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Engineering professor perceptions of undergraduate engineering student stress

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ABSTRACT

Engineering professors are well positioned to support their undergraduate students, who often experience diminished mental health. This paper examines engineering professors' perceptions of their undergraduate engineering students' experiences of stress. The described perceptions include when they notice student stress, which stressors they perceive, and supports that these students use. In this qualitative study, we interviewed 24 engineering professors and four career advisors at 18 institutions in the United States about these topics. Results show that these professors often had consistent access to notice indicators of student distress. They described key sources of student stress: balancing responsibilities, significant academic stress, and a culture of competition. They were less likely to notice student stressors associated with interpersonal relationships and identity-related stressors, which are less related to their role as professors. Supports that professors described included interpersonal relationships and health and wellness activities. This lays a foundation for encouraging engineering professors to support their students' mental health and wellness even more.

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Introduction

College students often face consistently high stress levels (Acharya, Jin, and Collins 2018; Negi, Khanna, and Aggarwal 2019), which negatively impacts both mental and physical health (Dhabhar 2014). Student mental health is widely valued across the globe, for example in North America (e.g. Abelson, Lipson, and Eisenberg 2021; Castillo and Schwartz 2013; Tormon et al. 2023), Asia (e.g. Dharmavarapu et al. 2022; Huang et al. 2023; Kaushani and Weeratunga 2023; Kim and Kim 2023; Wulandari et al. 2023), Europe (e.g. Dodd et al. 2021; March-Amengual et al. 2022; Rückert 2015), South America (e.g. Flores et al. 2021; Flores et al. 2021; Savio, Galantini, and Pachas 2022), and Australia (e.g. Browne, Munro, and Cass 2017; Said, Kypri, and Bowman 2013). Recent studies have shown that undergraduate engineering students in the United States face a high prevalence of diminished mental health (e.g. Danowitz and Beddoes 2020; Danowitz and Beddoes 2022; Jensen and Cross 2021; Sanchez-Pena and Otis 2021). However, these engineering students are less likely than other college students to seek professional help for support in their mental health

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(Lipson et al. 2016). Since continued high stress may lead to diminished mental health (Blackburn-Munro and Blackburn-Munro 2001; Karyotaki et al. 2020; McGonagle and Kessler 1990; Tafet and Bernardini 2003), there is a need to examine the environment surrounding engineering students' stress, stressors, and coping mechanisms. A better understanding of this environment will enable purposeful change to support student mental health and wellness. Previous studies on undergraduate engineers' stress experiences have been primarily quantitative (e.g. Acharya, Jin, and Collins 2018; Auerbach et al. 2018; Danowitz and Beddoes 2020; Deziel et al. 2013; Jensen and Cross 2021; Negi, Khanna, and Aggarwal 2019; Posselt and Lipson 2016; Danowitz and Beddoes 2018; Hargis et al. 2021), with more recent qualitative studies centering student voices (e.g. Ban et al. 2022; Beddoes and Danowitz 2022; Feil-Seifer, Parker, and Kirn 2022; Herrera et al. 2023; Jensen et al. 2023a; Mirabelli et al. 2020; Rulifson and Bielefeldt 2020; Wilson et al. 2022).

Professors are in key positions to support students' mental health since they significantly impact students' academic experience, which is often a primary source of student stress (Asghar, Minichiello, and Ahmed 2023; Bielefeldt 2022; Di Placito-De Rango 2018; DiPlacito-DeRango 2022; Godfrey and Parker 2010; Jensen et al. 2023a; Larcombe, Baik, and Finch 2022; Le, Hsu, and Raposa 2021; McKendrick-Calder and Choate 2023; Riva et al. 2020). For example, a professor likely interacts with their students each week, and noticing student distress has been described as the first step in professors supporting students' mental health (Wilson and Goldberg 2023). If we better understand professors' perceptions, we may be able to identify key systems that influence their perceptions. Understanding these systems will support changes to reduce student stress and thus support their mental health and wellness (Sanders et al. 2024; Thomas et al. 2022; Wilson and Jensen 2023). Though the concepts are closely related, we differentiate mental health and wellness for clarity. Wellness is a holistic concept with multiple dimensions that include but are not limited to emotional, social, mental, and physical health and satisfaction (Stoewen 2017). We define mental health as a component of wellness: a dynamic state that is inherently neither positive nor negative and describes a sense of internal equilibrium (Galderisi et al. 2015).

Previous work has examined engineering professors' perceptions of undergraduate student stress (Bielefeldt 2022; Feil-Seifer, Parker, and Kirn 2022; Sanders et al. 2024; Wilson, Hammer, and Usher 2021). This study is building on previous work to provide the breadth and richness possible with multi-institutional qualitative analysis. In this manuscript, we examine the experiences of 24 engineering professors from 18 institutions in the United States. We qualitatively explore their experiences and perceptions of supporting engineering undergraduate mental health and wellness. Due to the inherent correlation between stress and mental health and the ubiquity of stress in academia (Hurst, Baranik, and Daniel 2013; Nakalema and Ssenyonga 2013; Zeidner 1992), these findings may be transferable in countries outside of the United States.

Research questions

Our research questions are:

RQ1: What do engineering professors notice to indicate that their undergraduate engineering students might be stressed?

RQ2: For stressors that undergraduate engineering students experience, which sources did engineering professors notice and to what extent did they recognize these stressors?

RQ3: What do engineering professors describe as supports with which their undergraduate engineering students engage?

Theoretical frameworks

Two frameworks were used in the design and analysis of this research study.

Framework used in development

Godfrey and Parker's (Godfrey and Parker 2010) Framework of Cultural Dimensions in Engineering Culture was used as a theoretical framework (Magana 2022) to develop the interview protocol for this study. This framework was developed from data collected at a high-ranking university in New Zealand. It describes components of engineering culture such as how knowledge is valued, perceived norms, and common personal characteristics of engineers, as summarised in Table 1. This framework has been used in other works to examine undergraduate engineering culture (Jensen et al. 2023a; Jensen and Cross 2021; Sanders et al. 2024; Deters et al. 2024). This framework informed the interview protocol design; further details are provided in (Sanders et al. 2024). More details concerning the interview protocol and tying these to Godfrey and Parker's framework are presented in the Methods section, below.

Framework used in analysis

Bronfenbrenner's Bioecological Systems Theory (Bronfenbrenner 1979; Rosa and Tudge 2013) was introduced during the analysis (Magana 2022) to analyze and present the data in this publication. Bioecological Systems Theory describes the individual as being embedded within a complex, multilevel system with a reciprocal relationship between different aspects of their environment. The immediate environment or microsystem, such as one's home and family life, is most likely to influence an individual directly. The theory also acknowledges intermediate and macrosystems such as politics, social media, and other sociocultural aspects also influence individuals over time. Bioecological Systems Theory has been used to analyze the interaction of a person's wellness with their environment (Abelson, Lipson, and Eisenberg 2021; Dooris and Doherty 2009; Orme and Dooris 2010), including university students in general (Demetriou et al. 2017; Ertem 2020; Jones 2018; Mulisa 2019) and in engineering (Jensen et al. 2023a; Salem and Frank 2018). Our previous work has applied this to undergraduate engineering education (Jensen et al. 2023a) as depicted in Figure 1.

Figure 1 shows the Bioecological Systems Theory as applied to engineering education stressors and supports within the individual, microsystem, and mesosystem levels, including academic, career, and social stressors. Behavioural and cognitive supports are also shown, where examples of cognitive supports include scheduling, therapy, and attending study groups.

Bioecological Systems Theory was a valuable framework for use in analysis because it encompasses aspects of power and influence that are present in the interactions between an individual and their surroundings, called 'proximal processes' (Bronfenbrenner 1979; Rosa and Tudge 2013). Through the lens of Bronfenbrenner's theory, aspects of power and influence can affect both

Table 1. Summary of dimensions of engineering culture as described by (Godfrey and Parker 2010).

Dimension	Description
An Engineering Way of Thinking	This highlights the value engineers place on objective and reliable knowledge, where mathematics is considered infallible and work is approached with an unbiased mindset.
An Engineering Way of Doing	This focuses on engineers adhering to perceived norms, emphasising attributes like 'hardness' associated with masculinity and 'working through the pain' (Godfrey and Parker 2010, 12). Expectations include both competition and cooperation, with a shared acknowledgment of time constraints.
Being an Engineer	This dimension includes traits that engineers might describe themselves with, such as logical, practical, tough, conservative, and unemotional.
Acceptance of Difference	This portrays engineering as largely homogenous, with a stated appreciation for diversity, though individuals are expected to conform to established cultural norms.
Relationships	This describes relationship bonds as integral to the experience of engineering, and these are created through academic tasks.
Relationship to the Environment	This positions engineering academia within the wider academic context, emphasising a sense of autonomy and self-sufficiency as a department.

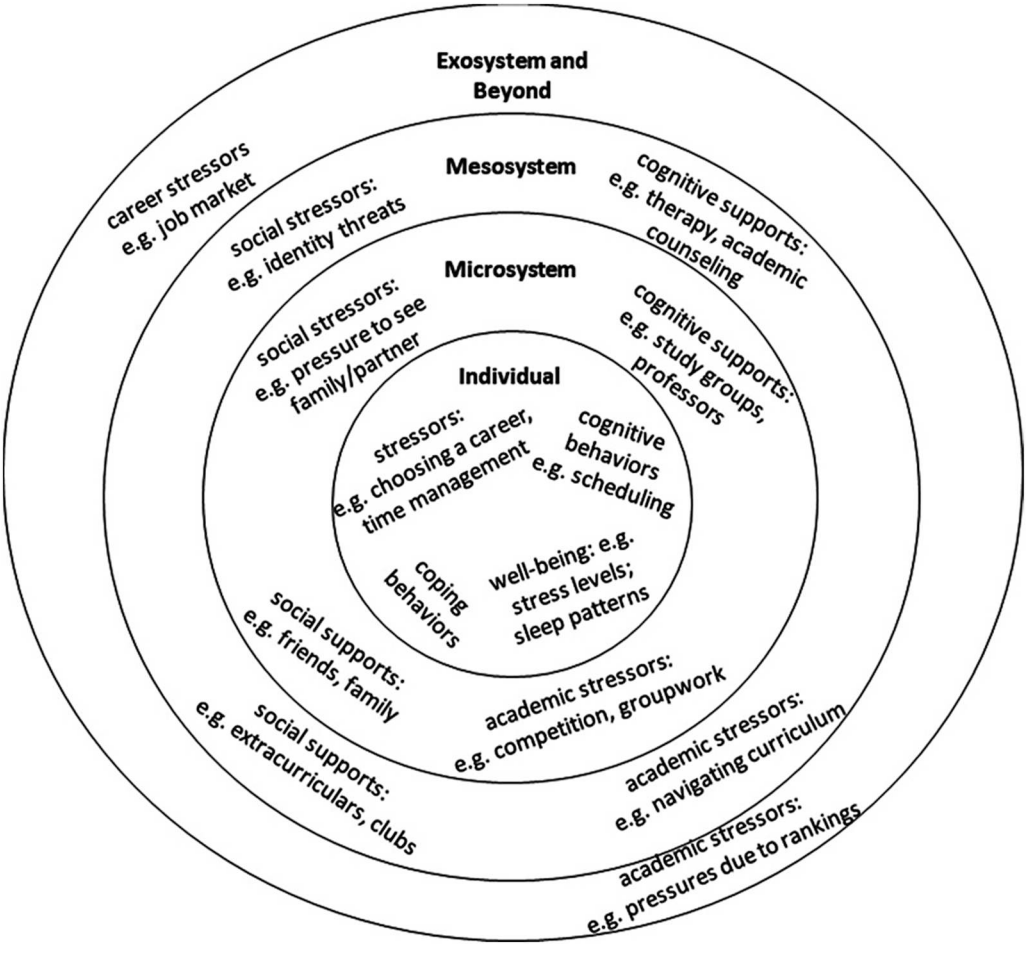

Figure 1. Framework based on Bronfenbrenner's Bioecological Systems Theory as presented in (Jensen et al. 2023, 6).

individual students' experiences of stressors themselves (e.g. choosing a career, pressure to see family), and also the sense of control that a student might feel over this stressor (i.e. because of a power dynamic between professor and student). Students' associated stress often decreases as their perceptions of control increase (Bakker and Demerouti 2014; Dawson, O'Brien, and Beehr 2016). In the microsystem, for instance, a student can experience pressure from participating in group projects during class. This student has less control over their group work than how they interact with a singular assignment (individual sphere of influence); however, they may be able to exert control in the situation through discussion with their group (microsystem). Farther from a student's sphere of influence, in the exosystem, a student may experience academic pressure to succeed relating to their school's rankings (Cross and Jensen 2018). Being in a further sphere of influence, the student may feel this stress less acutely, but they also have less control to influence or change this source of stress.

We are interested in professors' perceptions of student stress because professors often exist in students' microsystems, similar to the in-class group work example above. Professors' close proximity indicates that (1) professors may have access to recognise student stressors and supports and (2) professors may be able to significantly impact or change some of these student stressors and supports.

Bronfenbrenner's model can be used to stratify students' experiences of stress and supports that professors perceive. These categories were used to *a priori* determine a portion of the coding schema that was applied to the data presented here. Specific examples showing how this framework was mapped onto the research codes are presented in the Methods section.

Methods

We present results from 24 professors and four career advisors at 18 institutions in the United States. The primary focus of this manuscript is to describe engineering professors' perceptions of stressors that their undergraduate engineering students experience. Accordingly, career advisor experiences are included only when providing contextual detail and are explicitly named as career advisors when their perspective is included. The researchers' Institutional Review Boards approved this study (HUM00218022 for the University of Michigan and 20223 at the University of Illinois Urbana-Champaign). Our qualitative approach allowed for a flexible structure where new data could emerge, which is helpful when interpreting data, instead of testing an objective theory such as is common with quantitative processes (Creswell and Creswell 2017).

Positionality

As authors, our identities and experiences impact how we have engaged with this research (Secules et al. 2021). We are white or mixed-race American citizens who have had experience both leading engineering classes as instructors or teaching assistants, as well as taking engineering courses as students. Some authors identify as first-generation college students, from low- and middle-income backgrounds, as queer, as women, and as men. We believe professors are in a position to support our students, which includes an awareness of how their background and experience shape their experience as students. We all have unique experiences learning time management, though the theme of balancing responsibilities presented below is one we all continue to experience.

Participants and data collection

We contacted participants through ads in engineering educator email lists, e.g. through convenience sampling (Acharya et al. 2013). All who responded were offered the opportunity to interview, resulting in professors ($n = 24$) and staff career advisors ($n = 4$) participants. All interviews were conducted remotely via Zoom and only audio recordings were collected from this. Participants were offered the option to have cameras on/off to preserve anonymity. All participants were located at institutions in the United States. The participants who described themselves as staff worked as academic advisors, a non-professor role, and their jobs did not include teaching or research. Their jobs included advising students on which courses to take, supporting the department in designing the course schedule, and listening to and supporting students (Menke, Duslak, and McGill 2020).

Participants were all staff or professors who worked in engineering departments at 18 institutions. These institution types and sizes are defined by the Carnegie Classification of Institutions of Higher

Table 2. Institution classification for participants engaged in this study, reproduced from (Sanders et al. 2024).

Carnegie Institution Classification	Participant Count
Doctoral Universities Very high research activity (R1)	$n = 18$ (64%)
Doctoral Universities High research activity (R2)	$n = 3$ (11%)
Doctoral/Professional Universities (D/PU)	$n = 1$ (4%)
Master's Colleges and Universities Larger programs (M1)	$n = 6$ (21%)

Table 3. Institution size for participants engaged in this study, reproduced from (Sanders et al. 2024).

Carnegie Institution Size[a]	Participant Count
Very Large (>10,000)	$n = 1$ (4%)
Large (5,000–9,999)	$n = 15$ (54%)
Medium (2,000–4,999)	$n = 9$ (32%)
Small (500–1,999)	$n = 3$ (11%)

[a]Number of full-time equivalent enrolled students.

Education (American Council on Education 2023), a common framework for classifying institutions in the United States. Institutional data are summarised in Tables 2 and 3 respectively. Doctoral/Professional Universities engage in less research than Very High (R1) or High (R2) Research universities.

All participants were offered $50 in compensation for participating in a virtual interview that averaged 40 minutes of recorded content.

Participants who were professors had maintained their role for one to 20 years and described themselves as educators (over 90%), mentors (over 60%), and researchers (over 60%). Staff had been in their jobs between one and 10 years. Participants used feminine ($n = 20$) and masculine ($n = 8$) pronouns, and we present no further demographic data to preserve their anonymity. Pseudonyms and gender-neutral pronouns are presented here accordingly.

Interview protocol

The interview consisted of a semi-structured protocol and is described in more detail in (Sanders et al. 2024). Briefly, the protocol consisted of three primary sections: understanding mental health climate, student experiences of stress, and stress management and coping. In this study, we focus on questions related to staff and professor observations of student experiences regarding stress and mental health. Representative example questions are included below. Note that 'faculty' was used instead of 'professor' to align with the language most commonly used by the United States-based participants.

- Have you ever noticed undergraduate engineering students struggling with mental health issues? What does that look like to you?
- Do you think students and faculty in engineering struggle with particular aspects of well-being? Which ones, and why?
- How would you describe the relationship between undergraduate engineering students' stress and mental health?
- Can you describe things you have heard or learned undergraduate engineering students do to manage stress?

These questions ask about professors' perceptions of mental health as it pertains to Godfrey and Parker's dimensions of engineering culture. For example, questions included norms of what it means to 'Be an Engineer', whether struggling with mental health is common, and what mental health struggles look like. They also connect to the 'Engineering Way of Doing' that prioritises 'working through the pain' (Godfrey and Parker 2010, 12), by asking about possible impacts of mental health and the results of working in a high-stress culture.

Data analysis

Collected audio data was professionally transcribed and reviewed by the authors for clarity and redaction of identifying information. Transcript data was then subdivided by topic, with the topic presented here describing professor and staff perceptions of their students' experiences with

Table 4. High-level codes were implemented to bin and subsequently analyze participant responses.

Top-Level Code	Description
Stressors	Stressors that participants perceived students experienced. Example sub-codes include academic, career, time management, and social stressors.
Resources	Resources that participants perceived students using to cope with their stress. Sub-codes included social (ex. visiting with friends), behavioural (ex. exercise), and cognitive (ex. counseling).
Climate	Perceived climate of the engineering department or university. Subcategories included aspects of identity, perceptions of competition, and mental health stigma.
Question Answers	Participant answers to interview questions. For example: How would you describe the physical or physiological signs of stress in undergraduate engineers?

stress. Other presented work from this data includes participants' descriptions of a 'culture of wellness' (Vohra et al. 2022), professors' suggestions to increase support for student mental health and wellness (Jensen et al. 2023b; Johnson 2024), and professor and staff perceptions of responsibility to support student mental health and wellness (Sanders et al. 2024).

The first author thematically coded the section of the transcripts describing participant perceptions of their students' experiences (Taguette Project 2023) using a schema primarily based on Bronfenbrenner's Bioecological Systems Theory (Jensen et al. 2023a). She then used a thematic conceptual matrix to organise codes (Miles and Huberman 1994) while maintaining memos and notes in a codebook throughout this process (Saldaña 2021). The codebook, reported in Appendix A, was adapted from one first presented in Jensen et al. (2023b) that was developed to examine student stressors and supports. We uncovered stressors, especially in the students' mesosystem and beyond, that professors were less likely to notice than students since we employed a codebook that was first generated through student interviews. Top-level codes are described in Table 4.

Next, codes were compared across participants by the first author with support from the third author, and a resulting summary was compiled and reviewed by the team until consensus was reached (Schielke et al. 2009), thus engaging in communicative validation (Walther, Pawley, and Sochacka 2015). The resulting findings of interest were then grouped into research questions, with RQ1 mapping to 'Questions Answers', RQ2 mapping to 'Stressors' and 'Climate', and RQ3 mapping to the 'Resources'.

Though all participant answers were analyzed together, professors' perceptions of their students' experiences arose as a primary source of interest. As a result, this manuscript focuses primarily on professors' perceptions. Unique career advisor perceptions are also included, and their roles are explicitly described when discussed in the results. All other participants were professors.

Results and discussion

Qualitative results and corresponding discussion are presented in this section and describe: when professors noticed stress, observed sources of student stress, and sources of support for student

Table 5. Themes and summaries mapped to research questions (RQs).

When Stress Was Noticed (RQ1) Professor participants often described feeling regularly occurring access (e.g. regularly seeing students in class) to notice stress indicators, though they felt limited in what types of stress indicators they were able to notice.

Balancing Responsibilities: Source of Stress (RQ2) Our professor participants described an expectation that time management was critical for student success, and when students were unable to manage their time effectively, the students' wellness was often sacrificed.

Academics: Source of Stress (RQ2) Engineering professors in this study described academics as the most common stressor for students, and some described these stressors as exacerbated when students experience financial limitations.

Competition Culture: Source of Stress (RQ2) Professors commonly described a culture of competition within engineering that 'ebbs and flows', and some attributed a decrease in student wellness partially to this culture of competition.

Interpersonal Relationships, Identity, and Local Contexts: De-emphasised Sources of Stress (RQ2) Professor participants were more likely to notice stressors that most obviously overlapped with their spheres of interaction, such as students' in-class interactions and shared identities.

Supports for Stress (RQ3) Professors described student wellness supports as activities and structures that existed primarily outside of the classroom, including social support from friends and wellness activities such as exercise.

stress. Summaries for each theme are presented in Table 5. In each section, each theme is first described and accompanied by representative quotes. Then, the theme is briefly summarised in italics. Next, the sub-section finishes with a discussion of how this topic relates to the larger engineering education literature.

When stress was noticed

Professors perceived their students as stressed in primarily three ways: visual and audible cues of student fatigue, decreased student classroom engagement or grades, and changes in student mood (often to be more irritable or quiet).

Observable cues of fatigue were the most commonly described indicator of student stress. Mark described this as 'fatigue, just seeing the eyes drooping, the dragging'. Other descriptors such as 'rumpled' (Helen) or 'disheveled' (Emily) described students' clothes and hygiene. Stacy described 'that change in their voice when things are starting to get to be too much' as going 'hand in hand' with their perceptions of tiredness. Participants observed a variety of cues indicating tiredness, and they often correlated this with signs that a student was stressed.

Participants described decreases in productivity that indicated stress through both attendance, such as chronic lateness or absence, and reduced assignment performance, such as missing deadlines or working on homework in class. Gina observed stress when students were 'turning in things late, struggling to get things done, [and] struggling to show up for class'.

A few professors mentioned mood changes, most commonly anger, when students were stressed. Rosa shared, 'The patience for debugging activities goes out the window if they're stressed', and Alexis shared, 'Some people get so mad, angry for very little things'. In addition to noticing students as quick to anger, Margaret has observed 'excessive' crying and 'excessive' anger.

Interestingly, Max and Tiffany answered that they did not notice when students were stressed. Tiffany elaborated, 'I don't know, with undergraduate students, if I've seen signs of stress or anxiety. Again, "cause it's happening- it's in their head"'. Because Tiffany viewed signs of stress as an internal phenomenon, they did not expect to see external manifestations.

In summary, most, but not all, professor participants often felt they had reliable and continuous access to notice stress indicators.

Understanding engineering professor recognition of student stress is important because these perceptions likely influence when and how professors interact with students on these topics (Bielefeldt 2022; Wilson and Goldberg 2023; Wilson and Jensen 2023). For example, when professors recognise student stress, they may be more likely to adjust their actions to lessen student stress, thus working to mitigate stress. Indeed, many participants who noticed signs of students in distress described feeling a 'responsibility to intervene', which motivated them to take actions supportive of student mental health. More information on these perceptions is detailed in (Sanders et al. 2024). Due to regular contact with students in class, participants recognised changes from a student's previous appearance or mood that might not be apparent from a single interaction. Many of the changes noted by professors are consistent with those described by programs such as the Red Folder program (Counseling and Psychological Services 2023), which provides resources for academic leaders to recognise student stress.

Though only two of 28 participants described not recognising signs of student stress because stress is 'in [the students'] head[s]', it is possible that a higher percentage of professors hold these views. The view of stress as an exclusively internal mindset limits possible actions that professors may take to adaptively support student wellness.

This data aligns with our expectations from Bronfenbrenner's theory, where professors recognise signs of student distress through their frequent microsystem-level interactions. However, not all professors felt they would be able to recognise student stress, suggesting that increasing their perceived ability to recognise distress could offer future opportunities to support students. This is especially true if recognising student distress motivates professors to take action to support their students, which is supported by the analysis presented in (Sanders et al. 2024).

Balancing responsibilities: source of stress

Most participants described students' responsibility to balance competing needs and goals. Often, this equilibrium was difficult to achieve when students were thought to be unskilled at time management. Moreover, professors described student wellness as frequently sacrificed.

Competing student needs were often related to four quadrants: academic success, wellness needs such as sleep, social needs such as clubs and family, and career success. Shelly noticed these tradeoffs, saying 'There's kind of a running joke among undergraduate[s] that you can have good grades, sleep, a social life, but you have to pick only two of the three'.

This sentiment – that it is impossible for students to fully meet their wellness needs, excel academically, and maintain a healthy social life – was broadly echoed by participants. Many expanded this sentiment to include successfully continuing a career and thus financially supporting themselves during and after college.

Rosa shared that of these competing priorities, wellness activities such as sleep and exercise were most often sacrificed:

> When you have 18 credits and you have a job on campus on top of it because you have to pay for school … [self care is] the first thing that goes out the window … because you just need more time in your day. (Rosa)

This deprioritisation of wellness was echoed by Helen, who described students as 'sacrific[ing] other things, like food or sleep or some of your basic needs, in order to meet those [deadlines]'.

Helen continued their story with another common theme expressed by more than one-third of the professors interviewed – if students had better time management skills, they would be less stressed. Helen shared, 'I'm like, where are you having lunch? [The students say], "Well, I can't eat." I'm like, "No, you can eat. *You need to just schedule*"'. Helen then described that they had recently started to schedule their own lunch, which had significantly increased days with a lunch break. Almost all professors who mentioned student time management described it as a problem area or lack of skill.

Helen's description of continuing to learn their own time management and boundary setting indicates that professors may downplay the challenge of strengthening these skills. Shelly echoed this by describing: 'There's so much pressure on [students] academically, that maybe they don't have time to be a truly balanced individual. So I think – *and the faculty [professors] too, right*. There's a lot on [students'] plates and on [professors'] plates too'.

In summary, our professor participants described an expectation that time management was critical for student success. And, when students were unable to manage their time effectively, the students' wellness was often sacrificed (Adams and Blair 2019; Ban et al. 2022). *Our data align in that professors perceive student stress to stem from a lack of time management skills*.

Similar to our findings, Macan et al. (Macan et al. 1990) found that students who had 'perceived control of time' were more likely to report less feelings of overload, less tension, and higher work-life balance than their peers. Critically, many professors echoed the idea that engineering students are fundamentally overburdened by the academic system. This burden limits their ability to manage conflicting demands, including their wellness needs. Strategies to increase students' 'perceived control of time' might include (1) increasing their perception of control through strategies such as teaching time management (Adams and Blair 2019; Hernandez-Linares et al. 2017; Macan et al. 1990; van der Meer, Jansen, and Torenbeek 2010) and (2) providing opportunities for them to exert control over their time such as modifying deadlines or increasing asynchronous opportunities (Kyndt et al. 2014).

When professors envision students' challenges 'balancing responsibilities' as a source of stress, they describe student stress as existing at the individual level of Bronfenbrenner's Bioecological Systems Theory. Conversely, when professors describe students as inherently overloaded by the academic system, they describe cultural norms that exist in the exosystem and beyond. Both of these beliefs are not directly impacted by the professors themselves, and may thus lead professors to feel they have less agency in reducing student stress.

Academics: source of stress

Among competing priorities, academic priorities were the most commonly described. When discussing pressure around academics, student stress was described by professors as a result of both the students' worry about succeeding academically and the amount of work required.

Audrey described students' stress resulting from student worry, describing their 'fixation on a grade and wanting to do well'. Similarly, Sarah described students who 'come in and right after a test and they tell me they failed it', to which Sarah responds: 'Just hold on, you don't know your grade yet'. These students will often have performed well on the test despite feeling anxious about passing. Alexis also experienced this, sharing, 'Even my highest achieving students come to my office and then they say, "I don't feel I'm good"'. This description of student 'fixation' describes the students' emotional states and thought patterns as a source of stress.

Contrasting with student feelings as a source of stress, professors also described the engineering workload as a source of student stress. Harry shared: 'I mean, they're just overworked. They don't have time to do stuff that isn't completing … problem sets or lab reports'. Similarly, Tiffany shared, 'I think the course load causes stress'.

Professors described the heavy workload as increasing student challenges with time management. Ken described students as being 'stretched so thin' that they start projects and assignments 'maybe a day or two in advance […] [They will look] two days down the calendar [and] be like, "Oh my gosh, I've got this deadline coming up"'. Even though Ken tried to 'scaffold all the assignments', they still perceived time management as a struggle for students because of the high workload.

Several professors described financial stress as compounding academic stress. Helen described students taking higher course loads to pay for fewer semesters. Similarly, Marny described course dependency as a compounding stressor with financial stressors. Marny explained:

> You know, engineering [academia] is so tied up in dependency trees, that if you mess up in a class and you lose a semester, you might be losing a year … That year you might be needing to pay for [other things]. (Marny)

Marny described the need for money as a core component of student stress, recognising monetary limitations as deeply embedded within some students' experiences.

To summarise, engineering professors in this study perceived academics as the most common stressor for students, and some described these stressors as exacerbated when students experience financial limitations.

Previous literature from interviews of engineering students' experiences also reports the course workload as a key stressor (Jensen et al. 2023a), which aligns with these data and with similar reports of academics as a source of stress in Australia (Mcgraw et al. 2008), the Netherlands (Dewald et al. 2014), and the United Kingdom (Putwain and Daly 2014). When professors describe students' internal thoughts as a reason for stress, they describe this stress as internal to the student or within the innermost (Individual) level of Bronfenbrenner's model.

Interestingly, few professors directly mentioned their interactions with students, which are in the students' microsystems, as sources of students' academic stress. However, they did give examples of strategies they have tried to reduce stress, such as Ken's description of scaffolding assignments.

Other professors described aspects of academic stressors in the mesosystem that were further from students' locus of control, such as students' expected workload. Examining stressors that are in system levels more distal to the individual, Marny described course dependency (the need for one course to precede another) in the exosystem as a stressor. This course dependency is a compounding stressor with financial stressors in the students' macrosystem, which is a level beyond the exosystem in Bronfenbrenner's Bioecological Systems Theory. Previous studies examining student mental health support Marny's observations and have shown financial stress as a risk factor for diminished mental health (Kivimäki et al. 2020; Phillips Sarah Ketchen Lipson et al. 2018).

Competition culture: source of stress

Professors and career advisors perceived competition between students. Competition and the resulting stress were described as increasing with time due to ever increasing requirements for students to be more involved in extracurricular activities. Professors attributed social media as exacerbating this competition, which was described as negatively impacting wellness. Stress resulting from a culture of competition was described as cyclical with time, following 'ebbs and flows'.

Career advisor Jane described competition for jobs as 'a numbers game', where even for qualified students, there are still '500 applications for these 10 positions', resulting in a higher probability of rejection. Jane described both career-related rejection and competition as sources of stress. Similarly, career advisor Margaret shared, 'They're applying for the same internships; they're applying for the same co-ops and the same jobs. There is an inherent, built-in competition'.

Similar to the competition for jobs, Steve depicted an ever-increasing requirement for engagement with a variety of activities such as student organisations. They shared, 'I think [stress] is increasing a lot because the cutoffs and the requirements are becoming so, so, so, so much … [Now,] just a good GPA, won't count'. Mark further explained that these increased expectations add more stress: 'Sometimes they spend too much time on "fill in the blank," and then … because they're spending time with that, grades are suffering'.

Mark also shared that they believe social media negatively impacts student wellness:

> I think that stress is bigger now than it was. Back in the day [there was] … a little bit of the 'comparing myself to the person beside me,' and that happens all the time. But, now you have the internet … Now, it's really easy to compare yourself to someone else, not just at your institution, but other institutions as well. (Mark)

Mark explicitly described a rise of comparison culture over time that is permeated through the broader exosystem and beyond. Sarah also perceived students seeing the 'nicest', 'prettiest', or 'most successful' version of a person on social media as increasing stress. Similar to the job market, the number of available peers for comparison has expanded.

Competition between students also took the form of as bragging about their lack of sleep, or activities detrimental to their wellness. Emily succinctly captured this: 'If it wasn't a dick-measuring contest to see who got the fewest hours of sleep, right … I think that could contribute to a wellness culture'.

Emily attributes these 'contest[s]' to directly harming student wellness. Sometimes, professors attributed the level of competition to the engineering culture of program 'rigor'. Student 'perfectionism', or excessive competition within the student themself, was also included. Lila explained, 'It's generally a very rigorous program, and many students in engineering I find are overachievers'. Sarah shared, 'I think a lot of our students are perfectionists. I think that's common in engineering'.

Many professors described observing academic and career stress as cyclical, which several participants described as the 'ebbs and flows of the semester'. Participants often described cyclical stress on an intra-semester time scale, which Kara shared: 'There's an initial peak around midterms. And then … the last three, four weeks gets pretty bad'. Participants also described career fairs as particularly stressful, especially due to financial stakes for some students. While the amount of overall stress fluctuates in cycles, there was still a baseline stress level that Shelly described as occurring 'nearly daily'.

In summary, professors commonly described perceiving a culture of competition within engineering that 'ebbs and flows', and some attributed decreased student wellness in part to this culture of competition.

In academic literature, perceptions of competition (Posselt and Lipson 2016) and rigor (Riley 2017) have strong positive correlations with decreased wellness and increased inequity. Engineering has been described as normalising high stress and diminished self care (Jensen and Cross 2021). Studies examining competition as correlated to decreased wellness in engineering have been inconclusive (Sanchez-Pena and Otis 2021). Our data suggest that professors observe a relationship between decreased wellness and high competition in engineering, motivating future examination.

While competition manifests in the students' microsystem as described by professors in this theme, the prevalence of this stressor goes beyond singular or individual interactions in engineering. For both professors and students, this culture of competition exists in the furthest levels of Bronfenbrenner's Bioecological Systems Theory, the exosystem and beyond. This means that, while all members are affected by this culture, many may believe they have little power to change it.

Tang et al. (Tang et al. 2021) describe career development as impacting mental health, which our career advisor participants echoed. Career competition was perceived as negatively impacting engineering student wellness. Though described frequently by career advisors, career stress was infrequently described by professors as an observed source of stress for their students.

Interpersonal relationships, identity, and local contexts: de-emphasised sources of stress

When compared to literature (Jensen et al. 2023a), some of the stressors that emerged from previous engineering student interviews were de-emphasised in these data. These de-emphasised stressors included interpersonal relationships, identity, and local contexts. When professors did describe these stressors, it was often directly related to student assignments and productivity or aligned with an identity the professors held.

When describing social aspects that might be stressful for students, at least five professors included students' stress with their families, isolation due to the COVID-19 pandemic, and group dynamics in project assignments. Additionally, Ted and Stacy mentioned romantic stress, Audrey mentioned roommate stress, and Rosa described making friends as potentially challenging.

Professors likely were more aware of family stress, COVID-19-related isolation, and group project dynamics because these more closely overlapped with professors' spheres of influence. Emily described family stress as 'some family emergency or stress or tragedy', which is often shared with professors to obtain an excused absence. Professors also experienced COVID-19-related isolation in their own lives, and so they may have been more able to recognise these impacts. Professors are also more likely to learn about inter-group stressors – for example, Zoe shared, 'If you have a group that's not pulling their weight' – for projects in classes they teach.

Similarly, professors were unlikely to discuss identity-related stressors. Only approximately half of the professors mentioned identity-related stressors such as gender, first-generation, or international status as a student stressor. When professors did mention a demographic-related stressor, they were more likely to mention a stressor if it aligned with their identity. For example, Sarah shared: 'A lot of the mental health struggles that the women in engineering face have to do with sexism … [When] I hear [women] students bring up something to me, it's not stress about a class, … it's about their male colleagues'. In our sample, five professors who used feminine pronouns were the *only* professors who described gender-based discrimination like Sarah did.

In summary, professor participants were more likely to notice stressors that overlapped with their spheres of interaction, such as students' in-class interactions and shared identities.

Professors did not often describe events in student exosystems and beyond, such as a rise in anti-identity hate crimes (Abelson et al. 2020; Zhou, Banawa, and Oh 2021), as contributing to student stressors. Interpersonal relationships, such as stress with roommates and romantic partners, have been described as key student stressors (Coiro, Bettis, and Compas 2017). Though professors mentioned social stressors, their primary awareness of student interpersonal conflict exists within group work, not in student interactions that happen outside the classroom. Additionally, when professors described identity-based stressors, they were likely to share identities. This aligns with literature showing the value of shared identities in professor-student mentorship (Busch 2022; Linley et al. 2016; Newman 2011; Preuss et al. 2020). Future research is needed to explore how member identity contributes to cultural engineering microsystems.

Supports for stress

Professor perceptions of students' coping mechanisms primarily included student support offices; students talking to friends; behavioural activities such as sleeping and exercising; and consumables such as caffeine, alcohol, and marijuana.

When professors described cognitive (including emotional) resources and strategies students used to manage their stress, most discussed available offices of support provided by the university, such as tutoring or counseling at the student health center. Some professors, for example, Emily, described their counseling services as 'extremely overwhelmed' or inaccessible due to their location.

Professors infrequently mentioned cognitive mechanisms such as scheduling for student coping. One of the career advisors, Jane, described, 'I think a lot of our students … make lists to deal with things'. The other cognitive stress management tool that a professor, Shelly, shared was when students would 'focus on what they see as the most important thing and then just might not do something else'. Strategic task elimination provided one of only a few examples of cognitive stress management that professors described.

Exercise was the most frequently suggested behavioural stress reliever by professors, and it was always regarded as a 'healthy' stress management approach. Alexis shared, 'They do a lot of exercise … I hear that a lot'. Professors also commonly described perceiving students consuming caffeine, alcohol, marijuana, and other drugs as a stress management mechanic, though this was often viewed as 'unhealthy', particularly when in excess. Several professors also mentioned students playing video games. Even though many of these activities occur outside of the classroom, professors felt aware of the students' engagement in these activities.

Professors also described social support to manage student stress, with the most common being spending time with friends, both in and outside the classroom. Mark shared, 'Most of the students who handle stress well I've noticed are pushing hard on something else extracurricular whether it be athletics, artistic, or some other thing that they do'.

Mark described a connection between students' flourishing and their extracurricular activities. Another example of a social hobby was 'joining the team sports' (Ted), which integrates exercise and social support. In addition to time with friends and social hobbies, some professors included familial support — as Gina shared, 'FaceTiming and being with family' — among the social supports students used.

In summary, professors described student wellness supports as activities and structures that existed primarily outside of the classroom, including social support from friends and wellness activities such as exercise.

Several of the primary sources of coping strategies described by engineering professors align with those described by undergraduate engineering students, such as social support through relationships and also health and wellness activities (Ban et al. 2022; Graves et al. 2021; Jensen et al. 2023a; Roming and Howard 2019; Stevens et al. 2007). Professors described supports in the individual, microsystem, and mesosystem levels of Bronfenbrenner's Bioecological Systems Theory and were more likely to recognise behavioural or social rather than cognitive coping strategies within each level. An exception was the recognition of cognitive emotional supports in the students' mesosystems, such as counseling.

Implications

The following outlines our recommended actions for educators (microsystem), academic administrators (mesosystem), and engineering education researchers (exosystem) motivated by the results and based on the broader engineering education literature. These results are presented in order of increasing spheres in Bronfenbrenner's model.

Educators

Professors described perceiving coursework as a primary stressor for students, which aligns with student descriptions of their stress (Jensen et al. 2023a). However, professors described expecting

support for student stress to stem from sources outside of the classroom, not in changes to the classroom culture. There may be an opportunity for additional student support through changes to courses and classroom culture. Curricular and cultural change may help reduce student stress and improve student mental health (Baik, Larcombe, and Brooker 2019; Bowman 2010; Knutson et al. 2022; Orme and Dooris 2010; Slavin, Schindler, and Chibnall 2014). Examples include modifying courses to integrate skills training, such as time management, and content that promotes health, such as mindfulness (e.g. Baik, Larcombe, and Brooker 2019; Bowman 2010; Harper and Neubauer 2021; Knutson et al. 2022; Orme and Dooris 2010; Robotham 2008; Slavin, Schindler, and Chibnall 2014). Instructional practices may reduce stressors (Robotham 2008) such as engaging with current best pedagogical practices (Bowman 2010; Harper and Neubauer 2021). For example, transparent and structured assessment has been shown to reduce student stressors (Angelo and Patricia Cross 1991; Chiou, Wang, and Lee 2014; Murphy and Destin 2023). Another example might be policies that encourage students thinking ahead such as guaranteed-extension policies that require a student-created work plan (Talbert 2023). Previous research (Conley, Durlak, and Dickson 2013) found that in-class interventions were more effective than those out-of-class, with these authors hypothesising this may be due to in-class learning environments being more familiar and thus easier spaces for student learning.

Academic administration

Similarly, administrative policies may provide support for in-classroom support development. Incorporating activities that promote wellness (e.g. Baik, Larcombe, and Brooker 2019; Bowman 2010; Knutson et al. 2022; Orme and Dooris 2010; Slavin, Schindler, and Chibnall 2014), including socially aware active-learning strategies (e.g. Abelson et al. 2020; Buckley et al. 2004; Cech 2014; Lord, Przestrzelski, and Reddy 2019), can be time – and resource-intensive to develop. Dedicated departmental recognition, time, and funds often support professors incorporating these activities. Content that incorporates an awareness of student mental health shows promise for supporting student wellness (Abelson, Lipson, and Eisenberg 2021).

Researchers

Research is needed to evaluate the extended impacts of stress-reducing interventions in academia (Abelson, Lipson, and Eisenberg 2021). In addition to pretest-posttest assessments, longer-term evaluations of gained stress-management skills are recommended to measure the lasting impact of these interventions (Abelson, Lipson, and Eisenberg 2021). Further areas of interest for research include a comparison of the relation between the intention of change compared to actually incorporating wellness-focused actions both inside and outside of the classroom. This would be a step toward identifying barriers for professors engaging with these actions.

Limitations and future work

There are likely differences in professor perceptions that are influenced by university demographics such as institution size (Sanders et al. 2024), and future work is needed to examine differences in professor perceptions both by professor identities and by institution demographics. Future work is also needed to confirm the transferability of these results to institutions outside of the United States. Selection bias was introduced by our use of 'mental health' in the advertisement. While only a few participants described emotions as 'in [students'] head[s]', and thus something of which professors could not be aware, this may be a more frequently held belief than our dataset represents.

Conclusion

Engineering professors in this study described their consistent, weekly interactions with students as an opportunity to recognise signs of student distress. They identified academics, time management,

and competition as stressors that significantly impact student experiences. Additionally, professors were less aware of student stressors that do not as directly overlap with their spheres of direct influence, such as interpersonal relationships and identity. These findings highlights areas for potential change to decrease student stress and thus strengthen student wellness.

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Appendix A

This presents the codebook applied to participants' data to produce the results present in this paper. This codebook is adapted from one first presented in (Jensen et al. 2023a). This codebook divides the first three high-level codes presented in Table 4 by Bronfenbrenner's Bioecological Systems Theory. Asterisks (*) denote example instances that were not present in the original codebook and were added by the analysis in this paper.

Of note, the mental health resources described were divided into behavioural and cognitive, which is consistent with educational psychology literature on stress and coping (Lazarus and Folkman 1984; Thoits 1986). These literature describe behavioural coping as actions on the environment or self to change circumstances and mitigate stress. Cognitive actions include actions to alter the internal appraisal process and help mitigate feelings of stress through changing this appraisal. Our prior work (Jensen et al. 2023a) overlaid these definitions onto Bronfenbrenner's model through defining cognitive supports in the mesosystem to include resources such as attending therapy, since these resources most directly support these internal cognitive actions.

Code	Sub-Code	Example Instances
Agentic (Individual) Student Stressors	Academic	ex. exams, tests, imposter syndrome*, comparing self to others
	Career	ex. choosing a career
	Well-being	ex. sleeping enough
	Time management	ex. deadlines
Agentic (Individual) Mental Health Resources	Available behavioural	ex. hobbies, exercise, drugs/caffeine*, scrolling social media*
	Available cognitive	ex. scheduling, letting things drop*
	Used behavioural	ex. hobbies, exercise
	Used cognitive	ex. scheduling
Microsystem Stressors	Academic	ex. group work, peer-to-peer competition, imposter syndrome*
	Career	ex. getting an internship
	Social relationships	ex. family pressures, also includes time it takes to be in clubs*
Microsystem Mental Health Resources	Available social supports	ex. friend support
	Available cognitive supports	ex. office hours
	Used social supports	ex. friend support
	Used cognitive supports	ex. office hours
Microsystem Climate	Identity-based (non engineering)	ex. women
	Mental Health	ex. losing sleep for school work
	Motivation	ex. competitive climate
Mesosystem Stressors	Academic	ex. available curriculum, imposter syndrome*
	Career	ex. job market
	Belonging	ex. dept demographics
	Prestige	ex. university rank
	Location	ex. located far away, seasonal depression
	Money	ex. money needed
	Climate change	ex. climate change
Mesosystem Mental Health Resources	Available social supports	ex. clubs
	Available cognitive supports	ex. counseling
	Used social supports	ex. clubs
	Used cognitive supports	ex. counseling
Mesosystem Climate	Identity-based (non engineering)	ex. women, socio-economic status*, working a job. Note: any mention of participant awareness of
	Mental health	ex. engineers are more stressed