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Evaluating Students' Belonging in Two Engineering Departments

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Work in Progress: Evaluating Student's Belonging in Two Engineering Departments

Introduction

The need to be loved and belong is a fundamental human motivation. It is part of Maslow's hierarchy of needs, followed only after meeting a person's physiological and safety needs, and is an essential requirement before esteem and self-actualization can be achieved [1, 2].

A widely accepted definition of sense of belonging (SB) in higher education is presented by Strayhorn, who defines SB as "students' perceived social support on campus, a feeling or sensation of connectedness, and the experience of mattering or feeling cared about, accepted, respected, valued by, and important to the campus community or others on campus such as faculty, staff, and peers" [3]. Moreover, students' SB within a university includes their social and academic belonging. Social belonging relates to positive social interactions with peers, faculty, and campus community, whereas academic belonging relates to academic performance, academic self-efficacy, curriculum motivation, and perceptions of belonging within a professional discipline [4, 5]. SB is, therefore, one of the main contributors to students' academic success, persistence, and overall well-being. The literature reports that the lack of SB is perceived differently by different student groups and is critical for underrepresented students (e.g., first-generation and low socioeconomic status) to persist in college after the first year of study [6]. In engineering, women and underrepresented minority ethnic groups (e.g., Black, Latinx, Native Americans) are reported to possess a lower sense of belonging compared to white males [7-12]. However, this statement seems influenced by students' perceptions of fit with their institution. For example, a recent study found no difference in the SB of Latina and Latino students attending Hispanic Serving Institutions compared to other ethnicities [13]. SB can also increase as students progress in their programs, with sophomore students reporting lower SB than juniors or seniors [14].

Due to the importance of SB in students' success and retention, many activities and interventions are utilized to increase their SB in the classroom, department, campus community, and professional discipline. Important factors that increase students' SB include student-faculty interaction, robust and meaningful connection with peers, cultural and ethnic representation of faculty and peers, extra-curricular activities, participation in research and student clubs, faculty and department support, and pedagogical caring [9, 15, 16]. Successful interventions to increase students' SB at the university level include a pre-college assignment for students to become familiar with campus resources and a mentorship program for low-income students; SB in the classroom also increased by implementing learning communities, active learning strategies to promote in-class student-student interaction, and faculty behavior such as availability, respect, and approachability for students to ask questions about course-related material [6, 17-20]. The most common interventions to increase SB in engineering majors are related to the technical discipline. Not surprisingly, most engineering education interventions reported in the literature target first-year engineering women and first-generation/low-income students to increase their SB and engineering identity. Some intervention examples to retain this population of students include faculty and peer-mentoring, participation in internships with local STEM companies [21], interviewing a person of color in STEM [22], use of makerspaces for completing design

projects [23], summer bridge programs [24], first-year engineering student success course [25], and sociotechnical design projects since women tend to choose career fields that involve helping and working with people [26].

In this study, we are particularly interested in students' perceptions of belonging in the authors' home departments, Materials Science and Engineering (MSE) and Chemical Engineering (ChemE), at a large research institution. Both authors developed and delivered Student Success courses in their respective departments. The ChemE course has a total enrollment of 84 students over four quarters since Fall 2021 and it is open to all students in the department. The course objectives are to build community through informal social interactions, improve students' overall well-being by practicing self-care, and integrate professional development [27]. The MSE course has been offered twice since Spring 2023, with a total enrollment of 15 students. It aims to integrate first-year students into the MSE department and promote their academic success through activities including student panels and lessons on time management and wellness. The MSE seminar is based on an academic success strategies course developed at the start of the pandemic that emphasized time management, wellness, and reflective change [28]. Both courses were taught by department faculty and integrated significant peer interactions.

This study had two research questions:
  (1)   How do students perceive belonging in the two engineering departments?
  (2)   Are there differences in students' perceptions of belonging between students who attended the student success courses and those who did not?

The authors are collecting baseline data for future projects investigating SB within the departments and across engineering disciplines at the institution (RQ1). For research question 2, the authors hypothesize that participation in a department success course would increase the department SB.

Methods

Positionality Statement
Both authors of this work are women in engineering disciplines who were in the majority race in their undergraduate and graduate institutions. One author approaches this research from an ally's perspective and advocates for the undergraduate students in their program. The other author is a former low-income/first-generation student and the only Latina professor in her department. She approaches this research from the perspective of her background as an undergraduate student and as an advocate for students with similar cultural and socioeconomic backgrounds.

Data Collection and Analysis
The Engineering Department Inclusion Level (EDIL) survey [29] was used to answer the research questions using a seven-point Likert scale. This survey investigates students' perceptions of department belonging, pride, and diversity. Survey questions were added to the EDIL to collect the respondents' department, participation in one of the success seminar courses, and demographic information (gender, year of study, and first-generation status). A clerical error prevented us from collecting the race and ethnicity of the respondents. Students completed the survey in class without incentives. The Institutional Research Board (IRB) at the University of California, Davis (UC Davis) approved this work.

The survey was distributed at the end of the Spring 2023 quarter and received 52 responses. This work-in-progress reports survey results from several cohorts of students:
- Senior students enrolled in senior design courses in the two target departments
- Students enrolled in the departments' success courses

This project is in its initial stages, so priority was given to senior students since they were in the program for a longer time and would not take the survey in future years. Two respondents were from departments other than MSE and ChemE, so their responses were excluded. Data was analyzed using t-tests with a significance level of 0.05, while internal consistencies were calculated using Cronbach's alpha (α).

Demographic Information

Table 1 shows the demographic information of both departments as well as from the survey respondents. For both departments, the gender and non-first-generation status of survey respondents reflects overall department enrollment. The year of study for the department is determined by the number of units completed, which results in some students appearing more advanced (due to Advanced Placement and transfer course credit) than their progress within the degree program. Despite this known error, senior students are still over-represented in the survey. The large response rate for seniors is expected since they were a target cohort. Of the survey respondents, the seminar course was taken by 41% and 33% of the department respondents for ChemE and MSE, respectively. Students in the ChemE department may be majoring in either Chemical Engineering or Biochemical Engineering. However, the degree programs have significant overlapping coursework, so data was not collected to separate the two majors. The MSE department only has a single MSE major.

Table 1. Demographic information of departments and survey respondents

		Materials Science and Engineering (MSE)		Chemical Engineering (ChemE)	
		Department[a] (n=113)	Survey Responses (n=21)	Department[a] (n=308)	Survey Responses (n=29)
Gender	Men	71%	67%	59%	59%
	Women	27%	33%	40%	38%
	Non-binary/ not specified	3%	0%	1%	3%
First-generation	Yes	23%	24%	24%	41%
	No	73%	76%	54%	59%
	Unknown	4%	0%	22%	0%
Year of study[b]	Freshman	29%	33%	16%	0%
	Sophomore	24%	0%	22%	3%
	Junior	18%	0%	24%	7%
	Senior	29%	66%	38%	80%
Enrolled in seminar?	Yes	8%	33%	27%	41%
	No	92%	67%	73%	59%

[a] Department enrollment for the 2022-2023 academic year
[b] Year of study for the department is based on the number of units completed.

Results and Discussion

RQ1: How do students perceive belonging in the two engineering departments?

The primary objective was to conduct a preliminary investigation of SB in the two departments. As shown in Figure 1, students' perceptions averaged above five (out of seven) for all three EDIL scales of department caring, diversity, and pride, which is considered satisfactory by the authors. Furthermore, there was no statistically significant difference between the three EDIL scales, nor were there differences between the MSE and ChemE departments. Cronbach's alpha (α) for department caring, diversity, and pride were 0.97, 0.90, and 0.98, respectively. However, a review of the individual questions shows some interesting trends. The lowest score for each department was on the statement: "I feel needed in the department," which is a part of the department caring criterion. Similarly, the highest score for each department was on the statement, "I am respected by other students in this department."
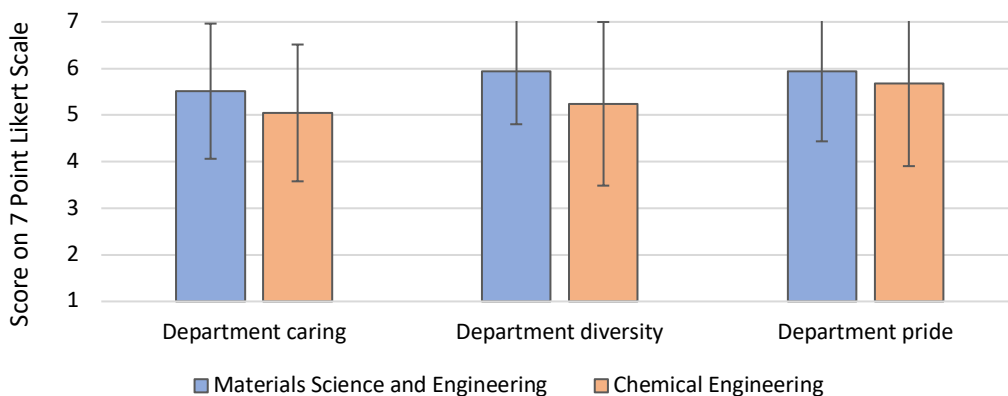

Figure 1. Comparison of departments on the composite EDIL scales. Error bars indicate the standard deviation.

A secondary objective was to evaluate the efficacy of the survey for a broader project on students' SB across other disciplines within the College of Engineering at the university. The authors note that larger samples would improve the analysis but are concerned whether the large uncertainties for each scale will hinder statistically significant findings.

RQ2: Are there differences in students' perceptions of belonging between students who attended the student success courses and those who did not?

The department success seminars provide significant small-group interaction with department faculty and peers, and it was hypothesized that these would increase students' SB. The respondents were categorized by their participation in the success seminars, and the average score for all scales remained above five (Figure 2), similar to RQ1. Unfortunately, the seminar did not significantly affect students' SB, regardless of the department and for any of the scales. This result contradicts the initial hypothesis. As noted for RQ1, students scored high/low in similar statements regardless of their participation in the seminar, e.g., both groups scored lowest on feeling needed by the department.

Several factors confound the analysis. As discussed in the introduction, students' SB can be improved through activities, including extracurriculars and undergraduate research. UC Davis has over 600 student clubs, the College of Engineering has support programs for underrepresented minorities, and there are department-based professional societies for

undergraduate students. Since the success seminars are only one of many resources, some students may find their department SB through these other programs rather than the seminars. Additionally, the authors note that senior students comprised the majority of respondents, particularly those who did not take the seminars. Past work found that students' SB is affected by students' year in the program[14], so the academic year differences may have obscured the effects of the seminar. A broader distribution of the survey within the departments could improve the comparison.
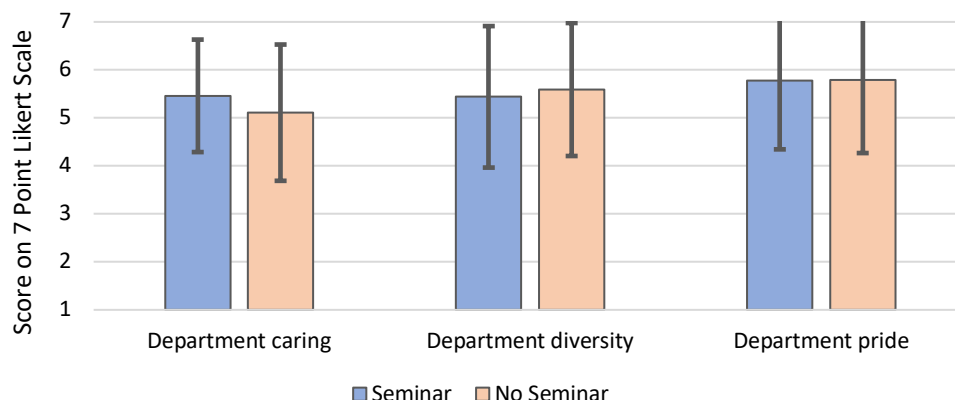

Figure 2. Students' SB on the EDIL scales of department caring, diversity, and pride, categorized by whether the students participated in the department success seminar. Error bars indicate standard deviation.

Conclusions and Future Work
This work found satisfactory levels of students' department belonging in the Materials Science and Chemical Engineering departments at UC Davis, using the EDIL scales of department caring, diversity, and pride. However, the study could not determine a significant effect of departmental student success seminars on the EDIL scales. One limitation is that the sample size prevented the investigators from differentiating students' experiences from majority versus marginalized groups (e.g., racial/ethnic minorities, first-generation status, LGBTQI* status). A more extensive investigation, such as across the College of Engineering at UC Davis, may provide more meaningful results. Future work could also consider how SB is affected by the development of students' engineering identity over time. Finally, the evaluation of the seminar course could be improved by investigating the students who enrolled, such as collecting historical demographic data from the courses or interviewing students about their decision to participate in the courses. Additional work is needed for departments to assess SB and evaluate specific interventions.

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