Work in Progress: Departmental Analysis of Factors of Engineering Culture

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Introduction
Engineering culture is described as unique compared to other academic disciplines. A 2010 study by Godfrey and Parker described engineering culture as one that has an expectation of harshness coupled with continuous struggles [1]. Rigor and competition within engineering programs perpetuates a perception of a "meritocracy of difficulty" [2] where student success can be described as "being able to take it" [1]. "Horrific" workloads create an environment of "suffering and shared hardship" [1]. This negative culture of hazing has been described as particularly unwelcoming to marginalized groups in engineering [3, 4]. The high stress from this culture of suffering and socially acceptable hazing in engineering may negatively impact student mental health.

Mental health of undergraduate students is a growing concern. Roughly 40% of college students (N = 62171) surveyed in the 2018-2019 Healthy Minds study report having been diagnosed with a mental health disorder in their lifetime [5]. Some studies have suggested that engineering students face higher levels of anxiety, stress, and depressive symptoms than non-engineering students [6, 7]. Concerningly, students who are underrepresented often face additional stress compared to their peers [8, 9] and may also be less likely to seek out help due to higher perceived stigma [10, 11].

Despite the influence of culture in the development of recruitment and retention programs in engineering, limited work has analyzed the effect of cultural differences between engineering disciplines on student mental health and the subsequent development of better mental health programs. In this project, we seek to bridge this research gap by identifying features of disciplinary subcultures in engineering that are correlated to mental health.

The present work is part of a larger mixed methods study that seeks to understand the role of mental health in engineering culture with the ultimate goal of informing proactive interventions to support student wellness [12-14]. The larger study included a quantitative survey of undergraduate engineering students followed by semi-structured interviews with a subset of survey participants. Our previous survey data analyses have measured rates of stress, anxiety, and depression for undergraduate engineering students at a large, public university and examined how these rates differ by social identities [14]. The goal of the analysis presented in this paper is to explore how mental health, perceptions of inclusion, and engineering identity differ across engineering disciplines.

Methods
All study procedures and instruments were reviewed and approved by an Institutional Review Board (University of Illinois Urbana-Champaign #18003). Data collection and participants were described previously [14]. Briefly, undergraduate engineering students were recruited by email distribution at a large, public institution to participate in the study by responding to the survey. Participants included undergraduate engineering students from 11 different engineering departments.

Measures. The survey used in this study is described previously [14]. The survey included measures of engineering identity; intention to pursue an engineering career; self-reported stress, anxiety, depression; and perceptions of inclusion. Self-reported stress, anxiety, and depression levels were measured by the Depression Anxiety Stress Scales (DASS-21). The DASS-21 is the shorter form of Lovibond and Lovibond's 42-item DASS instrument where participants are asked to indicate the frequency that they experienced the occurrence described in the item over the past week [15]. Sample items include "I found it hard to relax" and "I was aware of dryness of my mouth." Student perceptions of inclusion were measured using the Engineering Department Inclusion Level Survey developed by Lee et. al. Subscales include Department Caring, Perceptions of Department Diversity, and Department Pride [16]. Sample items include "It matter to me how I do in engineering" and "Doing well on engineering tasks is very important to me." Student identity levels with engineering were measured using the Identification with Academics subscale adapted for engineering [14]. Sample items include "I feel welcome in this department" and "Faculty in the department respect me." The Engineering Career item measured student beliefs that their career post-graduation would be related to engineering [17].

Analysis. The Kolmogorov-Smirnov and Shapiro-Wilk tests for normality found the data to not be normally distributed and indicated the data were suitable for nonparametric analysis. A Kruskal-Wallis H test was performed for each measure across departments to identify if there was a difference of average factor rankings between departments. Chi-square tests were conducted to test for association between departments and levels of self-reported mental health measures. Effect sizes for the Kruskal-Wallis test were calculated by the eta-squared measure [18]. We interpret η^2 equal to 0.01 as a small effect size, $0.06 < \eta^2 < 0.10$ as a moderate effect size, and $\eta^2 > 0.14$ as a high effect size [19]. When the Kruskal-Wallis H test was significant, we conducted a Dunn post-hoc test to determine differences between engineering departments. Spearman correlations tests were calculated between the average perceptions of Department Diversity score and representation of students and faculty who identify as women and are underrepresented in the engineering college. We implemented a preliminary alpha level of 0.05 to interpret our results and further used a corrected alpha level using a Bonferroni correction to adjust for multiple comparisons where appropriate and interpret effect sizes of our results [20].

Results
Average rankings for Engineering Career, Department Caring, Department Pride, and perceptions of Department Diversity were found to be significantly different between departments (Table 1). Self-reported average stress, anxiety, and depression rankings were found to not vary significantly between any of the departments. Engineering identity was significant before adjustment between some departments, but no difference between departments were significant when adjusted by the Bonferroni correction. A Kruskal-Wallis test showed there was a significant difference in Department Pride, Department Caring, perceptions of Department Diversity, and Engineering Career between engineering departments (Table 1), with $H(10) = 30.756$, $p = 0.001$ for Department Pride, $H(10) = 57.547$, $p = 1.05e^{-8}$ for Department Caring, $H(10) = 76.873$, $p = 2.05e^{-12}$ for perceptions of Department Diversity, and $H(10) = 81.773$, $p = 2.25e^{-13}$ for Engineering Career. The effect size for Engineering Identity, Department Pride, and Department Caring were considered small and the effect size for perceptions of Department Diversity and Engineering Career were considered moderate. A post-hoc test found that

Engineering Career is different between some departments. Physics and Bioengineering had the most occurrences of significant difference in ranks between other departments.

Table 1. Summary of Kruskal-Wallis H tests across departments for all measures.

Measure	N	H	df	p	η^2
Depression	977	9.793	10	0.459	--
Stress	977	12.134	10	0.276	--
Anxiety	977	12.549	10	0.255	--
Engr Identity	969	18.7	10	0.044*	0.0091
Dept Pride	974	30.756	10	0.001**#	0.0216
Dept Caring	974	57.547	10	$1.05e^{-8}$**#	0.0494
Dept Diversity	974	76.873	10	$2.05e^{-12}$**#	0.0694
Engr Career	972	81.773	10	$2.25e^{-13}$**#	0.0747

Engr: Engineering; Dept: Department; H: Kruskal-Wallis test statistic; df: degrees of freedom; η^2: eta-squared statistic; **p<0.01, *p<0.05, # significant at Bonferroni correction ($p < (0.05/8) = 0.00625$).

A Pearson Chi-square test indicated that the range of self-reported levels of anxiety (e.g., normal, mild, moderate, severe, extremely severe) was the only mental health measure to be significantly different between departments (Table 2). Self-reported stress and depression levels were not found to be significantly different between departments.

Table 2. Comparison of levels of self-reported mental health measures across departments.

Measure	χ^2	df	p
Stress	44.150	40	0.301
Depression	44.120	40	0.298
Anxiety	57.366	40	0.037*

χ^2: Chi-square statistic; df: degrees of freedom; *p<0.05

Perceptions of Department Diversity scores were found to be different across departments. Computer Science and Electrical and Computer Engineering differed significantly with other department diversity rankings. These departments are stereotypically dominated by men. To further explore these differences, we next analyzed correlations between average scores of perceptions of Department Diversity and representation of faculty and students within each department, shown in Table 3. Percent of underrepresented students was found to be positively correlated with the mean perceptions of Department Diversity ranking given by students.

Table 3. Spearman correlations (ρ) between average perception of department diversity scores and reported representation of faculty and students.

	1.	2.	3.	4.	5.
1. Percent Women Faculty	--	0.036	0.109	0.136	0.473
2. Percent Women Students	0.036	--	0.150	0.164	0.382
3. Percent Faculty who are Underrepresented	0.109	0.150	--	-0.123	0.114
4. Percent Students who are Underrepresented	0.136	0.164	-0.123	--	0.773**
5. Department Diversity Score	0.473	0.382	0.114	0.773**	--

**$p < 0.01$, *$p < 0.05$

Discussion and Future Work

Overall, these results suggest that engineering disciplines have distinct cultures and that engineering departments can influence perceptions of inclusion. Department Caring and Pride are ranked differently across engineering departments, suggesting that departmental factors can contribute to different feelings of department caring and pride. One student commented on the survey, "I find many professors' attitudes towards student work is "get it done" or "deal with it," while another praised their department for having "a very welcoming community and their academic and emotional support" and even citing it as having helped "led to my success in this department." Collectively these findings suggest that students notice and recognize how the department interacts with students, and that this is important on a department level.

We found that across engineering disciplines there is a different expectation about pursuing an engineering career after graduation. Students pursuing bioengineering, for example, were less likely to indicate that they planned to pursue an engineering career, which might be expected given the interest of some bioengineering students to attend medical or dental school.

Self-reported stress, anxiety, and depression was found to be high in our study [14], which agrees with previous work on mental health in college students [5]. However, while we found that the average self-reported stress, anxiety, and depression scores of all participants do not differ across engineering departments, the levels of severity of self-reported anxiety did differ between departments. Additional work is needed to understand stressors that are unique to different engineering disciplines and departments to identify proactive supports for students both at the college and department level.

Perceptions of Department Diversity is rated differently across departments, which may be expected as despite intense efforts the participation of women and groups underrepresented in engineering varies across engineering disciplines [21]. The percentage of students who are underrepresented correlated with the average perceptions of Department Diversity score, which suggests that students are aware of the diversity among their own peer groups. This result is echoed by student comments from the survey. One student shared,

The only racial minority that I think suffers systemic underrepresentation and lack of inclusion is the Black minority. That is problem with the student body doing the discrimination, not the faculty, at least as far as I've seen…

Another student stated,

Women just barely fall on the "treated good enough" side of that line just by sheer number of available resources to help balance out how the students treat them…(Name)

This quote suggests that women are not treated well by peers but may still feel supported and included because of college resources.

Another student commented on the difficulty of forming a network with other women in a department dominated by men,

It's not that women aren't respected in my department -- it's that it's hard to make close friendship networks, as a woman, with your fellow students when they are male. It's hard to be one of the guys.

This is consistent with previous work that has described the integration of women into engineering disciplines as linked with the ability of students who are women to embrace more masculine attributes [22]. Marginalized students are perceived to be treated differently by students, who are aware of the diversity or lack thereof in their department. Despite efforts to create diverse departments, some students still do not feel included.

Limitations There are a few limitations of the present work that limit the generalizability of the findings. First, the survey was conducted at a single institution and culture and student stressors likely varies across institutions. Further, our survey data include a single timepoint and do not capture longitudinally how student perceptions change nor identify factors that influence these perceptions within engineering disciplines. Future work that addresses these limitations will be beneficial in our understanding of disciplinary differences in engineering culture.

Conclusion
The purpose of the present study is to identify trends in student mental health and possible solutions. Average stress, anxiety, and depression were found to not be different among departments indicating a college-wide issue. Department Caring differed among departments suggesting that students are observant of their department's interactions with students. This allows for the possibility that departments can implement measures to promote more positive interactions between faculty and students, thereby increasing feelings of support and caring among students. The perception of a department's diversity is correlated with students who are underrepresented in engineering. To improve student well-being, we recommend, based on our study, that colleges enact trainings for instructors on diversity, accommodate students' mental health, and promote mental health services and resources during courses to reduce stigma. In future work, we will analyze the relationship between diversity and student feelings of caring and inclusion to evaluate departmental need for a targeted approached toward certain groups to improve overall student wellness.

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