Science, technology, engineering, and mathematics (STEM) undergraduate research experiences improve success, persistence, and promote a feeling of belonging to a community. Like their hearing peers, deaf STEM majors often participate in undergraduate research experiences. However, deaf students typically interact with hearing faculty lacking experience with deaf students and awareness of Deaf culture, which unintentionally impacts their research experiences. This interview study sought to understand deaf students’ research experiences and their relationships with hearing mentors. Findings indicate that lack of awareness of Deaf culture and lack of communication access impact students’ experiences. We make recommendations on improving deaf students’ research experiences.

INTRODUCTION

Science, technology, engineering, and mathematics (STEM) undergraduate research experiences improve success and persistence, and promote a feeling of belonging to STEM (1–3). These research experiences are important gateways to post-baccalaureate education. Deaf and hard-of-hearing (hereafter, deaf) STEM majors often participate in these research experiences. However, the setting of a research experience is very different than that of the science classroom, where interpreters are automatically assigned by the university’s disability services office and faculty–student interactions are typically fewer. In contrast, research experiences involve intense interaction, with commensurate benefits. Unfortunately, these interactions are predominantly with faculty who have little to no experience working with deaf students and who may have preconceptions about deafness (4,5).

The literature has shown that not having cultural competency and an understanding of deaf students’ life experiences negatively affects research experiences (5,6). Conversely, when mentors do understand an underrepresented mentee’s minority culture, mentees have improved outcomes, including higher graduating GPA and graduation rates (6).

Deaf students also often lack communication access to important information from their mentors (7). Unlike in classroom settings, interpreters are not typically available full-time at internships. Consequently, students may feel left behind, and information gaps may impact their research experiences. Deaf students may have difficulty with informal communication with lab-mates, resorting to indirect communication methods such as written notes or e-mail (5, 7).

Making STEM internships more deaf-friendly ultimately benefits everyone. Diverse teams are more successful at problem solving (8), which enhances the quality of science (9, 10). Deaf individuals, like all other groups of scientists, offer unique perspectives based upon their own life experiences, and these perspectives ultimately influence the research questions asked and downstream scientific discoveries. For example, genetic issues in the Ashkenazi Jewish population are well-studied because geneticists who were Jewish took an interest in their own population (11). Likewise, as representation of female medical researchers grows, women’s medical issues are increasingly studied (12).

Knowing the importance of cultural competency (5, 6), we interviewed deaf undergraduates and asked how they navigated internships with hearing mentors. We hypothesized that internships were successful when deaf students advocated for themselves and educated their mentors. Our interview data revealed four themes common to positive research experiences. We make recommendations on improving deaf students’ research experiences.
METHODS

Interviews

The question of deaf interns’ experiences in STEM is large and complex, with myriad issues involved. To begin to tease out important variables from this complexity, we used a qualitative approach. Interviews are a powerful methodological tool, revealing thinking, reasoning, and worldviews (13). Given the complexity of this research question, combined with the small study population, this qualitative approach is an appropriate methodological choice (13).

To recruit participants, we emailed Gallaudet University STEM majors who had participated in at least one undergraduate research experience with a hearing mentor. We developed the interview protocol based on our research question and previous work (5). Interviews focused on communication problems and effective strategies (Table 1). Two co-authors (MM and ZD) conducted 30- to 45-minute video-recorded interviews in American Sign Language (ASL) (Table 2).

Data analysis

Two co-authors (MM and ZD) translated the interviews from ASL into English using ELAN (tla.mpi.nl/tools/elan/). Translations were calibrated for accuracy and organized in MICROSOFT EXCEL. Each complete thought was coded using in vivo and descriptive coding to capture participants’ thoughts and identify major themes (14, 15). Authors coded the interviews individually, then compared and discussed codes until they reached agreement; thus, coefficient of reliability was not calculated (14). Patterns and themes were identified through this iterative process (14) (analysis described in detail in Appendix 1). Finally, we developed case studies based on typical internship experiences.

Efforts to ensure study credibility

We used multiple strategies to ensure study credibility and rigor. Interviews were videotaped and conducted in ASL, the participants’ primary language. Two co-authors conducted the interviews together to probe participants’ experiences in depth. Interviews were translated into written English by these co-authors, who have native fluency in ASL, to ensure accuracy. Translations were compared and disagreements resolved by discussion. Another co-author (CG) commented on translations, which were further clarified as needed. Finally, results were shared with participants for member-checking, an opportunity for them to respond to findings and build study credibility (13).

Institutional review board

This study (PJID #2514) was granted exemption according to 45 CFR § 46.101 on 23 November 2014 by the Gallaudet University IRB. Participants were informed about this study’s purpose in ASL and written English.

RESULTS

Common themes related to internship success

We uncovered four interrelated themes through qualitative analysis; these are identified in italics, e.g., Deaf Awareness. The first critical theme was the importance of awareness of Deaf culture and working with deaf students, called Deaf Awareness. Deaf culture is a set of learned behaviors from the Deaf community, a historically important group of deaf individuals who value American Sign Language and have values and traditions differing slightly from mainstream culture (16–19). Skills for working with deaf students include understanding the nuances of bilingual ASL/English education, maintaining consistent eye contact and visual attention during a conversation with students, and always providing a visual-friendly environment for the deaf student.

One example of such a skill is knowing to tap a deaf student’s shoulder gently if you wish to speak to her. Mentors with Deaf Awareness respect deaf individuals, see deafness as part of human diversity rather than overt disability, and enthusiastically provide communication access. Natalie described how her colleagues demonstrated Deaf Awareness:

My group [of colleagues] were more assertive; they wanted to understand and learn. They would ask me what the signs are [for different words] without hesitating. Of course they were speaking, but I could still see their motivation. They would ask by speaking to me or writing down things they want to learn. They signed “good morning” everyday to me. They asked me to teach them one sign everyday. I was fine with that because they wanted to learn. They learned 60 signs—30 each month.

Another participant, Skyler, described giving a presentation about how to make internships deaf-friendly and accessible:

The director of the program asked me to present about my experience at [redacted] conference. I gave a presentation about how we could improve future [internships] to provide better accessibility for deaf individuals. It was successful—someone from NSF asked me … to meet them [to] discuss how we can [make internships] more accessible. I told them that they should add … more hands-on activities, more visuals, and include more than one person who is deaf because, at [my second internship], I learned that when you pick individuals, be sure to pick two who are similar in some ways. If an international individual is picked, then be sure to pick another international individual [to include in the internship].
TABLE 1.
Interview protocol in English. Protocol is available in American Sign Language by request from the authors.

We are interested in learning about your experiences as a deaf intern in a research environment with hearing people. We hope to learn how you supported yourself as well as how others worked with you. There are no right or wrong answers. We are simply interested in your honest responses.

1. We know you may have a variety of internship experiences. Please briefly explain each internship. Summarize how (1) effective communication was in each internship—good, bad, so-so and (2) your overall feeling about each internship—good, bad, so-so. Also, tell us about your relationship with your advisor at each internship and their role in supervising you.

2. Let's focus on “x internship,” in which the communication was not good.

3. Walk us through a typical day in your internship. What was life as an intern like?
   a. What did you do? Did you work individually or as a team?
   b. Did you feel motivated to do this internship? Did you feel like you lost motivation to do the internship? If yes, why?
   c. Who did you talk with everyday? What did conversations with people look like? Lunch? Meetings? The general lab environment?
      i. If responds “ate alone” (etc.), follow-up to ask, is that what you'd prefer?
   d. Did you make friends? How? What kinds of strategies did you use to make friends? What kind of conversations did you have with friends?
   e. Did you feel like part of a team? Did you feel included (in conversations)? What kinds of strategies did you use? What strategies did other people use to make you feel included/part of a team?
   f. Were you involved in outside activities with your lab group (events, going to coffee, restaurants)?
   g. What were lab meetings like? What did your lab do to make communication a two-way street?
   h. What were one-on-one meetings with your mentor/supervisor like? What did your mentor do to make communication a two-way street?
      i. If interviewee comments about interpreting/captioning/note-taking: ask whether accessing services was easy or challenging? How did your mentor support you to access these services? Did you have any special strategies to access services?
   j. What was the worst part of your internship—something that you didn't look forward to? Follow-up: how would you resolve that if you could…?

4. What was your lab's overall attitude about deaf people?
   a. Did people ask about your deaf identity or show interest in learning about Deaf culture/ASL? Follow-up: Was the interest positive or condescending?

5. Did you develop a network as a result of your internship?
   a. What strategies did you use to develop your network?

6. Did you have any problems at your internship with discrimination being a deaf individual?
   a. Did you have any special strategies to get around these problems?

7. Is there anything your research mentor could have done that would have been helpful to you as a deaf person in STEM?

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TABLE 2.
Demographics of interview participants.

<table>
<thead>
<tr>
<th>Pseudonym</th>
<th>Age</th>
<th>Gender</th>
<th>Race /Ethnicity</th>
<th>Self-Identification</th>
<th>Preferred Communication</th>
<th>Type of Mentored Research Internship</th>
</tr>
</thead>
<tbody>
<tr>
<td>Celia</td>
<td>23</td>
<td>Female</td>
<td>White</td>
<td>Deaf</td>
<td>ASL</td>
<td>Biology research in an academic research lab</td>
</tr>
<tr>
<td>Natalie</td>
<td>21</td>
<td>Female</td>
<td>Hispanic</td>
<td>Deaf</td>
<td>ASL</td>
<td>Physical therapy clinic</td>
</tr>
<tr>
<td>Brian</td>
<td>29</td>
<td>Male</td>
<td>White</td>
<td>Deaf</td>
<td>ASL</td>
<td>Computer programming (government agency; a company; a Deaf-owned company; and a deaf school)</td>
</tr>
<tr>
<td>Skyler</td>
<td>20</td>
<td>Female</td>
<td>White</td>
<td>Deaf</td>
<td>ASL</td>
<td>Ecology research in two academic research labs</td>
</tr>
<tr>
<td>Annie</td>
<td>21</td>
<td>Female</td>
<td>White</td>
<td>Deaf</td>
<td>ASL</td>
<td>Chemistry research in an academic research lab; medical examiner office</td>
</tr>
</tbody>
</table>
Often, interns shared knowledge about Deaf culture, language, identity, and strategies for communication access with mentors and colleagues, helping them become *Deaf Aware.*

The second theme was the importance of *Self Advocacy.* Research experiences were more successful when interns advocated for themselves. *Self Advocacy* included not only advocating for communication access, but also educating colleagues and mentors about Deaf culture, identity, and effective communication strategies. Some participants gave presentations about Deaf culture and identity. Participants often informally taught colleagues basic ASL. For Natalie, *Self Advocacy*—giving a presentation about Deaf culture and ASL—improved a relationship with a colleague who made derogatory comments about her deafness:

> The first month was difficult but after [I gave] a presentation [about Deaf culture and American Sign Language], we would talk better. She would show up with new signs and asking if she signed them correctly. Then we bonded really well.

Some participants described their experiences with discrimination, explaining that a lack of *Deaf Awareness* at their internship motivated them to advocate for themselves. Celia explained:

> When the internship was nearing the end, we made a YouTube video with an interpreter. [The mentor] explained her expectations for our project... Then [she] said we were required to add captions for the video and said "You know what? The interpreters are the experts in translating ASL to English, so they should do it." Then the interpreter awkwardly interpreted it. I raised my hand—I would do it myself. I could do the captions myself. I did not need to rely on interpreters for that. I am confident with my English.

The mentor thought the interpreters should add the captions, which was not the interpreter’s job. When feeling discriminated against, some participants advocated for themselves, sharing culture, identity, and their abilities.

The third theme was *Mentor’s Advocacy.* Advocacy included respecting and supporting interns. It required active engagement with interns, for example, regular meetings about internship progress, being available to explain tasks, and defending and supporting interns in the face of discrimination or comments reflecting a lack of *Deaf Awareness.* Mentors could be more effective advocates with greater *Deaf Awareness.* Natalie describes how her mentor included her and provided appropriate communication access:

> Whenever a doctor or patient asked questions— the doctor [I worked with] always made sure to include me by asking me if I had any questions or answers. I could be involved—but I wouldn’t be if it weren’t for the interpreter. Sometimes I asked a lot of questions that the doctor didn’t think of. Sometimes I asked random questions. For example, I noticed a patient’s knee surgery incision—it really looked red. I asked what was put on the knee. The patient would be like, “oh, I put such and such on it.” Then I said, “no! never put that on [an incision]!”

For Natalie, the doctor’s advocacy to include her made her feel that her perspective was valued. Likewise, Skyler described how a professor at her first internship went out of her way to advise her about graduate school and provide networking opportunities, as well as clarifying lecture content when communication access was limited:

> I would go to that professor to chat about what I should do for graduate school and whenever I had questions about the lecture. She was so willing to help me. I told the program they should include more professors like her, who are very willing to include everyone. She was willing to go out of her way to talk to students.

These interactions made interns feel welcomed, valued, and supported. In contrast, when mentors did not provide feedback, or explanations about research activities, or were unwilling to provide communication access, intern–mentor interactions were limited and ineffective.

Finally, we identified a fourth theme: the importance of an *Internship Cohort.* At a minimum, internships should include two individuals with similar experiences and backgrounds (e.g., two deaf interns). One deaf intern alone may feel isolated. Interns can advocate for each other, communicate, and provide support. Annie describes stark differences between two internship experiences due to having (or not having) a deaf peer:

> The first internship, there were other deaf interns... in other departments. So if we all had nothing to do, we would meet up for 15 minutes or so [to chat]. It was nice. We all had the same majors and were in the same class at [the university]. We also lived at the same hotel, which was nice.

> The second internship, I talked to no one except for my boss, which was like 30 seconds every time. There was another intern, but we mostly had awkward silences because I was deaf and she was hearing. It was like she didn’t know how to approach me. Sometimes I would type something on my phone to talk to her, but it would get awkward everyday.

Being part of a cohort of deaf students made Annie feel welcome and provided socialization opportunities. In contrast, without a cohort, she felt isolated because conversation was limited. Other participants described additional benefits of a deaf cohort. Skyler explained that while
they worked on different research projects, “we worked together to understand everything as a whole.” In contrast, Skyler described working with an entirely hearing team at another internship: “Everyone was nice… but I was still left out.” Mentors and co-workers intended to be welcoming, but the deaf student was unintentionally excluded.

## Communication strategies

Several communication strategies were useful for communicating with hearing mentors and lab-mates. Successful communication strategies included interpreters, writing back and forth on paper and whiteboards, using Siri, texting, and willingness to teach and learn some basic ASL. For example, Natalie described a typical situation:

My office was very good about communication. We said good morning, what’s up, etc. They [co-workers and mentor] really picked up [ASL] signs for just me. Conversations were limited without the interpreter, of course, but with the interpreter, we chatted a lot about my life, where I’m from, [the university], and why I picked this internship, and so much more.

As Natalie described, this allowed for casual conversation, creating a deaf-friendly environment. She described another strategy for formal communication (e.g., meetings with her mentor):

If the interpreter wasn’t present for my meeting with [mentor], we would write things down, back and forth, summarizing so we can understand better. If the interpreter was present, then we would talk about things in depth. For example, [the mentor] always asked how I felt and how I thought I did and how I could improve, then [she] would tell me what she thinks I should do. In return, I would tell her what I thought she should improve. It was a two-way street.

Strategies such as writing back and forth on paper or laboratory whiteboards and texting were useful for discussing internship tasks and clarifying information. Celia explained a typical situation:

We [mentor, coworkers, and I] usually used the whiteboard to write everything, but after a while it was exhausting, writing and erasing everything. Later, we decided to use Siri instead. They would speak to the phone, then I would read and text back. That was so much easier.

## DISCUSSION

Our analysis of interview data supported our hypothesis, revealing four interrelated themes for successful internships: *Deaf Awareness, Self Advocacy, Mentor’s Advocacy*, and having an *Internship Cohort*. Mentors and colleagues who developed *Deaf Awareness* learned how to communicate with the intern, helped secure communication access, and challenged interns by empowering them. *Deaf Aware* mentors were also open-minded to learning about Deaf culture, language, and identity. As we hypothesized, *Self Advocacy*, interns’ willingness to support themselves and stand up for themselves, contributed to better internships. *Mentor’s Advocacy*, which was strongly related to mentors developing *Deaf Awareness*, was important. Finally, having an *Internship Cohort* allowed deaf interns to advocate and support each other and to feel included. In contrast, participants reported poor internship experiences when these factors were lacking. Participants also reported negative socialization and negative experiences when they lacked deaf peers, received little advocacy from their mentors, felt un-empowered to self-advocate, and perceived a lack of *Deaf Awareness*.

Interns sometimes faced communication issues related to their deafness, though the research activities themselves were not difficult. When the quality of communication between the hearing mentor and deaf intern was poor, interns needed more time to understand techniques before working independently and sometimes became frustrated. Deaf individuals vary in their preferred means of communicating with hearing people. We recommend that mentors discuss communication strategies with interns prior to the internship, including a fallback plan for when interpreters are not available.

Our results corroborate previous work that has shown that when mentors are aware of their mentees’ Deaf culture and identity, mentoring experiences are often successful (5) and, more generally, that a mentor’s cultural competence positively impacts minority students’ outcomes (6). Our study also supports work showing that deaf mentees value communication with ASL, awareness of Deaf culture, and mentors’ advocacy (5, 7).

Therefore, we recommend that hearing mentors and lab-mates be willing to learn *Deaf Awareness* (Fig. 1). We also encourage internship programs to include cohorts of deaf students. With an *Internship Cohort*, interns can advocate for one another and are less likely to feel isolated. If an internship cohort is not feasible, an online peer mentoring system could match interns from different locations, providing support and opportunities to share experiences and connect. Deaf interns could benefit from talking with deaf peers in their field. We encourage deaf interns to develop *Self Advocacy*, which may stimulate *Deaf Awareness* (Fig. 1). Interns can share information with mentors and lab-mates, e.g., DeafTec (https://www.deaftec.org/STEM/professionals). However, we caution that deaf interns should not be held responsible for educating others. Mentors and internship programs should be primarily responsible for creating a welcoming environment for all interns, setting positive examples for hearing mentees to emulate. Readers may use the case studies to develop *Deaf Awareness* (Appendix 2) and stimulate discussion about best practices for deaf-friendly STEM internships.
MAJOCHA et al.: DEAF INTERNS’ RESEARCH EXPERIENCES

Internship Programs:
- Recognize the importance of a cohort of interns from similarly diverse backgrounds
- Provide opportunities for interns to learn about diversity issues in inclusive and respectful ways

Deaf Interns:
- Informally educate colleagues about Deaf culture, identity, communication strategies, and ASL
- Host informal workshops or presentations

Deaf Awareness

Supplemental Materials

Appendix 1: Description of data analysis and example of our data analysis
Appendix 2: Case studies

Acknowledgments

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