A Transition Community for Deaf and Hard of Hearing Students in Engineering Programs

Dr. Raja S. Kushalnagar, Gallaudet University

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Abstract
Deaf and hard of hearing (DHH) students are underrepresented and less successful compared to their hearing counterparts in Engineering programs, as they tend to have less academic readiness. They also generally have lower ACT scores and lower content knowledge for introductory courses. DHH students face difficult adjustments in handling the demands and expectations of college level classes and specifically introductory mathematics courses. As a result, without appropriate support, most DHH students fail to succeed in introductory mathematics courses in their first year.
For this group of underprepared students, a transitional community and transitional engineering course has been shown to significantly improve their academic success. This paper describes 1) how the establishment of a community of peers with an appropriate academic support structure improves graduation persistence, 2) how a transition engineering program with an appropriate support structure improves success in succeeding in engineering and 3) resources available for instructors who have DHH students in the classroom.

Introduction
Physical communication and learning is not wholly contained in a single communication modality, (i.e., sight, sound, taste, touch, and smell). Comprehensive meaning in communication is conveyed through the synthesis of information and associated meaning from each modality. The absence of one or more of the five senses not only impacts brain plasticity, it shapes the brain's development and a person's contextual knowledge of the world.

Modern engineering activities such as labs, fieldwork, and design studios, demand a high level of visual and auditory function. For example, using a probe in electronics (Behm & Mondragon, 2014) involves multimodal activities that frequently engage multiple senses. Missing part of the multimodal communication causes both deaf or blind students to face accessibility and socialization issues.

As a result, DHH students often face significant barriers in pursuing their educational goals, especially if they wish to pursue engineering careers. Transition communities can aid students who are deaf or hard of hearing adjust to new multimodal environments and enhance their ability to access classroom information.

There were about 138,000 deaf and hard of hearing students in college nationwide in 2010 (Walter, 2010). State and federal efforts in support of Section 504 of the Rehabilitation Act of 1973 and the Americans with Disabilities Act of 1990 have enabled deaf students to attend the schools of their choice and obtain support. As a result, over the 38 years between 1972 and 2010, the percentage of deaf individuals attending college has increased by approximately 400%. The numbers of deaf students pursuing bachelor's degrees continue to show disparities compared to the general population. In 2009, 60% of deaf high school graduates attended some form of postsecondary education. Of these students, 57% attended two-year schools as compared to 48% for hearing students. On the other hand, 33% of deaf students were pursuing baccalaureate degrees compared to 47% of hearing students.

Moreover, DHH students have higher attrition rates (Walter, 2010), who found that hearing students have a 15% higher completion rate than their DHH peers. In addition, in comparison with their hearing peers, about 8% more DHH students never graduate from high school. This significantly impacts the pipeline, and as a result there is a far smaller fraction of DHH students who pursue graduate degrees. Between 1997-2006, 265,790 individuals received doctorates in science and engineering. Only 420 DHH individuals, or 0.2% of the total received doctorates in science and engineering (Hoffer, Hess, Welch, & Williams, 2007).

Barriers in Engineering Classes

Increased adoption and use of accessibility features not only increase inclusion in everyday life, they enhance social, legal and technical acceptance. DHH are likely to thrive and grow when paired with others who face similar issues, along with people seeking to provide support, rather than dealing with these challenges in isolation. The goal is not to merely increase inclusion for a few individuals, but to promote a more inclusive environment in which all can thrive and grow.

Deafness is low incidence and deaf individuals are thinly dispersed. This has several subtle implications -- for example, more than half of all deaf students have no classmates with similar challenges. Without appropriate support accommodations to facilitate inclusion by peers or to encourage interaction or group communication, they face participation barriers in informal social and formal learning communities.

Deaf and hard of hearing students will benefit from knowledgeable teachers who understand how to adapt materials that assume visual relationships by recasting the materials in neutral terms. However, deaf and hard of hearing students are likely to face hindrances from non-disabled students who do not have incentives to understand and adapt. Since much learning is conveyed peer-to-peer, this can be a serious hindrance to knowledge acquisition and reduce their participation. This can also trigger their disillusionment with education and withdrawal from society. They are likely to thrive and grow when paired with others with whom they can identify and from whom they can find support.

Deaf and hard-of-hearing students have varied educational backgrounds and face difficulties in obtaining access to knowledgeable sign language interpreters and captioners. Additionally, communication and attitudinal barriers can inhibit collaboration inside and outside the classroom. The transition from high school to college is a critical time because the student is moving from dependent to independent status.

There are accompanying changes in the expectations of the educational institutions. For instance, students must self-advocate and do more work outside class. Knowledgeable mentors and peers who share similar experiences can help these students to develop academic, technical, and self-determination skills despite potential barriers of inaccessible curricula and resources, inadequate support, and a lack of encouragement and role models (Marschark, Lang, & Albertini, 2002).

Regardless of this technology's availability, DHH students benefit from the pooled experience and wisdom of a community of similar peers and knowledgeable mentors. It's also worth noting that a community of peers is likely to have access to far more available resources than would a single person operating independently.

Need for Transition Programs

There are several reasons for the lower than expected percentage. Teachers and advisors are a vital resource for students in learning of career opportunities and directing their attention towards such goals. DHH students, starting in secondary school, are generally steered towards vocational or applied fields due to the belief they cannot succeed in more abstract fields. This belief is partly shaped by their delayed English and mathematics competency. Additionally, DHH students rarely can take engineering courses in high school and do not have access to information on the rigors and expectations in these majors. Many have simply never been exposed to the high level of problem solving skills needed for introductory courses for engineering majors. As a result, they are more likely to do poorly in an introductory engineering course or drop out of these programs. This failure to succeed presents not only a lost opportunity to pursue an engineering career, but perhaps a lost opportunity to complete their studies elsewhere.

In addition, unemployed deaf adults usually obtain for tax-subsidized social security disability payments, in contrast to employed deaf adults who pay taxes. So, it doubly benefits society to increase DHH student enrollment and graduation rates. DHH students that pursue engineering or other STEM (Science, Technology, Engineering and Mathematics) programs, would likely have greater success (better grades, higher persistence and graduation rates) if they have better academic support and feedback to determine their readiness for engineering or STEM disciplines. They would be more equipped to manage course and workload expectations.

TRANSITION COMMUNITY

We investigated the impact of a transition community with both peer learning and academic support in terms of introductory course success.

Peer learning

Various studies with college students have shown that academic and social integration factors significantly affect academic persistence and graduation rates (Dowaliby & Lang, 1999). On the other hand, due to communication barriers, especially in group settings, deaf adolescents in mainstream settings prefer to relate to other deaf students (Albertini, Kelly, & Matchett, 2012).

The most consistent predictors of social outcomes were the students' classroom communication participation and participation in extracurricular activities (Antia, Jones, Luckner, Kreimeyer, & Reed, 2011). College students with no prior exposure to deaf culture typically are isolated and alienated during their first year (Albertini et al., 2012). To mitigate the sense of isolation and alienation, and to boost student engagement, educators have tried different approaches of promoting interaction with peers, towards the goal of establishing a ''learning community'' among deaf and hearing students to encourage early academic and social integration. If successful, it would build on strategies and accommodations specific to the individual and enhances academic growth and social awareness for all students.

A learning community involves linking courses, instructors and students together to increase contact among students and faculty, and to create linkages between academic disciplines (Tinto, 1993). In a pilot study at X, 14 first-year students agreed to participate in a ''clustered learning environment'' with links among students and staff. When the learning community group (experimental group) was compared to a matched control group on aspects of classroom involvement, the experimental group had higher rates of class attendance, keeping up with homework and other course work. Such methodology seems promising particularly because the academic clustering has the potential of fostering social connections with peers and greater identification with the academic values of the institution.

Academic Support

X accepts DHH students who have ACT scores that show reasonable chance of success in college. Actual in-house testing places students into English and mathematics courses that fit their level of preparation.

X provides academic support for deaf students interested in pursuing a baccalaureate degree but at not yet at that level of study. Students accepted into the Associate of Science (AS) also known as the associate to baccalaureate degree program or 2+2 program, are often lacking in the math and or English competence for direct entry to the BS level program of choice. Of course, these are reflected in their ACT scores and/or placement scores. Using academic support in the form of direct sign or simultaneous-communication (voice and sign) instruction during their first year in math, English and some technical courses, students are offered a nurturing and supportive environment where they can catch up and even excel in their studies. After they attain an academic level on par with hearing peers, which takes approximately one year, then instruction shifts to traditional voice only instruction with the support of interpreters or captioners and note takers in the classroom, as well as a team of support faculty with a variety of communication modes.

X has an articulation agreement with the BS programs in Y. The AS degree articulation agreements allow for approximately one year of coursework that mostly consists of preparatory instruction in the more language supportive and nurturing environment explained above and the second year taking courses typical of those courses taken during the first year for hearing peers. Successfully completion of this AS degree assures acceptance into those baccalaureate programs in Y and leads to a higher percentage of graduates from these programs. This shows that even though hearing impaired students had much lower ACT scores than their hearing peers at the outset, academic support plays a key role in admittance into a baccalaureate program and successful completion of the program. As stated earlier, deaf students receive less academic preparation at mainstreamed schools than their hearing peers. Without additional intervention, it can be difficult for the deaf students to catch up with their hearing peers. Therefore, one of the core goals at X is to offer a nurturing, supportive environment where students with appropriate knowledge and motivation can catch up and excel in their studies.

TRANSITION COURSE

Per ABET curriculum guidelines, engineering majors require mathematics competency. This is met by successfully completing a calculus sequence that focus on problem solving. The academic learning issues faced in these courses is like the issues faced in learning in reading courses. Even if the student can read word problems, the student still needs to decode the concepts or terms used and apply them correctly to the problem or question. Depending on the objectives and content area, a question or task may require integrating content knowledge, problems solving ability, laboratory experience and ability to apply information (Patz, 2006). If these concepts and vocabulary are not fully captured, students are likely to do poorly.

Most mathematics course knowledge is tacit, so only a fraction can be verbalized or signed during a lecture. Often students pick this up by integrating lecture material within their mental schema by discussion and practice with their peers. In mainstream classrooms, deaf students have fewer opportunities to integrate academic knowledge, including reflection on experience. Given time and conceptual constraints, instructors normally have no opportunity to teach students how to develop a foundation to solve standard problem sets.

There are various resources available for assistance and guidance in working with the DHH population. These resources, some of which contain helpful suggestions from students and strategies that worked for other faculty, can be used to help classroom instructors make their teaching effort more effective with DHH students.

METHODOLOGY

We examined ACT scores for all deaf students enrolled directly in baccalaureate degree programs at Y or in 2-year degree programs at X from 1998 to 2016, a span of eighteen years. There were 180 students overall, and the score distribution was consistent over time and major. As discussed below in the analysis section, these scores showed a correlation between the deaf students’ ACT scores and program expectations.

Transition Community Analysis

Students were asked about their communication preferences at time of entry into X. The choices were to either to sign only, to sign and speak, or to speak only. About 50 percent of the students preferred to sign only, 25 percent preferred to sign and speak, and the rest preferred to speak only. Interestingly, there was no difference in graduation rate or passage rate among these groups. Although it might have been expected that students with more communication inhibition with hearing peers would not succeed as well as those with less communication barriers, this was not visible. That may however, be attributable to other variables involved, such as academic skills, social support and the like. There was a qualitative trend of increased graduation and passage rate when they were more involved in the peer learning support group.

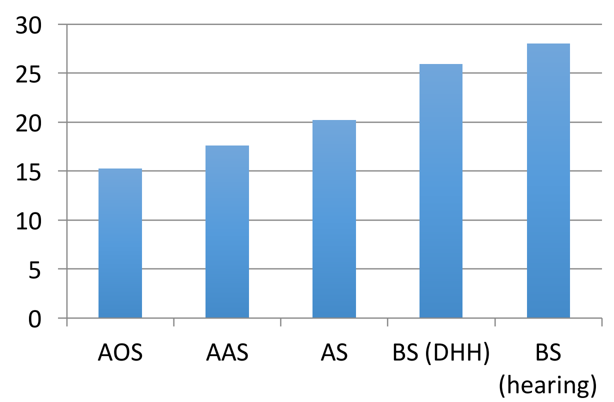

Figure 1: ACT scores by degree program

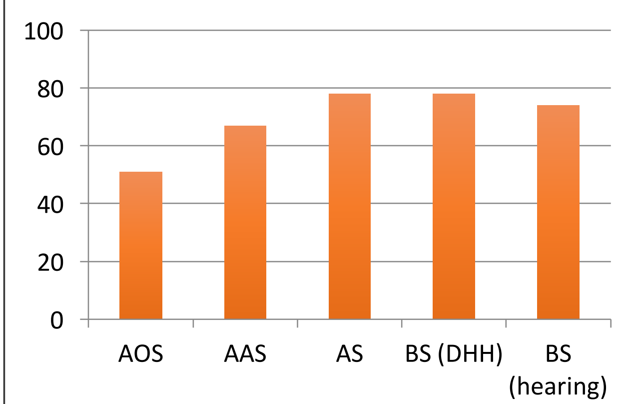

Figure 2: Graduation rate by student type

Transition Course Analysis

As shown in Figure 1 above, there was a clear correlation between the average ACT score and degree level. For the shortest and least language intensive 2-year degree, the Associate of Occupational Studies (AOS) degree, the ACT score was 15.19. For the two-year Associate of Applied Science (AAS) degree, which simultaneously prepares students for work in industry and for further study in four year programs, the average ACT score for students was 17.56. For the Associate of Science (AS) degree, which focuses only on giving students a solid grounding in preparation for further studies in four year programs, the average ACT score was 20.15. Finally, for the full four-year degree, i.e., (baccalaureate degree), the average ACT score for deaf students in the program was 25.95. In contrast, the average score of hearing students in Y was around 28.

Even though deaf students have lower ACT scores than hearing students in the baccalaureate level degree by little more than two points, their graduation rate is four percentage points higher (78% versus 74%) as shown in Figure 2. This disconnect between ACT scores and graduation rate for hearing and deaf baccalaureate level students is explained by the fact that there are many factors in academic success as measured by graduation rates. In addition to the factors mentioned above, i.e., academic preparation and challenges of learning using support services, there are other extraneous factors such as leaves of absence, financial troubles, difficulty in carrying full loads, dissatisfaction with social life, and changes in career interests. A pilot study interviewed 320 deaf students who were withdrawing from higher education or transferring to another postsecondary program and reported that inability to decide on a major area of study is an important factor related to persistence (Elliot, Stinson, Easton, & Bourgeois, 2008).

In 1998, the first year for which we have statistics available for deaf students, X did not offer a transition course for deaf transfer students. The transition course was carefully designed to teach about 90% of the course material taught in the first course of the mathematics sequence.

The distribution of ACT scores for students taking the transition course was evenly distributed between the maximum and minimum scores, and the average was 18.7. Interestingly, only 15 students out of the total enrollment of 180 students over eighteen years had scores of over the minimum ACT score of 24 required for most Engineering majors. In other words, the ACT score distribution of hearing and deaf students was distinctly bimodal, with only a slight overlap between them. Despite this clear separation between the two groups' predicted academic achievement by the ACT scores, the graduation rate for baccalaureate level deaf students is higher by four percentage points than baccalaureate level hearing students as shown in Figure 2.

Before the transition course was offered, the percentage of deaf students who obtained a passing grade in the first course of the calculus sequence was 28%. From 1999 onwards, X offered the transition course and mandated that all DHH students transferring to the Engineering programs take this course. As a result, the percentage of deaf students who obtained a passing grade on the first course of the sequence shot up to 60% in 1999 and slowly continued to climb thereafter. The transition course instructors developed and adopted strategies that focused on the two goals, e.g., content and social knowledge.

The goal of content knowledge focused on enabling DHH students to pick up the content knowledge necessary to make the transition from general mathematics to calculus and related engineering mathematics courses. The goal of social knowledge focused on aiding students' self-awareness and social skills to make the transition to a mainstream environment with interpreters and or captioners.

Future Work

A transition or pipeline program that combines both support in both the academic and social realm has been shown to improve outcomes for deaf and hard of hearing students in terms of improved grades in the engineering sequence at Y. "Pipeline" programs refer to coordinated strategies over the lifespan of the academic period that aim to increase the numbers of deaf students. The "pipeline" metaphor highlights the importance of growing the percentages of students from the input, i.e. kindergarten and minimizing leakage, i.e., drop outs at each stage in education, and to maximize output to the conclusion, i.e. graduation and successful career placement. For deaf students, there are some pipeline programs in addition to the ICS transition program, but currently, they do not cover all stages of the academic span, and therefore substantial "leakage" occurs at these gaps. Currently, there are no pipeline activities at other levels, especially kindergarten to middle school, for deaf students interested in engineering and mathematics. This can result in substantial leakage of deaf students interested in STEM at stages where there are no pipeline activities.

When competitive programs like Y's program use quantitative measures such as the ACT scores as a screening mechanism, this results in a disparate impact on deaf student acceptance and enrollment. Also, when deaf students are accepted without adequate academic, social and peer support, their academic performance and graduation rate are likely to suffer. The provision of physical accommodations and peer support has been shown to help. The establishment of a transition community and transition course demonstrates an alternative model that mitigates to some extent the disparate impact on the acceptance and enrollment of deaf students, without impacting eventual graduation and career success rates. It accomplishes this goal by balancing applicants' qualitative attributes (academic discipline, extra content learning, awareness of bachelor coursework expectations and other factors), along with quantitative criteria such as the ACT score. This enables the university to meet the goal educating more deaf students, even if they are generally underprepared, while also maintaining program quality.

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References

Albertini, J. A., Kelly, R. R., & Matchett, M. K. (2012). Personal factors that influence deaf college students' academic success. *Journal of Deaf Studies and Deaf Education*, *17*(1), 85–101. http://doi.org/10.1093/deafed/enr016

Antia, S. D., Jones, P., Luckner, J., Kreimeyer, K. H., & Reed, S. (2011). Social Outcomes of Students Who Are Deaf and Hard of Hearing in General Education Classrooms. *Exceptional Children*, *77*(4), 489–504. Retrieved from http://search.proquest.com/docview/877027156?accountid=108

Behm, G. W., & Mondragon, A. F. (2014). A Teaching Model for Teaching Deaf/Hard-of-Hearing and Hearing Students with Course Accessibility and Real World Product Design. In *2014 ASEE Annual Conference* (pp. 1–13).

Dowaliby, F., & Lang, H. (1999). Adjunct aids in instructional prose: a multimedia study with deaf college students. *Journal of Deaf Studies and Deaf Education*, *4*(4), 270–82. http://doi.org/10.1093/deafed/4.4.270

Elliot, L. B., Stinson, M. S., Easton, D., & Bourgeois, J. (2008). College Students Learning With C-Print's Education Software and Automatic Speech Recognition. In *American Educational Research Association Annual Meeting*. New York, NY: AERA.

Hoffer, T., Hess, M., Welch, V., & Williams, K. (2007). Doctorate Recipients from United States Universities: Summary Report 2006 (SRS 09-321). *National Opinion Research Center*. Retrieved from http://www.nsf.gov/statistics/doctorates/pdf/sed2006.pdf

Marschark, M., Lang, H. G., & Albertini, J. A. (2002). *Educating Deaf Students: From Research to Practice*. New York: Oxford University Press.

Patz, R. J. (2006). FOCUS ARTICLE: Building NCLB Science Assessments: Psychometric and Practical Considerations. *Measurement: Interdisciplinary Research and Perspectives*, *4*(4), 199–239. http://doi.org/10.1207/s15366359mea0404_1

Tinto, V. (1993). *Leaving college : rethinking the causes and cures of student attrition*. Chicago; London: University of Chicago Press.

Walter, G. (2010). *Deaf and Hard-of-Hearing Students in Transition: Demographics with an Emphasis on STEM Education*. Rochester, NY.