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Exploring Engineering Stress Culture in the First Year of Engineering

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Exploring Engineering Stress Culture in the First Year of Engineering

This empirical research brief describes an explanatory sequential mixed-methods study that explores the perceived stress levels of undergraduate students enrolled in a first-year engineering course. In recent years, there has been increased concern about the levels of stress students are experiencing in engineering programs. The concept of *engineering stress culture* encapsulates this research area: a set of beliefs held by engineering students that studying engineering and poor mental health go hand in hand [1, 2]. This culture is fostered by several common features of engineering curricula, such as heavy workloads, lengthy assignments, peer competition, course rigor, and lack of sleep [3, 4]. Jensen and Cross [1] provide some of the more comprehensive statistics on engineering stress culture from a sample of 1008 engineering students, which are concerning: nearly one-third of students reported stress, anxiety, or depression at levels of moderate severity or higher (29% for stress, 36% for anxiety, and 35% for depression). A nontrivial fraction of our students are struggling. Further, when disaggregating these findings by level (i.e., first-year, sophomore, etc.), we begin to see variation in stress levels, with first-year students experiencing significantly more stress than seniors [5]. However, work examining how different aspects of the engineering curriculum affect student stress is still needed to understand how best to support all students throughout the entire course of study, particularly in the first year of engineering, where attrition is most significant [6-8].

Research Aims

We aim to understand the pervasiveness of engineering stress culture in the first year of engineering. As such, this study explores the following research question: "What factors impact the perceived stress levels of undergraduate students enrolled in a first-year engineering course?"

Literature Review

Engineering is a field of study that consistently attracts ambitious students interested in a high probability of success in obtaining a job upon graduation [9]. However, there is an increasing body of evidence highlighting a significant underlying trend of psychological distress in a student's engineering education proxied by stress [2, 5, 6, 10-16], anxiety [17,18], and depression [10, 18, 19].

Among all of the above-mentioned negative psychological states, stress has been identified as the most prevalent and most studied condition in undergraduate engineering [20]; however, research into mental health and well-being (MHW) within engineering education remains relatively nascent. Studies report a spectrum of causes of stress in undergraduate engineering students, including academics (e.g., academic workload [3, 16, 21], exam pressure [22], programmatic [1], [3]) and personal (sleep deprivation [3, 15], social pressures [23, 24]). Although there is scholarship about the causes of stress, the effects of stress on engineering undergraduates seem to be relatively untouched territory. It is pertinent to note that engineering has one of the highest dropout rates in higher education, with institution-level research reporting dropout rates approaching 50% in some engineering degree programs, illustrating the persistence challenges faced by students [25, 26].

Given the limited research available, we must note that first-year engineering is no exception to the presence of stress. Ramteke et al. [5] found that first-year engineering students had significantly more stress than final-year students. Moreover, within the first year of engineering, underrepresented groups show substantially higher stress levels than their counterparts [27]. Keeping in mind that first-year engineering can be a bottleneck to the later years of students' engineering education and has the potential to either shape or break students motivation, our current work is part of a larger project that is investigating stressors impacting the MHW of first-year engineering student with emphasis on stress that will be used to help guide major curricular changes in the first year engineering program at a large Midwestern University. The anticipated outcome of these changes is improved student perceptions of engineering and, ultimately, success in their undergraduate engineering studies.

Research Design

We approached our research questions using an explanatory sequential mixed methods design [28]. Our research design combines a descriptive design and a generic qualitative approach [29] to explore variation in perceived stress levels among first-year engineering students. Figure 1 summarizes the research design, focusing on the integrative procedures it entails [30].

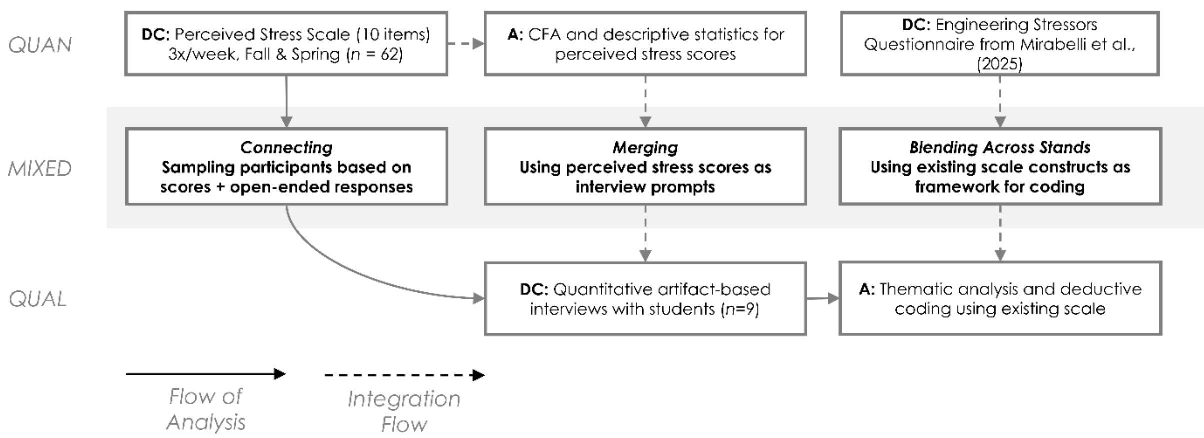

Figure 1. Procedural diagram of research design (DC = data collection, A = analysis)

Data Collection

Undergraduate students at a Large Midwest Urban University enrolled in a first-year engineering course (n = 134, N ~ 1400) were asked to complete a short survey three times a week at randomly generated times over the course of an academic year (two semesters), with 62 students responding at least 34 times, representing a 50% response rate to all surveys at the individual level. We administered the widely used Perceived Stress Scale (PSS) [31], which included a free-response section where participants elaborated on what was contributing to their stress that day.

To complement the survey results, participants were sampled using a combination of their stress values and open-ended responses with rich enough description and invited to participate in a 30-minute interview as a sequential mixed methods sample (n = 9) – connecting the quantitative phase to the qualitative phase [32]. Participants were selected to explore a wide range of stress levels and causes, including academic and personal concerns. During the semi-structured interviews, participants were asked to discuss their stress throughout the year and what contributed to it or helped alleviate it. For each interview, a graph of the participant's perceived stress level over the course of the year was created and used as a reference [33]. These plots showed their total score, as traditionally used, along with a selection of open-ended responses we were interested in delving into deeper with the students. An example graph is given in Figure 2.

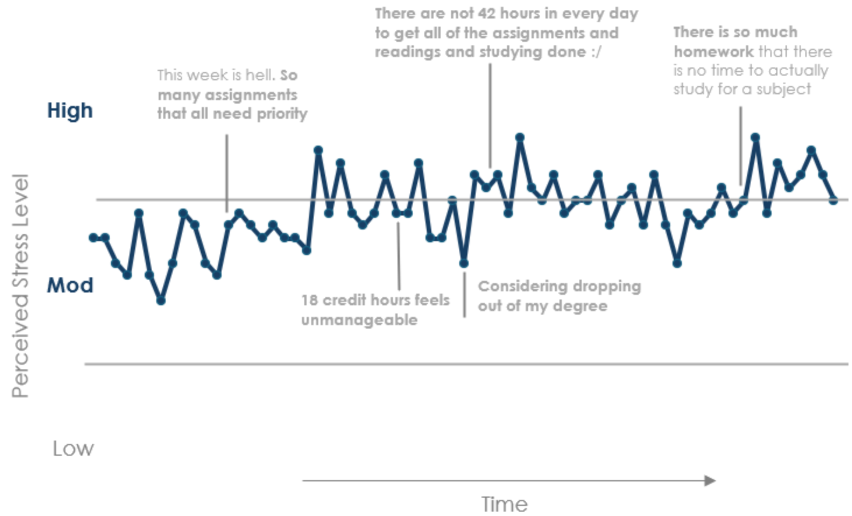

Figure 2. Example plot of perceived stress for a specific student

Our semi-structured interviews consisted of the following prompts: *During this last academic year, you responded to a survey about your perceived stress several times. When plotted, this is what your perceived stress looked like over all of the surveys you took. We've also appended some of your contextual comments. Walk me through this plot...*

1. *How did your stress levels change over time?*
2. *What were the most significant sources of stress?*
3. *How did you manage your stress?*
4. *To what extent was your stress linked to the first-year engineering courses?*

Analysis

To establish that the PSS exhibited appropriate construct validity and reliability, we analyzed Fall 2024 and Spring 2025 data using a two-level confirmatory factor analysis to capture within- and between-person variance with the lavaan package [34]. Consistent with the literature, we estimated a model with two correlated factors representing the positively and negatively worded items in the scale, "perceived self-efficacy" and "perceived helplessness", respectively [35]. We then calculated the composite reliability of the factors using the compRel function in the semTools package in R [36]. After establishing the model's suitability, we categorized students' average and lowest stress values using cutoffs from standard PSS calculators (e.g., [37]). The cutoffs essentially divide the range of scores into thirds: low stress corresponds to 0-1.3, moderate stress to 1.3-2.6, and high stress to 2.6-4. These labels were used to help select students for follow-up interviews.

We combined inductive and deductive coding for our qualitative analyses. First, data were analyzed using thematic analysis [38] to identify patterns of meaning across participants' accounts of their stressors over the course of the first-year engineering course sequence, focusing on the extent to which their stressors were personal or academic. Second, to align our results with the burgeoning research in this area, we consolidated our themes into the constructs of the Undergraduate Engineering Stressors Questionnaire: Identity-Related Engineering Stressors, Programmatic Mental Health Communication Issues, Expectations of Academic Stressors, Peer

Comparison Stressors, Preparation for Engineering Careers, Competition for Starting Careers, and Engineering Professor Issues [16].

Results

Perceived Stress Measurements

The model demonstrated excellent fit to the data. Absolute fit indices were strong, with a robust RMSEA of 0.045 (90% CI: 0.041–0.049) and standardized root mean square residuals of 0.032 (within) and 0.043 (between), indicating close correspondence between the observed and model-implied covariances. Incremental fit indices were also acceptable (robust CFI = 0.949, robust TLI = 0.933). Factor loadings were moderate to strong at the within level (0.39–0.57) and strong at the between level (0.57–0.73). Composite reliabilities confirmed good within-person reliability (0.71–0.78) and excellent between-person reliability (0.96–0.97). Overall, these results suggest that the measurement model reliably captures both stable trait differences and momentary state fluctuations in perceived stress.

Table 1 provides the descriptive statistics for the sample. Of the students in our sample, 60% reported a moderate level of stress on average, with 11% never reporting a stress level lower than moderate. In terms of PSS scores, these appeared to follow a normal distribution. The overall value of PSS, treating the scale as a single factor as traditionally used, was just high enough to be classified as moderate (M = 1.38, SD = 0.63). With the score decomposed into its two factors, perceived self-efficacy (M = 1.34, SD = 0.63) and perceived helplessness (M = 1.45, SD = 0.67) did not differ meaningfully, with the same moderate classification. The average lowest stress was classified as low (M = 0.54, SD = 0.52), whereas the average highest stress was moderate (M = 2.46, SD = 0.64).

Table 1. Descriptive Statistics for Variables (*n* = 62)

Variable	M	SD	Med	Skew	Kurtosis
Lowest Stress	0.54	0.52	0.35	0.60	-0.99
Highest Stress	2.46	0.79	2.50	-0.10	-0.70
PSS Overall	1.38	0.64	1.46	-0.15	-0.72
Perceived Self-Efficacy	1.34	0.63	1.42	-0.29	-0.99
Perceived Helplessness	1.45	0.67	1.54	-0.12	-0.63

Interviews

Next, we will describe our most salient qualitative findings as they relate to the Undergraduate Engineering Stressors Questionnaire factors [16]. The descriptive statistics for each selected participant are shown in Table 2, along with the rationale for their selection.

Table 2. Descriptive Statistics for Interview Sample (*n* = 9)

Student	PSS Mean	PSS SD	Min Stress	Max Stress	Sampling justification
P1	2.50	0.28	1.80	3.10	FYEC* mentioned often, high stress
P2	1.69	0.29	1.00	2.50	Personal and academic stressors, issues with team
P3	1.90	0.22	1.40	2.60	Descriptive, personal and academic stressors
P4	1.67	0.19	1.20	2.10	Descriptive, variety of academic stressors
P5	1.97	0.33	1.30	2.90	FYEC mentioned often
P6	2.23	0.28	1.30	2.80	Personal and academic stressors, issues with team
P7	1.77	0.22	1.40	2.40	Descriptive, FYEC mentioned often
P8	2.14	0.26	1.60	2.80	Descriptive, FYEC mentioned often
P9	1.97	0.24	1.50	2.50	Personal and academic stressors

*FYEC refers to the first-year engineering course that the students are enrolled in

Expectations of Academic Stressors. The most prominent theme identified across the data was the widespread expectation of encountering inevitable academic stressors as an engineering student. Students assumed that stress was an unavoidable aspect of choosing to study engineering and manifested in multiple ways, including issues related to assignment due dates, time management, and self-imposed expectations for high academic performance. Students often cited time management issues as a strong source of stress despite trying to plan around anticipated heavy workloads. As shown in P6's comment, "*FYEC was taking up so much of my time that I knew as I was doing. I was like, I need to be doing other things right now, but I physically can't because I got to spend so much time on this.*" Despite knowing he needed to do work for other classes and planning that time out, P6 still spent most of his time working on his engineering coursework. Similarly, P1 found herself overwhelmed by her workload, stating, "*I was struggling because while I might enjoy coding for FYEC, I didn't have the time to put seven hours into a code that I really was proud of. I just had to rush out this code that I didn't really feel great about. I didn't feel like it was a good representation of my ability because it was just super, super rushed*." These comments encapsulated the tension between the heavy workload and other responsibilities, aligning well with this construct.

Engineering Prestige Stressors. The most aligned comments with this factor concerned the normalization of stress culture. Like P1, students often held high academic expectations for themselves and the work they turned in, but faced time constraints, as P5 stated: "*If I have more time to be able to focus on multi, I should be able to get hundreds.*" Similarly, P3 mentioned, "*I guess it's kind of like the academic pressure I put on myself to do well in all of them. So it's not just getting it done, it's doing well on everything, which is more time and more energy, which makes it all more stressful."* Students don't just want to get their work done and turned in; they want to do their best work and want their grades to reflect that effort. However, the amount of work they have to do is a stressor in itself, compounded by the added pressure of not being able to turn in work of the quality they believe they are capable of. Perhaps most interestingly, students were unsurprised that they faced these stressors, as stated by P1, *"I don't particularly have a problem with how my first year went. I think it was hard, but it's also expected to be hard. If it was easy, then everyone would do it."* This culture of stress is normalized, even among first-year students. Therefore, when discussing these compounding issues that cause them stress, many students shrug them off as inevitable hurdles that must be overcome to become engineers.

Stressors from Peer Comparisons. Peer-related stressors emerged as another contributor to first-year engineering students' perceived stress, particularly within team-based and collaborative contexts. This differs from the original intent of the instrument's items, which are more about how students perceive themselves relative to others. Because engineering coursework often requires teamwork, it was not surprising that students identified peer interactions as a central aspect of their engineering experience. Stress frequently stemmed from perceived imbalances in workload, unequal skill distribution, time management and communication challenges, differing priorities among team members, and difficulties integrating social life with academic responsibilities. Several students described stress associated with comparing their own effort and contribution to those of their peers during team-based work. For instance, P3 explained, *"I was the one doing all of the paperwork and writing the code, which was incredibly stressful because that was not evenly workload distributed. That was not the time that I had allotted for it, and I was spending a lot of my life on that instead of doing other things."* Similarly, P9 noted, *"I mean, it was a distribution, it's a mix of both. We had one member that just wouldn't really work* *on the design work meaning she would brainstorm and ideate, but she wouldn't really actively do anything on the Gantt chart or the design notebook or do a 3D help in the 3D model or anything like that."* Perceived workload imbalance contributed to peer-related stress, particularly when students felt they were contributing more than others on the team.

Preparation for Engineering Careers. Preparation-related stressors were also another source of stress for some students, particularly surrounding the process of finding a co-op position. Students described anxiety related to attending career fairs and concerns about not receiving an offer due to limited experience and coursework. P7 explained this challenge by stating, *"I think the whole idea of getting a co-op is difficult, especially for first years. I think just because of significantly less experienced, less learned, you've taken less classes, so the companies are less likely to hire you."* Similarly, P9 described how attending the career fair heightened his stress by making him more aware of his perceived lack of preparation, explaining, *"the reason that was a common theme beyond that point was because after I went to the career fair, I realized the amount of things I didn't know and the things I needed to work on as in my skills, the skills I need to develop in order to land a co-op."* He continued by stating, *"the ones that do require so many skills that a freshman university student cannot possibly have because it's difficult to gather all that knowledge."* Exposure to industry standards worsened this stress by reinforcing feelings of inadequacy and unpreparedness.

Unobserved Factors. The factors for which we did not find substantial evidence to justify saturation of the existing themes from prior work included *identity-related engineering stressors, programmatic mental health communication issues, competition for engineering careers, and engineering professor issues.*

Conclusion and Future Work

When comparing our work to the literature, we find an unfortunate alignment with existing scholarship on academic workload [3, 16, 21] and social [23, 24] factors. With 60% of students in our sample reporting a moderate level of stress on average and 11% never reporting a stress level lower than moderate, we find that students' stress is explicitly linked to a variety of factors that align with the constructs of Mirabelli et al.'s [16] ESQ. We should note that although we did not find sufficient evidence for a subset of factors, we can still offer some contextual explanations. For example, first-year students are typically only exposed to two engineering faculty at this institution, potentially more depending on their major. Likely, students had not had enough experience with this stressor for it to be more salient. Since students are not yet fully integrated into the college, it is not entirely surprising to see programmatic mental health and communication issues as factors. In fact, the first-year courses explicitly advertise the availability of an embedded professional counselor, which counters the implication in the original items that the faculty do not care about student MHW [16]. Finally, students did not report experiencing identity-related stressors despite the well-documented evidence of marginalizing behaviors occurring in student teams [39]. It is possible our line of questioning did not unearth these.

These data are part of a larger project aimed at modularizing the first-year program, for which we are monitoring constructs of interest related to retention, including perceived stress. We plan to continue administering the PSS as described for the coming years, in addition to semesterly interviews with sampled students.

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