such universities as NTID and Gallaudet University, some of whom also contribute to the ASL-STEM Forum. Content experts in chemistry, physics, biology, and other areas discuss signs for the avatar dictionary work and simultaneously update the Science Signs Lexicon and ASL-STEM Forum.

Development of STEM sign resources in other sign languages, such as British Sign Language (BSL), is also available. Some of the signs might be useful and acceptable in ASL. Currently, two UK resources are in use:

- **Science Signs** (http://www.sciencesigns.ac.uk/). Science Signs was started in 2005 at the University of Wolverhampton for deaf students, professionals, and their interpreters.
- **Scottish Sensory Center** (http://www.ssc.education.ed.ac.uk/bsl/list.html). This project involved consultative meetings between the Scottish Council on Deafness, the Scottish Qualifications Agency, Learning and Teaching Scotland, staff from Moray House School of Education at Edinburgh University, and sign-bilingual teachers for deaf students in Scotland in 2003–2004.

Real-time captioning

Deaf and hard of hearing STEM students can benefit greatly from verbatim (word-for-word) or edited real-time captioning in lectures and meetings. Captioning in STEM fields can be challenging, because of the specialized language that is used and the captioner's degree of familiarity with the terms. An analysis of STEM lectures showed these lectures had approximately twice as many distinct words and were about 30 percent faster than TV programs (Kushalnagar et al. 2012). Currently, three main avenues for captioning exist:

- **Communication Access Real-time Translation (CART).** CART is provided by highly trained captioners who type in shorthand on special keyboards to keep up with natural speaking rates, word-for-word. Captioners normally undergo 2–4 years of training and must write 180 words per minute for 5 minutes with 96% accuracy (NCRA 2012).

Realistically, successful CART captioners must be able to type in bursts of up to 300 words per minute in order to consistently transcribe all real-time speech.

- **C-Print** (http://www.ntid.rit.edu/cprint/). C-Print and similar services respond to the high cost of CART by using a macro-based expansion approach that requires less training than CART. Although C-Print is not as expensive as CART, it is also not as comprehensive. Developed at NTID, C-Print is a kind of summarized transcription (Elliot et al. 2006). C-Print captioners balance the trade-off between typing speed and level of summarization, by providing a meaning-for-meaning, but not verbatim, translation of the spoken English content. C-Print enables operators who are trained in academic situations to consolidate and better organize text with the goal of creating a final product similar to class notes that may be more conducive to learning. C-Print's advantages are that C-Print captioners need less training and generally charge about half the rate of CART and that C-Print captures accurate meaning-for-meaning translations and its readability is high. Its disadvantage is that C-Print captioners normally cannot type as fast as the natural speaking rate nor can they produce a verbatim real-time transcript. More importantly, C-Print captioners can only effectively convey classroom content if they understand the content themselves. Researchers are investigating the feasibility of using crowds instead of professional captioners to provide real-time, word-for-word captioning (Kushalnagar et al. 2012, Lasecki et al. 2012).
- **Automatic Speech Recognition (ASR).** ASR platforms use probabilistic approaches to translate speech to text. These platforms face challenges in accurately capturing modern classroom lectures, such as extensive technical vocabulary, poor acoustic quality, multiple information sources, and speaker accents, to name a few. They also impose a processing delay of several seconds, and the delay lengthens as the amount of data to be analyzed increases. In other words, ASR works well under ideal situations, but degrades quickly in many real settings. Kheir and Way (2007) found that untrained ASR software had a 75% accuracy rate. With training, it could reach 90% accuracy in ideal situations with a single speaker, but this accuracy rate was still too low for use by deaf students. In the best possible case, in which the speaker has trained the ASR and wears a high-quality, noise-canceling microphone, accuracy can reach above 90%. However, when recording a speaker using a standard microphone on ASR not trained for the speaker, accuracy rates plummet to far below 50%. ASR continues to be an active area for research to improve its accuracy and to increase the number of environments in which it can be used.

Making STEM education more visually accessible to deaf and hard of hearing students

Deaf and hard of hearing students in the classroom must divide their visual attention between the teacher, the presentation, the interpreter or captioning, and their own note-taking. Moreover, issues such as viewing distance, obstructions, poor lighting, viewing angles, and missed audio cues may have a profound impact on deaf and hard of hearing students' visual perception and also limit their seating choices. In order to see everyone and participate in discussions, deaf and hard of hearing students might choose to sit in the back of the classroom. On the other hand, sitting in the back makes it difficult for students to understand sign language interpreters and read captions. Therefore, most deaf and hard of hearing students opt to sit in the front, so they can see information sources clearly. However, sitting up front may worsen viewing angles for visual aids and reduce students' viewing choices and sense of autonomy in their classroom learning and seating. For example, slides and other graphics can be hard to read when viewed at an extreme angle; likewise, interpreters who shadow instructors can end up in a location, which makes them hard to view. Despite suboptimal viewing angles, many students choose to sit in the front because the sign language interpreters and captioners prefer to sit in the front to better hear the instructor and see visuals, including slides (Kushalnagar and Trager 2011).

Because taking notes while watching the various visual components of a lecture is difficult, universities should provide notetakers for their deaf students. In addition, interpreters should work near the presentation screen, so they can easily point to items as needed. The Class Act website lists other techniques to help reduce visual dispersion for deaf and hard of hearing students in the classroom (http://www.rit.edu/ntid/drt/classact/).

At the K–12 level, several resources provide techniques to lessen the impact of competing visual demands, many of which can be adapted to postsecondary settings. For example, instructors can use simple pedagogical teaching tools, rather than technology, such as turn taking (by raising a pencil or a flag) and having an effective working relationship with the interpreter (Smith 2010). The National Science Teachers Association provides many resources on its website (http://secure.nsta.org), including a news bulletin that outlines different teaching tools for STEM K–12 classrooms (https://secure.nsta.org/about/pressroom.aspx?id=56080&print=true).

The ClassInFocus Project at the University of Washington explored the idea of putting all the visual elements of a lecture on one screen and allowing students to move the elements around to suit their needs. The elements include captions, interpreter (who could be remote), presentation slides, and instructor (Cavender et al. 2009).

The Accessible Viewing Device Project at Rochester Institute of Technology (http://www.rit.edu/ntid/avd) seeks to reduce the impact of visual “noise” in the classroom, such as bad lighting or poor viewing angles. It also investigates the idea of real-time replay to enable students to review missed visual information. If the student has missed important visual information from the interpreter or slide, they can rewind, review, and fast forward to catch up with the lecture. It also explores use of video enhancement algorithms, such as video zoom, to improve the viewing experience for deaf and hard of hearing students in the classroom.

This material is based on work supported by the National Science Foundation under CNS-0837508 and MCB-1232380.

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Chapter 6: Interpreting in STEM

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Introduction

Many deaf workshop participants cite a lack of qualified interpreters and difficulty accessing interpreting services as a major hurdle in their STEM education or careers. Because communication—both formal (classes or scientific meetings) and informal (hallway discussions, peer lunches)—is crucial to career growth, a lack of quality interpreting services can and does pose a major challenge for STEM professionals and students, both deaf and hearing.

To explore the issues and possible solutions to the challenges faced by interpreters in STEM fields, the workshop featured a panel discussion with interpreters who represent a broad range of experience in the field. Using the following questions, they explored issues such as how to prepare for STEM assignments and how to recruit more interpreters into the specialty.

How did you become interested in interpreting in STEM?

Most panelists reported having an interest in the sciences at an early age while attending primary and secondary schools, as well as postsecondary educational institutions. These interests led to a pursuit of knowledge and a foundational understanding of basic and complex concepts in STEM fields.

When embarking on interpreting careers, the panelists stated their educational interests enabled them to accept STEM interpreting assignments without feeling overwhelmed by or nervous about the material. This, in turn, led these interpreters to seek further information, knowledge, and the linguistic skills necessary to provide quality interpreting services in STEM.

One panelist reported that she actually became interested in the sciences primarily through working closely with a deaf scientist. Her growing interest then led to furthering her own education and linguistic skills to enhance her STEM interpreting.

How do you prepare for a STEM assignment? What external resources do you use?

The panelists outlined several strategies to prepare for interpreting assignments in STEM fields, including keeping abreast of emerging information in scientific fields through reading journals and/or listening to podcasts or recorded lectures. Some specific resources cited included:

- MIT and other postsecondary institutions' lecture archives

- National Public Radio (NPR) scientific broadcasts and podcasts
- Podcasts from both public and private institutions
- BrightStorm (http://brightstorm.com), which has online videos in spoken English presented at the high school level to assist students with STEM homework assignments
- Khan Academy (http://www.khanacademy.org), which has online videos in spoken English and text designed to teach various concepts in the STEM fields

Other helpful resources include the plethora of videos and vlogs on the Internet produced and posted by deaf professionals in various STEM disciplines. Interpreters tend to use these resources to see what sign vocabulary is being used by professionals and understand how they communicate the information in a visual rather than auditory modality. One panelist reported using study guides produced for college students and available at most bookstores to prepare for anatomy and physiology classes and the medical field in general.

Panelists also noted that the more experience interpreters have in various STEM fields, especially in the classroom, the less they need to prepare for certain assignments. For example, an interpreter who has interpreted five semesters of organic chemistry is better prepared for other chemistry-related assignments or bio-technology assignments than an interpreter who has no experience in chemistry. The latter interpreter must do much more preparation work to gain a basic understanding of the subject than the former, who can focus their preparation work on assignment specifics.

Interpreters who work primarily with deaf scientists and not students shared they collaborate with the scientists to identify resources that interpreters can use to prepare for specific assignments. These resources include PowerPoint presentations, presenter information, articles on specific topics being addressed in conferences and meetings, various Web resources, and "practice sessions" with deaf scientists who are presenting at conferences or meetings. An example of such collaboration is a website prepared by Susan Cargill at St. Mary's University in Nova Scotia, Canada, on interpreting for deaf academicians (http://www.smu.ca/academic/science/envstud/deaf.html).

The panelists unanimously agreed that the most important aspect of preparing for STEM assignments was working directly with deaf client(s) to ascertain their preferences for sign choices and other aspects of the interpreting interaction. Such information and preferences drive the interpreting process. Panelists also stated that interpreting in classroom settings and working with professionals in the field require different approaches and considerations by the interpreter. For example, expectations of a lecture in a classroom differ greatly from expectations of scientists doing field work. Discourse considerations also come into play in different settings, e.g., teacher-student vs. professional peer-to-peer interactions.

Are you familiar with or have you used the Science Signs Lexicon to prepare for STEM assignments? Are you familiar with or have you used the ASL-STEM Forum?

Most panelists were familiar with the Science Signs Lexicon and ASL-STEM Forum, recognizing these online resources as important and useful to interpreters working in STEM. However, they also noted STEM interpreters should not rely solely on these resources to prepare for assignments, because a conceptual, rather than a lexical, approach to preparation is often necessary.

That said, most panelists stated these online resources were of limited use to them for the following reasons:

(1) The jargon used in the resources was out of context. What interpreters experience during assignments is contextual, so while it is helpful to see signed vocabulary, it is not presented in a way that can be used in real and varying situations.
(2) The signs are not used widely enough to be recognizable across the country. Interpreters work with a wide variety of deaf individuals who come from various regions and who most often have their own set of sign vocabulary that has been generally agreed upon in their geographical area and discipline.
(3) The preferences of individual clients take precedence over Web-based tools.

All panelists agreed such resources would be more helpful if interpreters could access signed lectures or signed vocabulary presented in context (i.e., in sentences) via the Internet. They also stated that examples of scientific discourse presented in ASL would be extremely helpful.

What are some of the difficulties and challenges interpreters face working in the STEM fields?

The panelists reported experiencing several difficulties while working in STEM fields, couching their responses in terms of interpreting from ASL-to-English and English-to-ASL, as each presents its own challenges. In general, the panelists mentioned one of the most challenging aspects is the use of specialized jargon, both in ASL and English, in the various STEM fields and subfields. A thorough understanding of scientific discourse—genre, abstraction, jargon (in-context), nominalization, and multi-modality (Liberg et al. 2011)—is essential to providing a clear and coherent interpretation.

Challenges in ASL-to-English interpreting. One of the difficulties faced in STEM interpreting is pronunciation of specialized jargon. Interpreters must be familiar enough with general terminology to make educated guesses on how to pronounce specialized terms in spoken English. This challenge especially holds true for terms with Latin and Greek roots. One suggestion to alleviate this issue is to become familiar with how Latin and Greek roots are phonologically combined in scientific lexicon, as they span all STEM fields. Another difficulty is the interpretation of ASL classifiers into the appropriate technical/scientific English equivalent. All panelists agreed that familiarity with clients' communication styles and how they present technical/scientific jargon is one way to overcome this issue.

Challenges in English-to-ASL interpreting. All panelists agreed the most challenging aspect for English-to-ASL interpreting in all STEM fields was being able to visualize information as well as understand and use abstractions (e.g., chemical, mathematical, and engineering symbols, etc.). For example, in electrical engineering, the mathematical variable used to represent electrical current is *i*. Interpreters who are familiar with this abstraction might more accurately represent this concept by using the nonce sign *i* instead of *c* for electrical current. It should be noted that most interpreters, and especially those for whom ASL is a second language, shared this challenge, regardless of the fields they work in. Creating a visual representation (or representational schema) of STEM concepts requires a thorough understanding of the subject matter.

Panelists also reported lack of knowledge of signed lexicon in STEM fields—or simply lack of any such lexicon—posed interpreting challenges. Often, especially when working with students, it is the interpreter who assumes the task of identifying a specific sign to carry the meaning of a specific English word or concept. This strategy can lead to confusion and misunderstanding if the interpreter is unfamiliar with or does not have a foundational understanding of the subject matter.

The panelists unanimously agreed that it is easier and smoother to work with a specific client for an extended period of time as the "designated interpreter" (Hauser et al. 2008) in a particular field or as an interpreter in the classroom. This allows the interpreter and client to develop a rapport and shared ways of communicating. Having a designated interpreter also allows both the interpreter and client to become familiar with appropriate and acceptable placement and sightlines. Finally, this type of arrangement allows interpreters to gain and broaden their understanding of that particular discipline. Panelists noted that it was more difficult and challenging to work outside of the disciplines in which they most often interpret.

Finally, panelists admitted that it is challenging in some STEM assignments to express the content and not get lost in the words (although the words themselves are still valuable). In order to provide quality STEM interpreting services, interpreters must convey the equivalent content of the discourse, in both ASL-to-English and English-to-ASL interpreting, whether working with students in the classroom or working with professionals in the field.

How do you determine if you are qualified to work in certain STEM fields?

Panelists reported they relied mostly on past interpreting experiences and knowledge of certain STEM fields to determine if they were qualified for assignments in the classroom or in the field. All panelists mentioned that they had more familiarity with some STEM disciplines and less with others. For example, interpreters who are more familiar with biology and chemistry may elect to decline assignments in engineering or mathematics. Another determining factor was having deaf clients, especially those working as professionals in their given fields, request interpreters by name for specific STEM assignments. In some instances interpreters were not necessarily the most qualified, but the deaf client had an established rapport with the interpreter and was therefore willing to engage services and provide "on the job training." While this situation is not the most ideal, it often happens due to a lack of qualified interpreters for specific STEM assignments.

How do you approach working with qualified interpreters who are not knowledgeable about STEM fields?

Panelists discussed the value of communicating with non-STEM interpreters prior to an assignment to share information, resources (i.e., preparation material), and experiences in order to provide the most effective services. Interpreters should also address potential barriers—such as the perceived subordination of the non-STEM interpreter to the more experienced STEM interpreter—to ensure they do not inhibit effective team interpreting and to optimize the accuracy of the rendering of material.

How can we expand the pool of interpreters who are comfortable interpreting in STEM?

The panelists mentioned several strategies to expand the pool of interpreters who are comfortable providing services in STEM settings. Organized mentoring efforts and purposeful teaming with interpreters who want to enter STEM interpreting is one solution. These types of situations can be established in classroom settings as well as in the field when amenable situations arise. The difficulty of providing such opportunities lies in coordinating programs that will allow for mentoring and purposeful teaming. It is especially difficult for interpreters who work as independent contractors (as opposed to staff interpreters) to partake in these programs.

Panelists also discussed the importance of sharing knowledge and resources through networking as a way of generating interest in STEM interpreting. Experienced STEM interpreters might provide workshops and trainings at local, state, regional, and national levels as a way to generate interest. Unfortunately, and for various reasons, not many theoretical or skill-based workshops or trainings for interpreting in STEM fields are offered.

Finally, interpreter preparation programs can be another avenue to generate interest. Currently there are only two programs that offer specialty training for interpreting in healthcare settings, NTID in Rochester, NY, and St. Catherine University in St. Paul, MN. These programs help expand the pool of qualified interpreters in the medical field. If more programs offered such specialties in the STEM fields, it would generate interest and train more qualified interpreters. Most preparation programs do have specialized discourse classes, but these are not enough to provide the type of in-depth training an interpreter needs to qualify for work in various STEM settings upon graduation.

This material is based on work supported by the National Science Foundation under CNS-0837508 and MCB-1232380.

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Chapter 7: Where Do We Go From Here?

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Overall purpose of the workshop and white paper

The workshop brought together deaf and hard of hearing students and professionals as well as hearing individuals who are supportive of deaf and hard of hearing people in STEM. Workshop evaluations indicated the goal of bringing together deaf and hard of hearing people in STEM fields to network and begin productive and lasting mentoring relationships was successful.

The opening keynote addresses established the tone of the workshop, providing inspirational messages and introducing the idea of meaningful mentoring relationships. The keynote speaker, Harry Lang, professor emeritus, National Technical Institute for the Deaf at the Rochester Institute of Technology, outlined some of the many contributions deaf and hard of hearing people have made over the centuries in diverse fields of STEM. Lang has written several books and articles on the historical contributions of deaf scientists, engineers, mathematicians, and inventors, including: *Silence of the Spheres: The Deaf Experience in the History of Science* (Lang 1994), *Deaf Persons in the Arts and Sciences: A Biographical Dictionary* (Lang and Meath-Lang 1995), and *Contributions of deaf people to entomology: a hidden legacy* (Lang and Santiago-Blay 2012). His keynote provided workshop participants with a rich history of deaf and hard of hearing people who overcame communication and attitude barriers to succeed in STEM fields. Next, Becky Wai-Ling Packard, professor, Mt. Holyoke College, defined the different types of mentoring relationships and essential parts of the mentor-mentoree relationship. Her talking points resonated with workshop participants, and the principles of mentoring underrepresented groups in STEM, such as women, have implications for mentoring deaf and hard of hearing people (Packard 2003; Packard and Nguyen 2003).

The remainder of the workshop was a mixture of panels, presentations, and breakout sessions that allowed for interaction, inspiration, networking, and mentoring opportunities between workshop participants.

Evaluation of the workshop

As shown in the remarks on the evaluation forms, the aims of the workshop were clearly accomplished. The following responses to the question, "What did you like the best about the workshop?" illustrate participants' overall sense of satisfaction:

> *"The networking, observing scientists from different disciplines talking about their work"*
>
> *"Sharing STEM interests together"*
>
> *"Inspired me! Knowing that there are so many deaf and hard of hearing people in the science field"*
>
> *"The breakout sessions—they were very informative"*
>
> *"Networking and meeting new people"* (made by several participants)
>
> *"Very inspirational, informative, and resourceful"*

"Content and purpose excellent"

Overall, many participants found the workshop to be very beneficial, and they wanted future workshops to continue networking and exchanging information (Table 4).

Table 4. Results from the end-of-workshop evaluation

Question	**Yes**	**No**	**Unchecked**	
Overall, did this workshop meet your needs?	86%		14%	
	Excellent	**Good**	**Fair**	**Poor**
I found the amount of interaction and discussion in the design of the workshop to be:	48%	52%	**0%**	**0%**
I found the presenters to be:	83%	17%	**0%**	**0%**
Please rate your overall reaction of the workshop.	59%	41%	**0%**	**0%**

Several participants made useful suggestions for future workshops in response to the question, "What would you recommend to be changed or improved in future workshops?" For example, several attendees expressed a desire to hear more about individual deaf and hard of hearing professional's work in STEM as well as more examples of successful strategies and experiences with mentoring:

"Would like more networking and presentations by high school students, graduate students, and professors"

"Not enough of a showcase of individuals' work"

"Wish I met people in my field"

"The structure of the sessions sometimes inhibited more free-flowing discussions, rapport between participants"

"More than one session that I wanted to attend simultaneously"

Products resulting from the workshop

The first important outcome of the workshop was the desire of participants to stay in contact with other attendees for the purpose of networking and mentoring. During the last session of the workshop, participants discussed how to form a mentoring network. There was general consensus that a Facebook page would serve effectively as an initial starting effort that could be easily maintained. Immediately following the workshop, the coordinators established the Deaf and HoH Scientists, Engineers, and Mathematicians group at https://www.facebook.com/groups/163266577141486/. The Facebook group is advertised on Dr. Caroline Solomon's faculty Web page (http://www.gallaudet.edu/faculty-staff/biology/solomon_caroline.html) so that it can be found through various search engines. Currently, over 50 individuals have joined this group, and it continues to grow. In time, the Facebook group may transition to include access for those who do not use social media. The Facebook group has already shared information about various online resources and discussed topics, such as how to best interview for a job, obtain better interpreting services in graduate school, identify scholarship and internship opportunities, and handle conference calls.

The second important outcome of this workshop is this white paper, which disseminates the information that was discussed and includes information from research as well as a summary of the participants' experiences. Intended as a useful guide to current students and professionals in STEM areas, this white paper will be available on Solomon's faculty Web page and distributed through various national organizations for deaf and hard of hearing people, K–12 programs for deaf and hard of hearing students, university disability offices, the Registry of Interpreters for the Deaf, and other interested stakeholders such as the National Science Teachers Association (and its affiliated group, Science Association for Persons with Disabilities), American Association for the Advancement of Science (and its affiliated group, Foundation for Science and Disability), and the American Chemical Society.

Recommended future products

Workshop participants suggested several products that would be beneficial to them and future generations of deaf and hard of hearing scientists, engineers, and mathematicians. The NSF and other funding agencies are encouraged to support the following types projects in the future:

(1) **A lecture series of deaf and hard of hearing scientists discussing their research.** An example of this is found at TED.com, where deaf percussionist Evelyn Glennie discusses her creative and passionate interpretation of music (http://www.ted.com/talks/evelyn_glennie_shows_how_to_listen.html). An independently organized TED event (TEDx) for general topics in deafness has been launched (www.tedxislay.com) but no deaf or hard of hearing scientists, engineers, or mathematicians, with the exception of deaf linguist Carol Padden, have presented their own research through this venue. A lecture series would serve as inspiration to students and also would provide interpreters with the context they need to better prepare for interpreting assignments in STEM. In addition, it would serve as a form of networking to inform others in the field.

(2) **A database of professional societies and/or organizations that have experience with deaf and/or hard of hearing people in STEM.** This list would allow deaf and hard of hearing people to know which societies or organizations have been supportive of providing access to their members. If a professional society or organization appears to resist providing services, positive experiences and solutions from other societies or organizations could help in discussing and negotiating access for a conference or workshop.

(3) **A database of cued speech and sign language interpreters who have STEM interpreting experience, including their contact information and familiarity with STEM fields.** The purpose of this database is twofold. First, it allows those involved with mentoring of interpreting students to locate appropriate interpreters. Second, deaf and hard of hearing professionals can quickly and easily identify highly qualified interpreters for local, regional, and national STEM conferences and workshops.

(4) **A website that allows for mentoring and networking and that is available to all users (i.e., not restricted to Facebook); a clearinghouse for relevant research on deaf and hard of hearing people in STEM.** Rochester Institute of Technology was recently awarded a NSF grant (HRD-1127955) to establish the Deaf STEM Community Alliance (http://www.rit.edu/ntid/dhhvac) to provide academic support resources, such as remote tutoring and mentoring, communication access, and a virtual scientific community. Although

this project is geared toward the academic success of STEM undergraduate and graduate students, its model could be replicated on a larger scale to include other stakeholders, such as deaf and hard of hearing professionals, interpreters, and K–12 students and educators.

Summary

This workshop represented the first time in recent memory that a significant number of deaf and hard of hearing men and women from STEM fields met to discuss their experiences and share ways to enhance educational and employment opportunities. Our intention was to begin establishing networking opportunities and create a base of information for those who will enter undergraduate and graduate programs and the workforce in the future. The quantitative and qualitative evaluation data demonstrated that participants felt genuinely excited about the opportunities to proactively increase the number of deaf and hard of hearing people in STEM fields. The information gathered from presenters and panelists represented a first, meaningful step in developing a knowledge base to make STEM more accessible. With appropriate follow-up, the new resources for technical signs, mentoring, networking, and information sharing summarized in this workshop white paper may usher in a new era of inclusion and access.

This material is based on work supported by the National Science Foundation under CNS-0837508 and MCB-1232380.

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