

WIP Unseen: Examining the Link Between Disability Status and Students' Sense of Belonging in Undergraduate Engineering

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Abstract

Over the past few decades there has been a growing interest in understanding the individual and systemic factors that positively and/or negatively impact the educational experiences and outcomes of underrepresented students in engineering. Students of color, women, and students with disabilities (SwD) often face barriers and challenges within engineering programs (National Academies of Sciences, Engineering, and Medicine, 2016). In turn, these experiences shape their educational and psychosocial outcomes, often in ways that differ from their overrepresented peers (i.e., white men).

Interestingly, while there is a robust collection of literature that examines the experiences and factors that impact outcomes for women and students of color pursuing undergraduate degrees in engineering, there is scant literature that focuses on SwD (Lee, 2014). Additionally, while current engineering education research provides insight on the effects that environmental factors (e.g., faculty language in the classroom) and individual psychosocial factors (e.g., sense of belonging) have on the experiences and outcomes for undergraduate engineering students, few studies have examined these specifically among SwD. This lack of research is problematic, as there continues to be increased enrollment of SwD in postsecondary engineering programs, but the number of these students completing engineering degrees remain low compared to their nondisabled peers (NSF, 2019).

Sense of belonging among engineering undergraduates, that is feeling accepted and connected at one's institution, and within one's major and courses, is a critical component that impacts students' success and persistence (Freeman et al 2007; Strayhorn, 2012; Tinto, 2017; Wilson et al., 2005). Engineering students who report low sense of belonging are more likely to switch out of engineering into other non-STEM disciplines (Benson et al., 2018; Seymour & Hewitt 1997; Walden & Trytten, 2007). Interestingly, much of the literature that focuses on the sense of belonging of underrepresented groups in postsecondary engineering is centered on minority students and women, while SwD are often not discussed (Groen, 2018; Vaccaro et al., 2015).

As research continues to demonstrate the connections between students' sense of belonging, academic, and social outcomes, it becomes increasingly important to examine potential links between disability status and sense of belonging. Coupled with the understanding that students with disabilities are enrolling in postsecondary STEM programs at rates similar to their nondisabled peers (NSF, 2019), this study explores the link between disability status and sense of belonging as part of a larger research project investigating student outcomes of engineering undergraduate students. This preliminary work is guided by the following research question: is there a link between disability status and undergraduate engineering students' sense of belonging? Study results, implications for practice, and recommendations for future research are discussed.

Examining the Link between Disability Status and Students' Sense of Belonging in Undergraduate Engineering Programs

Even though federal legislation provides equal access to higher education, students with disabilities remain underrepresented in postsecondary science and engineering fields. The National Center of Education Statistics (2023) reports that in 2019-20, approximately 21 percent of undergraduates reported having a disability. In 2020, the number of non-institutionalized working age (25-64 year-old) adults with disabilities holding an associate degree or some college was 9.1%, and the same population with a bachelor's degree was 3.7% (U.S. Department of Commerce, 2021). Comparatively, the degree attainment of adults without disabilities was 26% and 25% respectively (U.S. Department of Commerce, 2021). In 2021, 3% of the STEM workforce (ages 18-74) had at least one disability. Of that 3%, roughly one-third held a bachelor's degree or higher (National Center of Science and Engineering Statistics (NCSES), 2023). Further, due to self-reporting of disability status in postsecondary education, it is possible that the number of students with disabilities attending two- and four-year schools, and those enrolled in science, technology, engineering, and mathematics (STEM) programs are underreported (Wolanin & Steele, 2004). Even taking non-disclosure into account, numbers presented here indicate that students with disabilities are indeed enrolling in postsecondary education and are choosing to pursue an education in STEM fields. Unfortunately, the persistence and retention rates of students with disabilities are lower than their non-disabled peers (Coghill, 2020; Fleming et al., 2018). Society is full of diverse problems and these problems are best solved by people of all backgrounds, cultures, and abilities working together to engineer solutions (Wulf, 2002). If the United States is to continue to remain a leader in fields of science and engineering, then it is critical for diverse student populations to have positive

educational experiences in these field.

Sense of belonging among engineering undergraduates, that is feeling accepted and connected at one's institution, and within one's major and courses, is a critical component that impacts students' success and persistence (Freeman et al., 2007; O'Hara et al., 2020; Strayhorn, 2012; Tinto, 2017; Wilson et al., 2005). Within engineering education literature, students' sense of belonging has been identified as a critical factor that impacts their academic success, persistence, and well-being (Freeman et al., 2007; Good et al., 2012; O'Hara et al., 2020; Strayhorn, 2018; Wilson et al., 2015). A sense that a student belongs can manifest at different levels within academic settings: (1) at the institutional or university level; (2) at the major or program level; (3) and at the course or classroom level, with some arguing that belonging is most salient at the classroom level (Wilson et al., 2015; O'Hara, Bolding et al., 2020). Students enrolled in engineering programs who report a low sense of belonging are more likely to switch out of engineering (Benson et al., 2019; Marra et al., 2012; Seymour & Hewitt, 1997), and show decreased interest in pursuing engineering careers (Good et al., 2012; Lichtenstein et al., 2014).

Developing a sense of belonging in engineering learning environments can be particularly difficult for women, students of color, and students with disabilities because of the racism, sexism, and ableism they encounter throughout their postsecondary journey, however, students experiencing marginalization have also been known to resist systemic factors that marginalize them (Espinosa, 2011; Reinholz & Ridgway, 2021; Rodriguez & Blaney, 2021).

Interestingly, much of the literature that focuses on the sense of belonging of underrepresented groups in postsecondary engineering is centered on minority students and women, while neurodiverse and students with other disabilities are often not discussed (Groen, 2018; Vaccaro et al., 2015). Addressing this gap in the literature on sense of belonging of

students with disabilities in engineering learning environments can help promote inclusive practices in undergraduate engineering and challenge ableist assumptions that are often present in engineering education (Cech, 2023).

The Current Study

As research continues to demonstrate the connections between students' sense of belonging, academic, and psychosocial outcomes it becomes increasingly important to examine potential links between students identifying as having a disability and their sense of belonging. Coupled with the understanding that enrollment of students with disabilities is increasing in postsecondary STEM programs, this paper presents findings of the link between disability identity and sense of belonging as part of a larger research project investigating student outcomes of engineering undergraduate students (NCSES, 2023). This preliminary work is guided by the following research question: is there a link between students' disability status and undergraduate engineering students' sense of belonging?

Method

Sample and Procedures

Data for this project included survey responses as part of a larger validated survey measuring motivation and attitudes of engineering students (MAE; Benson et al., 2018; O'Hara et al., 2020). Participants were undergraduate engineering students from first year through senior year ($n = 1143$; 27% identified as having 1 or more disabilities/73% no disability). Table 1 below lists percentages for additional participant demographic information. The survey was distributed in the spring semester of 2022-2023 academic year and was administered electronically using Qualtrics software. A recording of instructions and link to survey were distributed within pre-selected courses, one from each program year. Data were de-identified.

Incomplete responses and cases that did not respond to disability status questions were not included.

Table 1

Participant demographics

Demographic		Percentage
Race/Ethnicity	American Indian or Native American	1.6%
	Asian	7.4%
	Black or African American	5.9%
	Hispanic, Latino, or Spanish Origin	6.1%
	Middle Eastern or North African	1%
	Native Hawaiian or Other Pacific Islander	<1%
	White	75.2%
Some other race or ethnicity	6.4%	
Gender	Men	62.7%
	Women	34.6%
	Gender nonconforming/gender nonbinary	<1%
Academic Year	First-year	72.3%
	Sophomore	5.6%
	Junior	13.4%
	Senior	8.6%

Note. $n = 1143$. Percentages don't equal 100% due to participants' ability to select multiple categories.

Measures

Sense of Belonging

Students' sense of belonging was measured using 20 items from the Motivations and Attitudes in Engineering (MAE) scale (Benson et al., 2019; Fernandez et al., 2016; Kirn et al., 2016; O'Hara et al., 2020). Within the MAE survey, students' sense of belonging is measured at

three different levels: university, engineering major, and the course level. Within MAE, sense of belonging is defined as one's being a part of and fitting in within a community/environment.

Sense of belonging- university level. The MAE scale measuring sense of belonging at the university level consists of five items that assess students' sense of belonging within their university. Items were answered on a 7-point Likert-type scale (1= Not at all, 7= Very much so). An average score across items was calculated with higher scores reflecting higher sense of belonging at the university level. A sample item for sense of belonging- university level is "I feel there is a sense of community at this school."

Sense of belonging- engineering major level. Sense of belonging at the engineering major level consists of ten items that measure students' perceptions of belonging within their engineering major. Items were answered on a 7-point Likert-type scale (1= Not at all, 7= Very much so). An average score across items was calculated with higher scores reflecting a higher sense of belonging at the engineering major level. A sample item for sense of belonging at the engineering major level is "Engineering faculty and staff in engineering make me feel wanted and accepted."

Sense of belonging – course level. Five items within the MAE survey measure students' sense of belonging at the engineering course level. Students are asked to respond to these questions with regard to the engineering course in which they are enrolled while taking the survey. Items were answered on a 7-point Likert-type scale (1= Not at all, 7= Very much so). An average score across items was calculated with higher scores reflecting a higher sense of belonging at the engineering course level. A sample item for sense of belonging at the course level is "I feel supported in my engineering course."

Disability Status

Disability status was determined by students' self-reporting. Students were asked to describe their disability/ability status regardless of whether they received academic accommodations through the university's student accessibility office. Students were able to select any disabilities that applied. Selection choices included: (1) a sensory impairment (vision or hearing), (2) a learning disability (e.g., ADHD, dyslexia), (3) a long-term medical illness, (4) a mobility impairment, (5) a mental health disorder, (6) a temporary impairment due to illness, (7) a disability of impairment not listed above, or (8) I do not identify with a disability or impairment.

Results

Table 2 presents descriptive statistics for each construct of interest. On average, students felt like they belonged at all three levels, with students having a slightly stronger sense of belonging at the university level than at the engineering major and course level.

Table 2*Descriptive statistics of variables*

Variables	No Disability			Disability		
	N	Mean	<i>SD</i>	N	Mean	<i>SD</i>
Sense of Belonging: University	863	5.86	0.980	310	5.51	1.18
Sense of Belonging: Engineering Major	863	5.73	1.08	310	5.42	1.13
Sense of Belonging: Engineering Course	863	5.86	1.11	310	5.55	1.22

A one-way multivariate analysis of variance (MANOVA) was conducted to determine the effect disability status on students' sense of belonging at three levels—University, Engineering, and Engineering Course. The MANOVA assumption of equality of covariance

matrices failed due to a significant Box's test, $Box's M = 41.76, F(6, 2129837.38) = 6.933, p < .001$. While MANOVAs are generally robust to this type of violation (Pituch & Stevens, 2016), there were unequal group sizes and as a result the more conservative Pillai's Trace statistic was used (Azen & Walker, 2011; Field, 2018; Pituch & Stevens, 2016). Results indicated a multivariate main effect for disability status, $Pillai's Trace = .024, F(3) = 9.397, p < .001$.

Univariate results indicated that there was a statistically significant difference in mean sense of belonging at the university level between the groups, $F(1, 1171) = 26.521, p < 0.001, \eta_p^2 = 0.022$. Bonferroni's Test for multiple comparisons found a mean difference in university level sense of belonging between students who identified as having a disability and those who indicated no disability at all, $\Delta = -0.353, p < 0.001, 95\% CI [-0.487, -0.218]$. A significant mean difference was found in sense of belonging at the engineering major level, $F(1, 1171) = 18.101, p < 0.001, \eta_p^2 = 0.015$. A difference of, $\Delta = 0.308, p < 0.001, 95\% CI [0.166, 0.450]$ was found between those who identified as having no disability and those who identified with a disability. The Bonferroni Test for multiple comparisons was used to evaluate the significance of the mean difference. Students who identified as having a disability also significantly differed on sense of belonging at the engineering course level, $F(1, 1171) = 16.590, p < 0.001, \eta_p^2 = 0.014$. Students who had a disability had lower mean for engineering course belonging compared to students with no disability, $\Delta = -0.307, p < 0.001, 95\% CI [-0.454, -0.159]$.

Discussion

Research continues to demonstrate the connection between students' sense of belonging, their persistence, and overall academic success (Freeman et al., 2007; O'Hara et al., 2020; Wilson et al., 2005). Moreover, research within engineering education has marked sense of

belonging as being critical to engineering students' success (e.g., Good et al., 2012). Yet, students who experience marginalization still find it difficult to increase their perception of feeling like they are a part of their engineering programs despite their unique ability to normally persist in a system stacked against them (Espinosa, 2011; Reinholz & Ridgway, 2021; Rodriguez & Blaney, 2021). This study highlighted the critical gap in the literature concerning students with disabilities and the lack of discussion regarding their sense of belonging in engineering education. As students with disabilities continue to enroll in post-secondary engineering education programs, it is important to continue to study the impact engineering education might have on these students' sense of belonging.

Addressing the disparities marginalized students face is crucial for improving education outcomes and integrating students with disabilities in engineering programs. The findings of this study demonstrate that students with disabilities consistently rate their sense of belonging at the university, engineering major, and course levels significantly lower than their non-disabled peers. These results provide preliminary empirical evidence that students with disabilities are less likely to feel like they belong. Furthermore, our results contribute to the understanding of disability intersecting with educational experiences within engineering students—an area of research that remains less explored compared to other marginalized groups (Vaccaro et al., 2015). Understanding the factors that contribute to lower sense of belonging at all three levels can help educators and student affairs practitioners work to provide informative and effective development opportunities for higher education personnel to ensure that the experiences of students with disabilities in engineering programs are positive and equitable.

Descriptive statistics, in our results, indicate that overall undergraduate engineering students in the sample, on average, have a relatively strong sense of belonging at all three levels.

However, intergroup comparisons revealed that at all three levels, students with disabilities had significantly lower sense of belonging than their non-disabled peers. This discrepancy suggests that physical or programmatic access is insufficient for students to truly feel included and underscores the need to broaden current frameworks of sense of belonging to adequately incorporate the unique challenges faced by students with disabilities. Moreover, this broadening should include factors that, not only influence sense of belonging for engineering students with disabilities at the engineering major level, but their overall college experience especially within academic spaces.

Practical Interventions

To readily incorporate the findings from this research, we offer some practical interventions for institutions, faculty, and practitioners to consider. With the caveat that multifaceted interventions are often the most effective. It should go without saying, but engineering programs should implement comprehensive training for faculty and staff that is targeted at understanding the needs of students with disabilities, with a particular focus on inclusive classroom environments that actively promote a sense of belonging. Institutions and departments should consider developing more robust support structures that go well beyond what is typically considered an accessibility service. For example, creating opportunities for students to be mentored with peers or professionals who might share similar experiences. Perhaps one of the strongest interventions to support and promote sense of belonging would be curriculum and pedagogy adjustments that include more diverse perspectives, especially including those of people with disabilities. For example, this could involve integrating case study examples that highlight the contributions of engineers with disabilities into, and across, program content. We would be the first to suggest that none of these interventions are easily implemented. Nor are

they accomplished by individual faculty and staff or even individual departments. Our decision to include sense of belonging at three different levels underpinned the complexity of the response needed to create effective change in engineering education writ large. These are just a few suggestions to stimulate further thought and action.

Limitations

This work examined intergroup differences of undergraduate engineering students' sense of belonging. Despite the notable and significant differences between students with disabilities and students without disabilities' sense of belonging, this work is not without limitation. Chief among them being the limits of solely using quantitative methods. Quantitative inquiry can only provide so much data to answer this question, and therefore additional research should include critical qualitative and multi-method approaches to further investigate these findings.

Moreover, this study was conducted at a single institution and results should be interpreted with caution and not generalized. Future work will seek to do multi-institution data collection. This would allow for more fine-grained and nuanced analyses. Future research should include open response questions or participant interviews to better identify the factors that are contributing to the lower sense of belonging being experienced by students with disabilities, compared to their non-disabled peers. Finally, as previously mentioned, students must self-identify as having a disability, and it is possible that disability status could be underreported. This calls into question current methods and techniques institutions use to adequately identify students with disabilities.

Conclusion

This preliminary research sought to examine if there was a difference in engineering students' sense of belonging based on their disability status. It was determined through this work

that it is possible that engineering students with disabilities might experience a lower sense of belonging at the university, engineering major, and course level, than their non-disabled peers.

While the greatest difference between students with disabilities and their non-disabled peers was seen in sense of belonging at the university level, there were still significant differences in sense of belonging at the engineering and engineering course levels.

The evidence from this study calls for a concerted effort to rethink how inclusion is practiced in engineering education—we must move beyond compliance towards genuine inclusivity. When engineering programs better serve all students, they enrich the profession with diverse perspectives that are crucial for innovative problem-solving in a global context. Better yet, as institutions of higher education seek to create more equitable and inclusive experiences for students, it is imperative that we also critically examine the factors that lead students with disabilities to feel like they do not belong in engineering spaces. It is time that the hidden become seen, it is time this population gains a seat at the table.

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