Disability and Engineering: A Case of "Othering"?

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Disability and Engineering: A Case of “Othering”?

The Americans with Disabilities Act (ADA) (2009) defines disability as (A) "a physical or mental impairment that substantially limits one or more major life activities of such individual, (B) a record of such impairment; or (C) being regarded as having such an impairment." For Americans with disabilities, the right to equal opportunity is protected by law. Under ADA, hiring discrimination is prohibited and reasonable accommodations must be made for employees with disabilities. Particularly relevant to colleges and universities, The Rehabilitation Act of 1973 prohibits institutions that receive federal funding from discriminating against individuals with disabilities, as well as from excluding such individuals from participating in or benefitting from federally-funded programs and activities. American institutions of higher education receiving federal funds are, like workplaces, required to make reasonable accommodations for students with disabilities.

Because disability can be visible or invisible—ranging from hearing impairment to dyslexia to autism—appropriate accommodations vary and may include extra exam time, note-taking assistance, adaptive technology, assistance with learning/studying techniques, or different exam formats [1]. Unlike K-12 education, accommodations during college study are contingent upon student self-advocacy; in order to receive an accommodation, students must file disability documentation with their school's disability services center and request an accommodation. The request may or may not be approved. Further, university officials cannot legally disclose a student's personal health information to faculty, so it is up to the student to inform their professors about their condition and approved accommodations [2].

Despite recent postsecondary enrollment gains for students with disabilities, barriers to success persist, particularly for students in STEM [3]. These barriers stem from both institutional factors such as lack of faculty awareness of disabilities and disability services, inaccessible facilities, and inadequate disabilities services and personal factors such as lack of student disclosure, stigma, feelings of "otherness," and feelings of inadequacy [4] [5] [6] [7]. Such barriers inhibit students with disabilities from entering into STEM career fields, negatively affecting the labor force. The National Science Foundation [8] reported that scientists and engineers with disabilities work full-time at rates lower than their counterparts without disabilities, and that 11% of individuals under 75 have a disability. More research must be done to understand the challenges students with disabilities face in STEM college programs.

Certain types of disabilities and disorders are more common among STEM students. For example, students with Autism Spectrum Disorder (ASD) are more likely to gravitate toward STEM fields than the general population and students with other types of disabilities [9]. Because autistic traits are higher in males than females, this may contribute to the STEM gender gap [10]. Students with ASD contribute to engineering work in meaningful ways, as they bring diverse perspectives and thought processes, the ability to think pictorially, and enhanced duration of focus [11] [12]. Therefore, students with disabilities require an inclusive and safe environment that nurtures their abilities and reinforces their value and contributions [9] [12]. This is also true of students with a range of visible and nonvisible disabilities, collectively referred to as neurodiverse students [13].

Intersection between disability status and other "other" statuses compounds experiences. Little research has explored multiple "other" statuses, especially with regard to students with

disabilities. “A major critique of the minority group, social construction, and disability studies paradigms...is that they have failed to fully consider and problematize intersectionality of other social identities” ([14] p#; see also [15]). Sommo and Chaskes [16] call for an understanding of the complexity of diversity within communities of disability, owing to the variations of disabilities that are encompassed, as well as the difficulty in account for interactions with other variables “within the matrix of oppression” (pp 52-3); “it can be difficult to delineate the point at which the physically imposed limitation ends and the socially constructed oppression begins…” (p. 49).

In this article we focus on undergraduate engineering students, comparing those with and without a self-disclosed disability. We begin with a review of research that has been done on engineering students with disabilities, describe the current study and present its results, and discuss suggestions for improvement.

Literature review

Engineering Students with Disabilities: Because disability is not always visible and because college students must self-identify as disabled, it is difficult to know the true number of engineering students with disabilities. This section will review literature about students with disabilities’ commitment to the engineering major and career, their extracurricular engagement, their feelings of self-efficacy in engineering, and their perceptions of “otherness.”

Commitment to the engineering major and career: According to the National Science Foundation [8], students with disabilities enroll in undergraduate science and engineering fields at similar rates to their non-disabled counterparts. Fewer students with disabilities, however, enroll in STEM graduate programs [17] [18]. Nuances can be seen among STEM enrollment trends of students with disabilities. For example, students with Autism Spectrum Disorder are more likely to persist in a 2-year community college and twice as likely to transfer into 4-year college STEM programs than their peers [19]. Reasons that students with disabilities are deterred from choosing engineering as a major include a lack of engineering role models who have disabilities, parent and teacher misconceptions about disabled students’ ability to succeed, lack of school and career counseling, structural/physical barriers, and lower participation rates in STEM-related courses and activities [5] [18]. Moon et al. [18] also point to a lack of training for STEM elementary school teachers in inclusive pedagogy and accommodations for students with disabilities, which may contribute to a chilly climate, which contributes to disinterest in the field and subsequent underrepresentation of students with disabilities in middle school STEM education.

Despite entering science and engineering fields at the same rate as their non-disabled peers, a gap exists in college degree attainment. According to 2015 data, 33% of the U.S. population has a Bachelor’s degree or more, compared to only 14% of individuals with disabilities [20]. Hawley, Cardoso, and McMahon [17] attribute attrition of STEM students with disabilities to programmatic, economic, psychological, and attitudinal barriers. For example, students with physical disabilities often face architectural barriers such as laboratory table height, inaccessible equipment or instrument, and lack of elevators to reach facilities [17]. A non-inclusive school culture and negative faculty attitudes toward disabilities greatly impact students’ commitment to the engineering major and career. Efforts to increase retention of students with disabilities and

other marginalized students include curriculum redesign and greater diversity when hiring faculty [21] [22].

Self-Efficacy: Self-efficacy, the belief in one's ability to succeed, has been found to be a critical skill for students with disabilities. STEM fields, especially, attract a higher concentration of students with autism spectrum disorder than any other disability category [23]. Research shows that students with disabilities have a malleable sense of self-efficacy, and that a positive sense of self-efficacy influences their academic success and persistence in STEM classes [24]. Jenson et al. [24] found that STEM college students with disabilities gained self-efficacy when they engaged in applied learning and team projects, received peer feedback, saw other students with disabilities succeed, and had supportive faculty/classmates.

Self-efficacy is tied to self-advocacy and self-determination. Even after students demonstrate self-advocacy by disclosing their diagnosed disability to the college, they often need to come to a self-understanding that involves recognition of what other supports or strategies they need to employ in order to succeed. Denhart's [25] qualitative study of eleven students with disabilities revealed that ten of those students felt self-understanding was a key strategy to overcome barriers they faced in higher education. For those students, self-understanding meant recognizing how one learns, understanding that differences could be beneficial, and knowing how to get what they needed out of the system.

Students with disabilities may also underestimate or overestimate their self-efficacy and capabilities [26]. Underestimation of capability contributes to a lack of interest in STEM fields due to lack of confidence. Overestimation of capability may dissuade some students with disabilities from seeking support or requesting accommodations. Lee [27] found that students with disabilities are less likely to ask for accommodations in college STEM programs, which may be related to an overestimation of self-efficacy.

Extracurricular engagement: Astin's [28] seminal theory of student involvement suggests that students are more likely to persist in college if they engage in extracurricular activities. In addition, the theory holds that the more involved a student is, the greater the students' learning outcomes and personal development. Empirical research has since supported his theory [29] [30]. However, students with invisible disabilities such as emotional and behavioral disorders as well as physical disabilities may be less likely or able to engage in campus activities or organizations [31].

Extracurricular activities are particularly beneficial for advancing interest in STEM, as they offer hands-on experiential learning and discovery, exploration of career options, networking opportunities with other students interested in STEM, and familiarity with cutting-edge research and technology [5]. Wilson et al. [32] found that participation in extracurricular activities has a significant correlation to engineering students' self-efficacy. Dunn, et al. [5] highlight barriers that students with disabilities face in pursuing STEM majors and careers. Their case study of a high school student with a learning disability suggests that participation in extracurricular activities in middle school (such as a science summer camp) increased interest in higher-level STEM courses in high school.

For students whose disability identity intersects with another underrepresented minority group, educational consequences can be even more severe. Black, Hispanic/Latinx, and Native American students, who are overrepresented in special education, are less frequently exposed to higher-level STEM material required for college [17] [18] [33] [34]. Gottfried, Bozick, Rose, and Moore [35] found that high school students with disabilities took less advanced science and mathematics courses. However, their nationally representative sample consisted of an overrepresentation of Black and Hispanic/Latinx students. Because identity is multidimensional and intersectional, Walden et al. [36] suggest the use of the phrase "underrepresented minority" is not only exclusionary, but will soon be factually inaccurate as U.S. demographics shift; they instead recommend the term "excluded identities."

Perceptions of "otherness": Students with disabilities in general report feeling "different" from their counterparts, possibly in part to being misunderstood or misrepresented by others [37]. While providing necessary accommodations can increase disabled students' success, the accommodation process itself can be a constant reminder to students that they are 'different' than other students. Researchers have also experimented with informal accommodations, which may include given a quiz at the end of a class so that a student who has a documented disability may have extra minutes, rather than requiring the student to take the quiz at the disability services unit in order to receive extra time [2]. This approach allows the student to be part of a more inclusive environment rather than being segregated from peers due to being 'different.' At the same time, Spingola [38] suggests that most literature approaches disability from a deficit perspective in trying to 'fix' engineering students with disabilities rather than perceiving them as valued and equal.

STEM students who are disabled face additional stigma of being "othered." Use of equipment, chemicals, instruments, or electronics can sometimes prove challenging to students with disabilities and therefore additional supports and accommodations may be necessary to facilitate their safety and academic success. Barga [39] reports that one professor labeled a student with a learning disability a "dangerous engineer," and sought to have her removed from class and the engineering department. Our implicit biases also play a part in 'othering' college students with disabilities. Rao and Gartin [7] found that engineering and law professors are significantly less willing to provide accommodations to students with disabilities than professors in other disciplines. Even when documented and approved, faculty may perceive students who request accommodations as lazy, deceptive, or avoiding work [17]. Love et al. [40] found that STEM faculty had difficulty defining and understanding STEM students with invisible disabilities. Empathy, a trait that is less frequent in those with high analytical abilities like engineers, may play a role in 'othering' STEM students with disabilities and reluctance to provide accommodations [41] [42].

Disability at the current university

The setting of our research is a growing research university located in the mid-Atlantic region. It has seen explosive growth since 2012 when it opened an MD-granting medical school and a year later acquired a second DO-granting medical school. The university is named after its benefactor, who provided a $100 million gift to strengthen the region's engineering capacity. This gift spurred the creation of a College of Engineering that has six academic departments:

Civil/Environmental Engineering (CEE), Chemical Engineering, Biomedical Engineering, Mechanical Engineering, Electrical/Computer Engineering, and Experiential Engineering Education. In 2016, the Civil/Environmental Engineering department received a five-year National Science Foundation grant, one of twenty-one in the country. The program aims to develop students' professional identity through well-functioning departments that embark on cultural, curricular, and institutional change. The program places an emphasis on inclusion of underrepresented groups and increasing STEM diversity within academia and the workforce. CEE is thus in its first year of intensive efforts to increase the number of underserved students in the program, including women and underrepresented minorities, and promote inclusivity through its curriculum, pedagogy, and climate. While most measures of diversity focus on underrepresented racial/ethnic minorities and women, the CEE department was interested in addressing both visible and non-visible elements of diversity. Most students with disabilities fit into both of these groups.

Approximately 10% of engineering students report having a disability and 41% of those students use the disability resources office at the university. To receive accommodations within courses, housing, and dining services, students submit a one-page Disability Registration Form and medical documentation of the disability to the Disability Resources office. If approved, the student is given an acceptance letter to provide to their professors each semester. Other services provided by the Disabilities Resources office include academic coaching and tutoring, an academic honor society for high-achieving students with disabilities, introduction to Universal Design, transition resources, and faculty mentors.

In the following we present results from a survey conducted in the university's College of Engineering (COE) in the AY 2018-19. The purpose of the survey was to monitor change for the climate of diversity and inclusivity during the third year of the NSF-funded project mentioned above.[1] Students were asked about their experiences and perceptions of inclusivity regarding several categories of potential 'otherness': gender and sexual orientation, race/ethnicity, religion, socioeconomic status, first-generation college, and disability. The anonymous online survey asked for self-identification in terms of these categories, their levels of comfort in various situations (being the only one of their identity or status, speaking about their identity or status, being with others of their identity or status), being singled out in classrooms because of their attributes, observations of bias or harassment based on these attributes, their perceptions of self-efficacy in their classwork and major, and their commitment to a future in engineering.

In this paper we present the results regarding students who identified as disabled in comparison to students who did not so identify. Throughout the paper we use the terms "students with disabilities" and "students without disabilities" to identify the two groups of students. In the tables, for purposes of brevity, we use the terms "disabled" and "non-disabled," recognizing that the "non-disabled" often have at least minor disabilities, while the "disabled" often have many

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able-bodied features as well. Note that we are limited by self-disclosure, and cannot comment on the non-disclosed student population, which has been estimated to be as high as 27% [43].

Engineering students with disabilities in the sample

The survey was completed by 214 students in the College of Engineering: 33 (or 15.4%) of these students identified as having a disability. Thirty-nine percent of disabled engineering students were first-year, 27% sophomores, 15% juniors, 12% seniors, and 6% were graduate students. They were distributed across all of the undergraduate programs in engineering (biomedical, chemical, civil and environmental, electrical and computing, engineering education, and mechanical). The majority (94%) identified as [non-Hispanic] white [HH2] compared to 92% of their non-disabled peers. Twenty percent identified as female compared to 26% of their, while 18% identified as having a sexual orientation other than heterosexual, a higher proportion than just 4% of their peers without disabilities. They rated their parents'/guardians' income as higher than non-disabled students (65% $100,000 or higher vs. 44% of those without disabilities) and had similar concerns about financing the rest of their college education (approximately 5% very concerned), but a larger percentage of their peers without disabilities were working for pay during the current academic year (54% vs. 36%) [HH3]. About 15% of students who identified as disabled also identified as first-generation college students, similar to their peers who did not identify as disabled.

In terms of their academic background, the students with disabilities reported lower high school class ranks (40% of students with disabilities graduated in the top 10% of their class, compared to 55% of the students without disabilities), were just as likely to have participated in extracurricular STEM activities in high school, and were slightly less likely to have taken AP or Honors STEM courses in high school. At this university, they are more involved in extra-curricular activities, including student/professional engineering societies, engineering service clubs, the engineering learning community, internships or co-op opportunities, and mentoring programs. They were as likely or more likely than their peers to participate in non-engineering, campus-wide extracurricular activities related to their other identities as women, sexual orientation, or students of color[2] .

Disability as a status experienced as "other"

Students were asked how comfortable they felt being with people whose identity was different than their own. They were not asked this about the disability status, but about race/ethnicity, gender, religion, sexual orientation, and socio-economic status. Discomfort was interpreted as a sign of identifying as "other." The majority of students responded that they were "very comfortable" in most of the situations. Students with disabilities were less likely to be comfortable being with people whose religion (56% vs. 67%) and sexual orientation (57% and 69%) is the same as their own and whose religion (48% vs. 61%) and gender (49% vs. 58%) are different from their own. They were also less comfortable saying what they think about religious issues (21% vs. 29%), gender issues (27% vs. 31%), sexual orientation issues (21% vs. 29%), socioeconomic issues (40% vs. 52%), and sexual orientation issues (38% vs. 49%). Students with disabilities were slightly more comfortable than their peers in speaking with others about

2

their socioeconomic background (27% vs. 39%) and being in situations where they are the only one of their other identities. This suggests that their "othering" has more to do with these overlapping identities than their disabled status. (Table 1)

Note that although most of the differences between students with and without disabilities are not statistically significant (at $p<.05$), there is a general pattern which indicates clearly the direction of difference; results are bolded in the following tables when there are particularly large differences between the students with and without disabilities.

Table 1
Comfort in following situations…
% very comfortable

Survey Item	Disabled	Not Disabled	Total
Being with people whose:			
… race/ethnicity same as my own	58.6	63.6	59.3
… religion is same as my own	**55.8**	**66.7**	**57.5**
…gender same as my own	58.6	63.6	59.3
…sexual orientation same as my own	**56.9**	**69.3**	**58.9**
…SES same as my own	54.7	60.6	55.6
…race/ethnicity different from my own	49.2	54.5	50.0
…religion is different from my own	**48.6**	**60.6**	**50.5**
…gender is different from my own	**49.2**	**57.6**	**50.5**
…sexual orientation is different from my own	47.0	51.5	47.7
…SES different from my own	51.9	54.5	52.3
Speaking with others about:			
… my race/ethnicity	47.0	51.5	47.7
… my religion	41.4	39.4	41.1
… my gender	47.0	51.5	47.7
… my sexual orientation	45.9	45.5	45.8
…my SES	**39.2**	**27.3**	**37.4**
Saying what I think about:			
…race/ethnicity issues	35.9	33.3	35.5
…religious issues*	**40.3**	**51.5**	**42.1**
…gender issues	37.0	39.4	37.4
…sexual orientation issues	**38.1**	**48.5**	**39.7**
…socioeconomic issues	39.8	45.5	40.7
Being in situations where I am the only one of my:			
…race/ethnicity	**29.3**	**21.2**	**28.0**
…religion	**28.7**	**21.2**	**27.6**
…gender	30.9	27.3	30.4
…sexual orientation	29.3	21.2	28.0
…socioeconomic status	30.9	27.3	30.4

* Chi-square significant at $p<.05$.

Disability interfering with identification with the engineering community
Students with disabilities were less likely to "feel like you are part of an engineering community" all of the time or usually (65% vs. 71% for students without disabilities). They are also less likely to feel welcome in the college of engineering (78% vs. 85%), feel wanted in the college of engineering (47% vs. 57%), and feel valued by the college of engineering (40% vs. 50%). Finally, they were less likely to think that engineering faculty cared about them as a person (56% vs. 70%) or that the college of engineering cared about them (56% vs. 66%) (Table 2).

Table 2
Student interaction/identification with engineering program
%Usually+All the time (combined)

Survey item	Disabled	Non-Disabled	Total
Team projects are valuable	71.0	79.5	78.1
Feel like you are part of an engineering community	**64.5**	**71.2**	**70.1**
Like studying with other students in group	61.3	54.6	55.7
Involved in student study groups	36.6	38.7	38.4
Engineering students at Rowan help each other succeed in class	77.4	85.9	84.5
Lab work divided equally among members of lab group	61.3	66.3	65.5

Table 3
Overall education satisfaction
% Strongly Agree + Agree (combined)

Survey Item	Disabled	Non-Disabled	Total
I feel welcome in the college of engineering	**78.2**	**84.7**	**83.6**
I take pride in the fact that I am a student in the college of engineering	84.4	85.9	85.7
Faculty members in the college of engineering care about me as a person	**56.3**	**70.2**	**67.9**
There is at least one faculty member in the college of engineering that I can count on.	78.2	75.3	75.8
The college of engineering really care about its students	**56.2**	**65.9**	**64.3**
I feel wanted in the college of engineering	**46.9**	**56.8**	**55.1**
I feel needed in the college of education	31.3	31.7	31.6

I am valued by the college of engineering	**40.6**	**49.7**	**48.2**
The college of engineering really values the student.	**43.7**	**57.9**	**55.6**
The college of engineering is very inclusive	62.5	69.3	68.3
The college of engineering is very diverse	43.8	47.5	46.9
I would rather remain in the college of engineering than Disabled to another college at this university	87.6	82.9	83.6

Disability and academic issues

The students with disabilities were also more likely to report some difficulty getting help or support from classroom faculty (28% vs. 47%) and advisors (36% vs. 46%) (Table 4). Just under three-quarters felt comfortable meeting their professors for academic help always/usually vs. 82% of the students without disabilities. Students with disabilities were less likely to feel their work was graded fairly by professors (84% vs. 92%) and fewer felt that engineering faculty inspired them to study engineering (56% vs. 67%) (Table 5). Although students with disabilities reported similar comfort levels asking questions in class, they reported being more comfortable with understanding the course material (84% always/usually vs. 77%). Over half felt overwhelmed by the amount of homework, compared to 38% of the students without disabilities. Finally, students with disabilities rated their academic skills slightly lower than students without disabilities (13% vs. 9% responding that they were below or far below average) (Table 6). In terms of extracurricular activities, students with disabilities had participated in STEM activities just about as often as their peers without disabilities (Table 7). The same finding was seen regarding participation in non-STEM activities (Table 8).

Table 4
Please indicate how often you have difficulty getting help or support from…
% never

	Disabled	Non-Disabled	Total
Tutors	53.3	55.4	55.1
Advisors*	**35.5**	**45.5**	**43.9**
Other students	43.8	44.0	43.9
Classroom faculty	**28.1**	**47.3**	**44.2**

*Chi-square significant at $p<.05$.

Table 5
Overall education satisfaction
% All the time + usually (combined)

Survey item	Disabled	Non-Disabled	Total
Educational experience here rewarding	90.7	85.4	86.3

I feel as though I belong in this engineering environment	78.2	78.1	78.2
I would recommend this school to siblings or friends	87.5	86.7	86.8
The school provides environment for free and open expression of ideas, opinions, and beliefs	81.3	84.7	84.1
Do your professors treat you with respect?	90.7	91.4	91.4
Are you able to understand course material?	**84.4**	**77.3**	**78.4**
Are you comfortable asking questions in class?	65.6	68.2	67.9
Do your professors think you have lower ability than you actually have?	12.9	14.7	14.3
Do your professors grade your work fairly	**83.9**	**91.5**	**90.2**
Professors take your suggestions and comments in class seriously	**77.4**	**82.9**	**82.0**
Comfortable meeting your professors for academic help	**71.9**	**81.7**	**80.1**
Do you understand what your professors expect of you?	84.4	85.3	85.3
Do your professors inspire you to study engineering?	**56.2**	**66.5**	**64.8**
Professors keep office hours	96.7	92.1	92.8
Professors encourage you to attend their office hours	81.2	85.4	84.7
Do you meet with your professors for extra help?	25.1	21.0	21.7
Professors move through course material too quickly	18.7	18.9	18.9
Feel overwhelmed by amount of homework	**56.2**	**38.4**	**41.3**
Feel satisfied with overall experience with professors	90.7	85.4	86.3

Table 6
Compared to other students in my classes, I think my academic abilities in my ENG classes are….

	Disabled	Non-Disabled	Total
Far below average	0.0	1.2	1.0

Below average	12.5	7.2	8.1
Average	46.9	44.0	44.4
Above average	37.5	43.4	42.4
Far above average	3.1	4.2	4.0

Table 7
Number of STEM activities at this university that students have participated in

	Disabled	Non-disabled	Total
0	21.9	25.3	24.8
1	34.4	34.3	34.3
2	21.9	23.0	22.9
3+	21.9	17.4	18.1

Table 8
Number of non-STEM activities at this university that students have participated in

	Disabled	Non-Disabled	Total
0	31.3	34.8	34.3
1	21.9	20.8	21.0
2	18.8	19.7	19.5
3	9.4	10.7	10.5
4+	18.8	14.1	14.7

Disability and self-confidence in engineering

Given their greater difficulty academically and their lower satisfaction and feeling of integration with the engineering community, it is perhaps not surprising that students with disabilities are less likely to express confidence in themselves as engineering students or as engineers in the future. They are less likely to agree or strongly agree that they are well suited for their major and less confident that they will find a job as an engineer when they graduate (Table 9). Accordingly, only 56% of students with disabilities reported being very likely to work in an engineering-related field ten years from now compared to 64% of their peers (Table 10). Surprisingly, however, students with disabilities have higher aspirations for obtaining master's and PhD degrees (48.4% and 22.6%) than their peers (41.5% and 7.9%) (Table 11).

Table 9
% Agree/Strongly Agree

Survey item	Disabled	Non-Disabled	Total
I am well suited for my choice of college major	71.9	79.6	78.4
I am confident of my overall ability	78.2	78.5	78.5
I am confident in my ability to succeed in my college engineering courses	75.1	79.7	78.9

I am competent in the skills required for my major	75.0	76.7	76.4
I am confident someone like me can succeed in an engineering career	81.3	82.8	82.6
I expect engineering will be a rewarding career	93.8	92.1	92.3
I will have no problem finding a job when I obtain an engineering degree*	**53.2**	**73.0**	**69.7**
My engineering coursework will prepare me for a job in engineering	75.0	76.8	76.6

*Chi-square significant at p<.05.

Table 10
Likelihood of working in engineering-related field 10 years from now

	Disabled	Non-Disabled	Total
Very unlikely	0.0	3.0	2.5
Not likely	3.1	1.8	2.0
Not sure	9.4	12.7	12.1
Possible	31.3	18.7	20.7
Very likely	**56.3**	**63.9**	**62.6**

Table 11
Highest degree in engineering expected to complete

	Disabled	Non-Disabled	Total
I do not intend to get an engineering degree	0.0	0.6	0.5
Bachelors	29.0	50.0	46.7
Masters	48.4	41.5	42.6
PhD	**22.6**	**7.9**	**10.3**

Discussion

The students with disabilities in this particular engineering college tend to be primarily "mainstream" in terms of their sex, race, socio-economic status, and first-generation college status. Slightly more of them identify as having a sexual orientation other than heterosexual than among students without disabilities, but this is still a small percentage. They have a higher percentage identifying as having ADD/ADHD, having an Autism spectrum disorder, speech and language or visual impairment. One-fifth preferred not to disclose what disability they have, also not uncommon. It is expected, further, that there is a population of students with disabilities who do not self-disclose and were thus not identified in the survey of the engineering students.

Their pre-college academic background was somewhat weaker than students without disabilities: a smaller percentage ranked in the top 10% of their class. In the university, they were somewhat more likely to feel they were academically below average than their counterparts without disabilities, but the differences were not large. They were as likely or more likely to participate in extra-curricular STEM and non-STEM activities compared to their peers without disabilities, which is known to be related to academic success and persistence for the general engineering student population.[3]

While the students with disabilities did not express many feelings of "otherness," they were not asked about their disability status in terms of feeling different or "othered." Other studies have identified some feelings of difference related to the disability status, and this is something we will try to identify both through individual interviews that are currently being conducted and in our fifth-year survey.

They were less likely to feel part of the engineering community or feel welcome in the college of engineering, although the majority still felt part of the community and college. They did, however, express that they felt less welcome, valued or wanted in the college of engineering than the students without disabilities, and were less likely to think the engineering faculty or the college as a whole cared about them as a person or a student. These findings are in line with the results in previous studies of students with disabilities in engineering or STEM fields.

They also faced more challenges academically and expressed more difficulty getting help or support from classroom faculty and advisors. They did, however, seem to be able to get help from other students similarly to students without disabilities, liked studying with other students and were as involved in study groups as other students were. They valued team projects and lab work in groups. Integration with other students is often a weakness for students with disabilities in engineering, but they did not seem to have much difficulty in this regard. Previous studies have found that students with disabilities gain self-efficacy in team projects and in situations where their peers provide feedback; this seems to be a strength in this program.

Fewer saw themselves working as an engineer ten years from the time of the survey than did their peers without disabilities, but surprisingly, more of the students with disabilities intend to continue to graduate school.

Thus, in this program there seem to be fewer obstacles to engineering identity than in other programs that have been studied. Nevertheless, the students with disabilities did appear to have more challenges academically and in getting help from faculty and advisors, and they were less likely to feel part of the engineering community or feel welcome in the college of engineering than other students. Therefore, there is room to explore the sources of these challenges and to intervene.

One avenue we are exploring is through in-depth interviews with some of the students with disabilities, to try to understand the sources of their challenges. We will also try to explore the

[3] Note that while LGBTQ+ students also participate as much as other students, they still are more likely to leave engineering than their peers who are not LGBTQ+ [45].

extent to which there is a non-disclosed population with disability who could benefit from some type of intervention. Making sure that resources are publicized is one way to encourage self-advocacy and awareness of the types of help that are available, which students with disclosed disabilities recognize as essential for success.

Another avenue is to identify the attitudes of faculty to students with (disclosed) disabilities and provide faculty workshops to dispel prejudice or lack of empathy with students with disabilities. Rule and Stefanich [44] found that some faculty do not understand differences between different types of disabilities and they sometimes make assumptions that accommodations are being requested to gain an advantage rather than out of real need. Providing universal design instructional strategies, a case-by-case approach to accommodations, and regular professional development on how to deal with disabilities has proven to be helpful. Coordination with the broader university office may result in helpful workshops and support for faculty who understand the need to be more accommodating and supportive.

Because there is a relatively small population of students with disabilities in the college of engineering, it may also be worthwhile to join with other STEM fields for faculty and student workshops that are particularly related to STEM types of fields. As we learn more about the engineering students, we will reach out to other majors to try to empower students with disabilities who have similar challenges as the engineering students.

References

[1] K. Raue and L. Lewis (2011). Students with disabilities at degree-granting postsecondary institutions (NCES 2011-018). U.S. Department of Education, National Center for Education Statistics. Washington, DC: U.S. Government Printing Office. Retrieved from http://nces.ed.gov/pubs2011/2011018.pdf

[2] T. Shepard and A. B. Hoxie, I did not anticipate this: Experiences from the early years. *ASEE Annual Conference Proceedings,* Indianapolis, IN, 2014.

[3] United States Government Accountability Office, *Higher education and disability: Education needs a coordinated approach to improve its assistance to schools in supporting students (GAO-10-33).* Washington, DC: United States, 2009. Retrieved from https://www.gao.gov/assets/300/297433.pdf

[4] G. M. Bettencourt, E. Kimball, and R. S. Wells, "Disability in postsecondary STEM learning environments: What faculty focus groups reveal about definitions and obstacles to effective support," *Journal of Postsecondary Education and Disability*, vol. 31, no. 4, pp. 387–400, 2018.

[5] C. Dunn, K. S. Rabren, S. L. Taylor, and C. K. Dotson, Assisting students with high-incidence disabilities to pursue careers in science, technology, engineering, and mathematics. *Intervention in School and Clinic, 48,*(1), 47-54, 2012.

[6] H. Jeannis, M. Goldberg, K. Seelman, M. Schmeler, and R. A. Cooper, Barriers and facilitators to students with physical disabilities' participation in academic laboratory spaces. *Disability and Rehabilitation: Assistive Technology*, 1–13, 2019.

[7] S. Rao and B. C. Gartin, Attitudes of university faculty toward accommodations to students with disabilities. *Journal for Vocational Special Needs Education*, *25*(3), 47-54, 2013.

[8] National Science Foundation, *Women, Minorities, and Persons with Disabilities in Science and Engineering: 2017.* Retrieved from https://www.nsf.gov/statistics/2017/nsf17310/

[9] X. Wei, J. W. Yu, P. Shattuck, M. McCracken, and J. Blackorby, Science, technology, engineering, and mathematics (STEM) participation among college students with an autism spectrum disorder. *Journal of Autism and Developmental Disorders*, *43*(7), 1539–1546, 2013.

[10] E. Ruzich, C. Allison, B. Chakrabarti, P. Smith, H. Musto, H. Ring, and S. Baron-Cohen, Sex and STEM Occupation Predict Autism-Spectrum Quotient (AQ) Scores in Half a Million People. *PLoS One, 10*(10), e0141229, 2015.

[11] S. Baron-Cohen, S. Wheelwright, A. Burtenshaw, E. Hobson, Mathematical talent is linked to autism. *Human Nature* 18(2): 125-131, 2007.

[12] I. Zytynski, A waste of talent? Making space for autism in engineering. *The Engineer,* Jan 23, 2015.

[13] J. Dusek, D. Faas, E. Ferrier, A. Goodner, A.L. Sarang-Sieminski, A. Waranyurat, A. Wood. Proactive inclusion of neurodiverse learning styles in project-based learning: A call for action. *ASEE Conference Proceedings*, Paper ID 22897, 2018.

[14] E.A. Peña, L.D. Stapleton, L.M. Schaffer. Critical perspectives on disability identity. *New Directions for Student Services* 154 (Summer): 85-96, 2010.

[15] A. Liasidou, Critical disability studies and socially just change in higher education. *British Journal of Special Education* 41(2): 120-134, 2014.

[16] A. Sommo, J. Chaskes. Intersectionality and the disability: Some conceptional and methodological challenges. *Research in Social Science and Disability* 7, 47-59, 2013.

[17] C. E. Hawley, E. Cardoso, and B. T. McMahon, Adolescent to adulthood in STEM education and career development: The experience of students at the intersection of underrepresented minority status and disability. *Journal of Vocational Rehabilitation, 39*, 193-204, 2013.

[18] N. W. Moon, T. L. Todd, D. L. Morton, and E. Ivey, E, *Accommodating students with disabilities in science, technology, engineering, and mathematics (STEM): Findings from research and practice for middle grades through university education.* Atlanta, GA: Center for Assistive Technology and Environmental Access, College of Architecture, Georgia Institute of Technology, 2012. Retrieved from https://advance.cc.lehigh.edu/sites/advance.cc.lehigh.edu/files/accommodating.pdf

[19] X. Wei, E. R. Christiano, J. W. Yu, J. Blackorby, P. Shattuck, and L. A. Newman, Postsecondary pathways and persistence for STEM versus non-STEM majors: among college students with an autism spectrum disorder. *J Autism Dev Disord, 44*(5), 1159-1167, 2014.

[20] W. Erickson, C. Lee, S. von Schrader, *Disability Status Report: United States*. Ithaca, NY: Cornell University Yang Tan Institute on Employment and Disability, 2016.

[21] S. Sgoutas-Emch, L. Baird, P. Myers, M. Camacho, and S. Lord, We're not all white men: Using a cohort/cluster approach to diversity STEM faculty hiring. *Thought & Action, 32,* 1, 91-107, 2016.

[22] K. Jahan, J. Everett, M. Jalayer, W.T. Riddell, A. Iranmanesh. Developing inclusive pedagogy for civil engineering courses. Prepared for presentation at *ASEE 2020.*

[23] P. Shattuck, J. Steinberg, J. Yu, X. Wei, B.P. Cooper, L. Newman, A.M. Roux. Disability identification and self-efficacy among college students on the autism spectrum. *Autism Research and Treatment,* Article ID 924182: 1-7, 2014.

[24] R. J. Jenson, A. N. Petri, K. Duffy, A.D. Day, and K. Z. Truman, Perceptions of self-efficacy among STEM students with disabilities. *Journal of postsecondary education and disability, 24*(4), 269-283, 2011.

[25] H. Denhart, Deconstructing barriers: Perceptions of students labeled with learning disabilities in higher education. *Journal of Learning Disabilities, 41,*6, 483-497, 2009.

[26] Y. P. Weatherton, R.D. Mayes, C. Villanueva-Perez. Barriers to persistence of engineering students with disabilities: A review of the literature. *ASEE Conference proceedings.* Paper ID 19583, 2017.

[27] A. Lee, A comparison of postsecondary Science, Technology, Engineering, and Mathematics (STEM) enrollment for students with and without disabilities. *Career Development for Exceptional Individuals, 34,* 72–82, 2011.

[28] A. Astin, Student involvement: A developmental theory for higher education. *Journal of College Student Development, 40*(5), 518-529, 1984.

[29] T. W. Cadwallader, M. Wagner, and N. Garza, Participation in extracurricular activities. In M. Wagner, T. Cadwallader, and C. Marder (with R. Cameo, D. Cardoso, N. Garza, P. Levine, and L. Newman). *Life outside the classroom for youth with disabilities. A report*

from the National Longitudinal Transition Study-2 (NLTS2). Menlo Park, CA: SRI International, 2013.

[30] A. N. Palmer, W. Elliott III, G. A. Cheatham, Effects of extracurricular activities on postsecondary completion for students with disabilities. *The Journal of Educational Research, 110*(2), 151-158, 2016.

[31] J. T. Cooper, B. A. Pruitt, Creating opportunities for success in college settings for students with emotional and behavioral disorders. *Beyond Behavior*, *14*(3), 23-26, 2005.

[32] D. Wilson, D. Jones, M. J. Kim, C. Allendoerfer, R. Bates, J. Crawford, T. Floyd-Smith, M. Plett, and N. Veilleux, The link between cocurricular activities and academic engagement in engineering education. *Journal of Engineering Education, 103*(4), 625-651, 2014.

[33] W. Blanchett, V. Mumford, and F. Beachcum, Urban school failure and disproportionality in a post-*Brown* era. *Remedial and Special Education, 26,*2, 70-81, 2005.

[34] R. J. Skiba, A. S. Simmons, S. Ritter, A. C. Gibb, M. Karega Rausch, J. Cuadrado, and C. Chung, Achieving equity in special education: History, status, and current challenges. *Council for Exceptional Children, 74*, 3, 264-288, 2008. Retrieved from https://www.census.gov/newsroom/releases/archives/miscellaneous/cb12-134.html

[35] M. A. Gottfried, R. Bozick, E. Rose, R. Moore, Does career and technical education strengthen the STEM pipeline? Comparing students with and without disabilities. *Journal of Disability Policy Studies, 26*, 4, 232-244, 2016.

[36] S. E. Walden, D. A. Trytten, R. L. Shehab and C. E. Foor, Critiquing the "underrepresented minorities" label. *ASEE Conference Proceedings*. ASEE Annual Conference & Exposition, Salt Lake City, UT, 2018.

[38] E. M. Spingola, Literature review on disability participation in the engineering field. *ASEE Conference Proceedings*. ASEE Annual Conference & Exposition, Salt Lake City, UT, 2018.

[39] N. Barga, Students with disabilities in education: Managing a disability. *Journal of Learning Disabilities,29*, 4, 413-421, 1996.

[40] T. S. Love, N. Kreiser, E. Camargo, M. Grubbs, E. J. Kim, P. L. Burge, S. M. Culver, STEM faculty experiences with students with disabilities at a land grant institution. *Journal of Education and Training Studies, 3*, 1, 27-38, 2015.

[41] C. Rasoal, H. Danielsoon, and T. Jungert, T, Empathy among students in engineering programmes. *European Journal of Engineering Education*, *37*, 427–435, 2012.

[42] J. Stobel, J. Hess, R. Pan, and C. A. Wachter Morris, Empathy and care within engineering: Qualitative perspectives from engineering faculty and practicing engineers. *Engineering Studies*, *5*, 137–159, 2013.

[43] S. Grimes, J. Scevak, E. Southgate and R. Buchanan, Non-disclosing students with disabilities or learning challenges: Characteristics and size of a hidden population. *The Australian Educational Researcher*, *44*(4), 425–441, 2017.

[44] A.C. Rule and G. P. Stefanich, Using a thinking skills system to guide discussions during a working conference on students with disabilities pursuing STEM fields. *Journal of STEM education: Innovations and Research, 13* (1), 43-54, 2012.

[45] B. E. Hughes, Coming out in STEM: Factors affecting retention of sexual minority STEM students. *Science Advances 4*(3), https://advances.sciencemag.org/content/4/3/eaao6373 , 2018.