Deaf and Hard of Hearing Students' Perspectives on Undergraduate Mathematics Experience

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*Deaf and hard of hearing (D/HH) students face many challenges in the study of undergraduate mathematics. Unfortunately, minimal literature exists in this area, evidencing the need for further research. Through five qualitative survey responses from D/HH students, we identified common themes of concern in addition to a number of specific struggles (and a few successes) encountered by each of the respondents in their own undergraduate mathematics courses. From these students' experience, we can identify further areas of research with the goal of developing new educational tools for mathematics instructors with deaf or hard of hearing students. In doing so, we can help give equal opportunity to mathematics students regardless of their level of hearing.*

*Keywords:* deaf, hard of hearing, student perspective

According to Walter (2010), around 60% of deaf/Deaf/Hard-of-Hearing (D/HH[1]) high school graduates enter some form of higher education, but only around 23% of D/HH ages 25-64 have graduated from college. This statistic makes one wonder about how undergraduate mathematics education for D/HH students is factored, since mathematics is predominantly a general education requirement. We add on to the undergraduate mathematics education literature by exploring D/HH students' experiences in mathematics: What roadblocks and successes happened in their mathematics education?

## Background Literature

When analyzing how D/HH students experience mathematics at the undergraduate level, it is important to understand the different K-12 educational backgrounds they come from. Three common educational backgrounds for D/HH students are center schools (schools dedicated to D/HH students), integrated classrooms in main-stream schools (D/HH students in class with hearing peers), and self-contained classrooms (D/HH specific classrooms in mainstream schools) (Kelly, Lang & Pagliaro, 2003). D/HH students entering higher education who take math courses are typically in integrated mainstream classes. This can be a disadvantage to students who did not have the same mathematical experience as their hearing peers before entering their first undergraduate mathematics course. One study has shown that students in self-contained K-12 classrooms and center schools are exposed to fewer discrete mathematical concepts (Pagliaro & Kritzer, 2005); another has shown "teachers of [K-12] deaf students continue to place relatively less emphasis on the development of critical thinking, reasoning, synthesis of information, and other essential skills needed for effective problem solving" (Kelly, Lang & Pagliaro, 2003, p. 116). These teaching differences provide insight into D/HH students' mathematical performance and reasons behind the need of accessibility accommodation in educational settings.

Even when it comes to standardized testing for D/HH students, there is a need for accommodation. The SAT-HI was created with the intention of measuring D/HH students'

[1] It should be noted that the term "deaf" refers to a person who does not hear; "Deaf" refers to the identity of a person who is typically proud to be Deaf and be a part of the Deaf community.

knowledge more accurately than the SAT taken by their hearing peers. These accommodations include translation of testing materials into ASL and screening the students for the correct grade-level test for each section (Qi & Mitchell, 2011). These accommodations are made mainly due to the English barriers D/HH students face. Over 95% percent of deaf children are born to hearing parents (Mitchell & Karchmer, 2004), and many of these children miss vital opportunities as a child for developing language acquisition (Spencer & Harris, 2006). This late language acquisition follows D/HH children through their education and shows itself through testing performance.

A study that analyzed periodic test results from the Stanford Achievement Test for D/HH students from 1969-2003 demonstrated that while D/HH students' standardized testing has shown to be improving over the decades in certain areas, in 2003 the median grade level equivalence for mathematical procedures has decreased to right above a sixth-grade level for students who are 18 years old. (Qi & Mitchell, 2011). This same study showed that the median test scores in 2003 for mathematical problem solving was below a sixth-grade level and reading comprehension was below the fourth-grade level in students at the end of high school. Reasons for lower reading comprehension include the mode of acquisition or the way in which someone learns the meaning of words (Wauters, van Bon, Tellings, & van Leeuwe 2006) and mathematics ability has been shown to stem from "more restricted opportunities for incidental learning" (Kritzer, 2009, p. 418). While many might be testing at a lower grade-level than their hearing peers, there has been an increase of D/HH students entering higher education (Walter, 2010).

Access to higher education for deaf and hard of hearing students has been promoted by the passing of laws such as the Vocational Rehabilitation Act in 1973 and Americans with Disabilities Act of 1990. Both aided in the increase of admission by prohibiting students' rejection by reason of their disability. New admissions have increased the number of D/HH students in postsecondary education, and, because of this, there is a call for a wider range of accommodations. These accommodations tend to be in the form of interpreting services such as a physical interpreter or speech-to-text services. Coming into higher education, D/HH student barriers are addressed by the accessibility resources available to the campus, but perhaps are less informatively addressed by the instructor (Lang, 2002).

## Methods

Our methodology for this study was conducting a qualitative online survey to determine some of the first roadblocks or successes D/HH students face in undergraduate mathematics. The reason we chose to conduct a survey for qualitative research was for a few reasons. There is a language barrier between researcher and participant that couldn't be accommodated for due to a lack in financial resources. A two-way in-person ASL interpreter can run for up to $145 an hour. While ASL interpreter over-the-phone rates are cheaper, this would pass the financial obligation onto the participant if they do not qualify for government-funded video phone access. In future research, in-person interviews will be preferred.

The survey was an anonymous online survey consisting of six open ended questions and two multiple choice demographic questions. We sent a survey link via email or in closed Facebook groups to prospective participants that fit our criteria for the survey. The initial criteria for the survey was that the individual identifies as Deaf/deaf or Hard of Hearing and has taken a mathematics course at the undergraduate level. We allowed the survey to be open for all ages over 18; this variety in age of participants can help to establish a roadblock timeline to analyze the evolution of difficulties or successes D/HH students may face in an undergraduate

mathematics course. We then used open coding, specifically structural coding, to label using themes (Namey, Guest, Thairu, & Johnson, 2008; Saldaña, 2009).

## Results

*Table 1. Participants' Background*

| Participant | Undergraduate Mathematics Courses Taken | Identification | Age Range |
|---|---|---|---|
| Student 1 | "Survey of Mathematics 1, Survey of Mathematics 2, Statistics and Probability at [Medium Undergrad University]" | Deaf/deaf | 35-44 |
| Student 2 | "pre-calculus, calculus I, calculus II, calculus III at gallaudet university calculus I at [Midwest Community College] (audit)" | Deaf/deaf | 25-34 |
| Student 3 | "I took Data Analysis and College Algebra through [Small Midwest State University]" | Deaf/deaf | 18-24 |
| Student 4 | "I have taken Elementary Statistics at [South Community College] and College Algebra at [SCC] as well." | "I am culturally Deaf with a classification of Severe on the Audiogram"[2] | 18-24 |
| Student 5 | "I took college algebra, statistics, and quantitative methods at [Large Midwest State University]" | Hard of Hearing | 18-24 |

In table 1, all five participants and their backgrounds in mathematics education are displayed. When asked about their experience in those courses, four out of five of the students responded with negative descriptions: "a little difficult", "challenging", and "awful". Student 4 went into detail about receiving the letter grade D in College Algebra, and how that grade was out of character: "this is the only D I have received in College, other than that I have no C's, 3 B's, and 23 A's". The student who did not specify a negative experience, Student 3, mentioned their "experience was okay… I made an A in both courses and used CART (Communication Access Real-time Translation) as an accommodation."

Three out of five respondents mentioned struggles related to the instructor writing notes on the board with their back turned. Student 4 stated, "Not only is it hard to see what steps are happening until they stay away [from the board], but I miss almost all their explanation when their mouths are facing the board. I confronted my Physics professor about this & she wish I had told her sooner." Student 1 mentioned there was "not enough of writing problems on the board… [there was] No tutoring support available due to conflict in interpreter schedule and tutoring hours."

[2] An audiogram is a graph that shows hearing test results. A classification of "Severe" is testing 70 to 90 dB higher than normal (NHT Staff, 2014).

In terms of successes, four out of five of the respondents mentioned their grade as a success in their courses: "I had the highest grade," "I made an A in each class," and "…I learned and survived college algebra." Student 4 elaborated on their grade they received in a physics class, and although it is not considered a mathematics course, this participant felt it was important to include in reflection of their undergraduate mathematical experience:

> Earning an A in Physics was greatly credited to my classmates who assisted me & the TA who gave tutor sessions. Nonetheless, I am an extremely visual learner and people who taught me visually helped me advance the most. When people try to explain things with words with no visual aid it's much harder for me to grasp the concept.

Student 1 stated "taking the class with a deaf friend" as an example of a success in the classroom. Two out of five of the students mentioned successes related to online activities. Student 5 recalled having online homework assignments: "we were required to purchase the online homework assignments that explained things with captions and had you practice problems. That is how I learned and survived college algebra." Student 1 mentioned "taking the math course online with ALEKS program" as a success, but then went on to say, "It's not the best. I still struggled…" Finally, Student 5 stated, "Anytime the professor can use one of those projection things that allows them to face the class while working out the problem greatly helped."

## Discussion

### D/HH Experiences Related to the Course

The main goal of the survey is to determine some baseline difficulties and successes for D/HH students in an undergraduate mathematics environment. These open-ended surveys can assist us in generating more research questions. In this survey, we inquired specifically about the participants' difficulties and successes. First, we included a neutral question about experience to give the respondent a chance to give their initial thoughts about undergraduate mathematics. When asked, 4 out of 5 of the students responded with negative mathematics experiences; this seemed to be common to students regardless of D/HH classification (Betz, 1978).

Three responses specifically mentioned struggles in the course directly related to the instructor facing the board. One of the other responses mentioned under-utilization of the board for presenting materials. Student 5 suggested professors use a projector while teaching; this will still give the students the visualization of the material being learned while keeping the professor turned to the class. If the professor makes a point to face the students while explaining the material, this will help the students who rely on lip-reading as a mode of receiving information. This simple change (where possible) can make a difference in D/HH students learning environment as well as hearing students who learn more efficiently in a visually-engaging classroom.

Another theme that stood out was related to the instructor's speech. Even Student 1, who mentioned having an interpreter for the class, mentioned the professor "spoke through the lesson fairly quickly". For a student that has an interpreter in the classroom, they are relying on not only their own understanding of the material, but the interpreter's relay of information. Receiving information through a secondary perspective will provide its own challenges, and for students who have an instructor that goes over new material quickly, this can heighten that roadblock.

When asked about successes in undergraduate mathematics, four out of five of the respondents mention successes related to their grade in the class. Course grade outcome is unrelated to their deafness, but external motivation and rewards are still considered a large goal with many students. While only one student specified visual aids helped to bring them success in the classroom, online-related responses such as ALEKS add a visual element to the math course. Student 5 mentioned having captions with the online assignments which can help with understanding. Typically, with online courses, students can also dictate the pace at which the materials or assignments are presented, giving them more control over the communication of the course information. Student 3 mentioned using CART as an accommodation, which can help the student avoid missing information when the instructor's back is turned. It also allows more time to read the information on-screen rather than watching an interpreter and taking notes simultaneously.

**Representation of D/HH Students**

There was only one student, Student 2, who took any type of calculus class in this survey. It should be noted that this respondent took calculus classes at Gallaudet University, the only university designed for teaching D/HH students. Although this is a small sample, this agrees with the previous literature on D/HH higher education statistics (Walter, 2010). Her experience was "challenging as [she] was the only female in most classes." She took all of her non-audit classes at Gallaudet University. The female student population has consistently remained the majority since 1999 according to Gallaudet's enrollment records available online (Gallaudet University Office of Institutional Research, 2018). Since calculus is a required class for most STEM majors, her answer raises questions of D/HH female underrepresentation.

## Conclusion

This paper outlines individual D/HH students' initial perspective on their undergraduate mathematical experience. Challenges identified in this study include breaks in communication between instructor and student, speech patterns of the instructor, and possible underrepresentation of D/HH female students. These challenges can be addressed by accessibility resources in higher education institutions and regarded by mathematics instructors seeking information related to teaching these students. Successes identified in this study include visual aids such as online-related elements in the course, usage of the board, and D/HH specific accommodations. Further research should be done to determine potential effects of a math course taught in visually-stimulating environment; developing this environment requires a composition of different visual elements in and out of the classroom similar to the ones mentioned previously. There should also be more exploration into the pedagogical effects of an instructor explaining materials while facing away from the classroom. This study gives direction for future research related to D/HH undergraduate mathematics students whose experiences we believe should be addressed more thoroughly.

## Questions for the Reader

1. What pedagogical actions could be taken to create a more visually-stimulating classroom?
2. What pedagogical actions could be taken to lessen communication breaks in the classroom?

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